Report on the earthquake impact to Kashiwazaki-Kariwa NPP

Senior Regulators' Meeting
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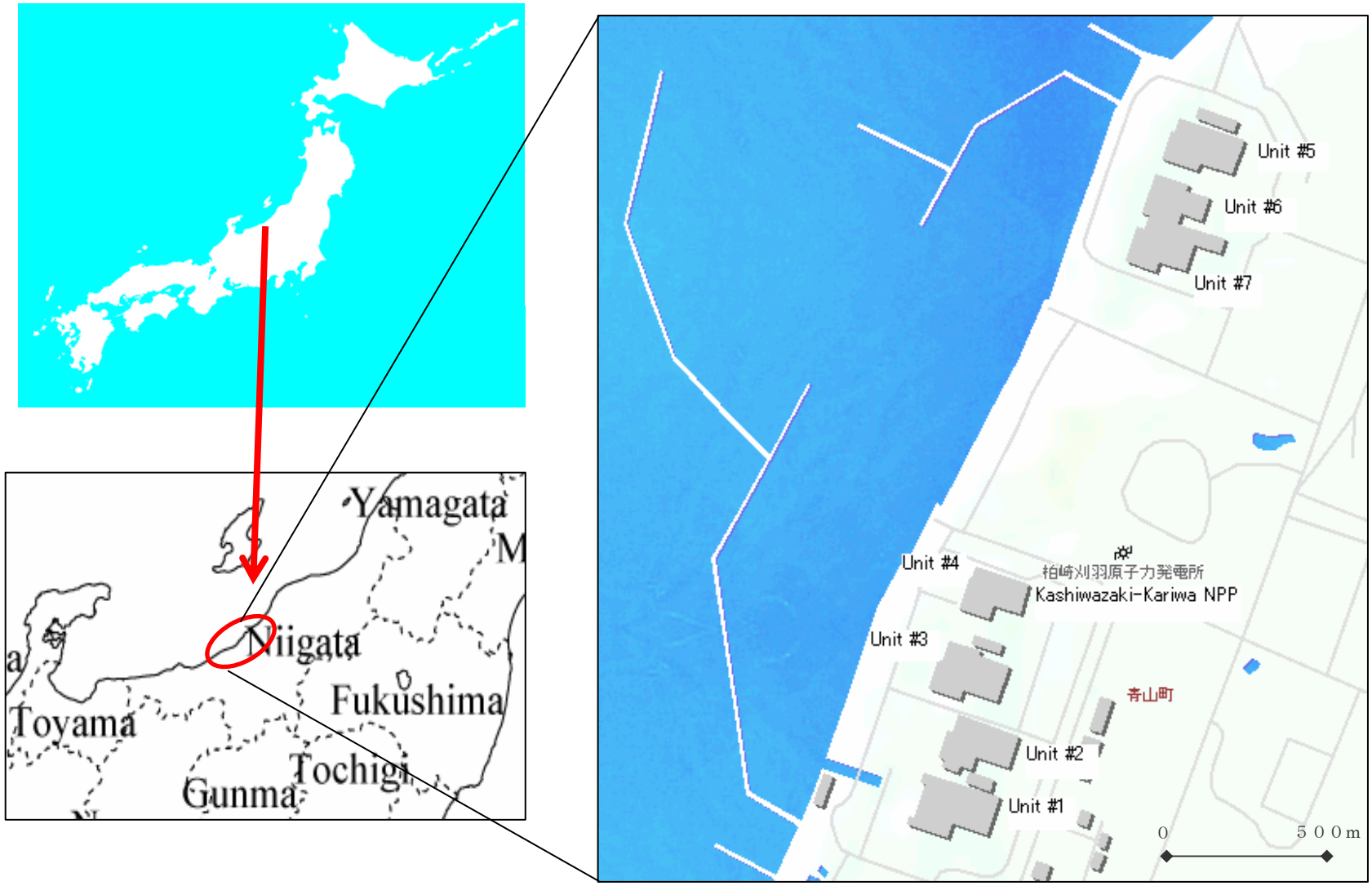
（Reference）The Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities

1. Outline of Kashiwazaki-Kariwa Nuclear Power Station

Location of Kashiwazaki-Kariwa Nuclear Power Station



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Outline of Kashiwazaki-Kariwa Nuclear Power Station

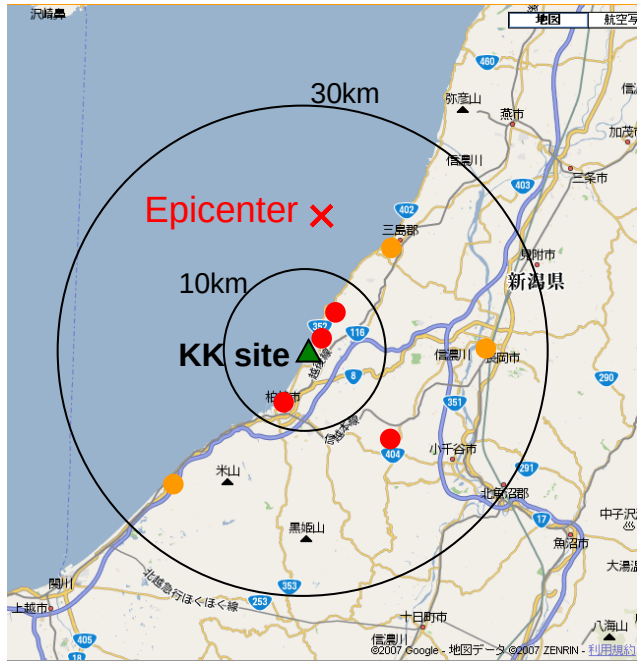
Unit	Start	Type	Output	Contractor
1	1985	BWR-5 / Mark II	1,100MWe / 3,293MWt	Toshiba
2	1990	BWR-5 / Mark II	1,100MWe / 3,293MWt	Toshiba
3	1993	BWR-5 / Mark II mod.	1,100MWe / 3,293MWt	Toshiba
4	1994	BWR-5 / Mark II mod.	1,100MWe / 3,293MWt	Hitachi
5	1990	BWR-5 / Mark II mod.	1,100MWe / 3,293MWt	Hitachi
6	1996	ABWR	1,356MWe / 3,926MWt	Toshiba/Hitachi/GE
7	1997	ABWR	1,356MWe / 3,926MWt	Toshiba/Hitachi/GE
Total			8,212MWe	

2. Outline of the earthquake

Specification of the earthquake

- The Niigataken Chuets-oki Earthquake in 2007
- July 16, 2007 10:13 a.m. JST (01:13 UTC)
- Epicenter: 16km from Kashiwazaki-Kariwa Nuclear Power Station

  Hypocenter: 17km below the seabed off Jo-Chuetsu area, Niigata prefecture
- Magnitude 6.8



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Situation of Kashiwazaki-Kariwa NPPs

- When the earthquake occurred,

  unit #3, #4 and #7 : in operation

  unit #2 : start-up (not critical)

  unit #1, #5 and #6 : outage for the periodic inspection

- Units #2, #3, #4 and #7 automatically shut down, detecting high seismic acceleration.

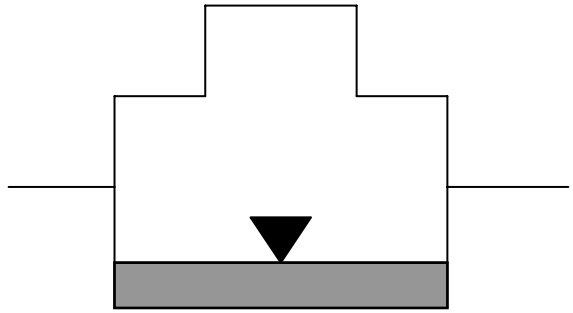
  - observed seismic acceleration was greater than the design value

Outline of Ground Motion (1)

Observed Peak Ground Acceleration at Lowest Floor of the Reactor Building

(gal)

	North-South Component	East-West Component	Vertical Component
Unit #1	311(274)	**680(273)**	408(235)
Unit #2	304(167)	606(167)	282(235)
Unit #3	308(192)	384(193)	311(235)
Unit #4	310(193)	492(194)	337(235)
Unit #5	277(249)	442(254)	205(235)
Unit #6	271(263)	322(263)	488(235)
Unit #7	267(263)	356(263)	355(235)



Numbers shown in ( ) are the design values.

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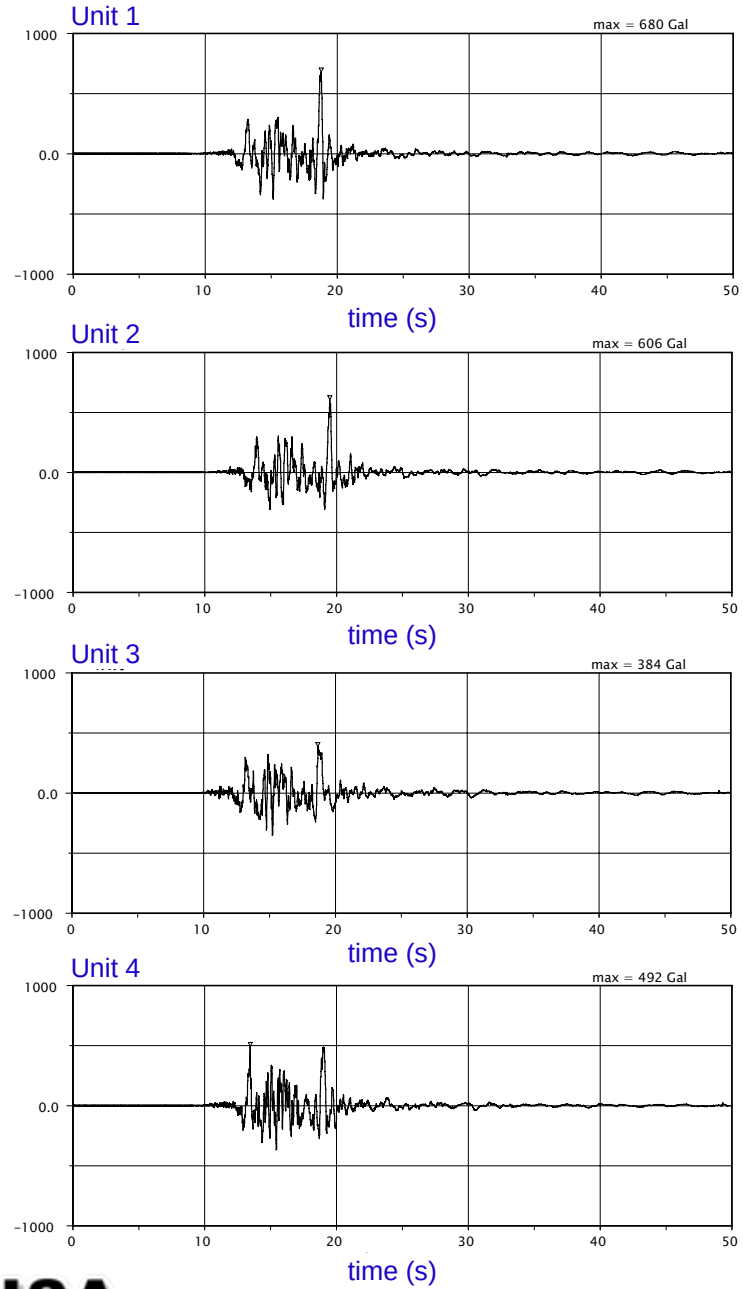

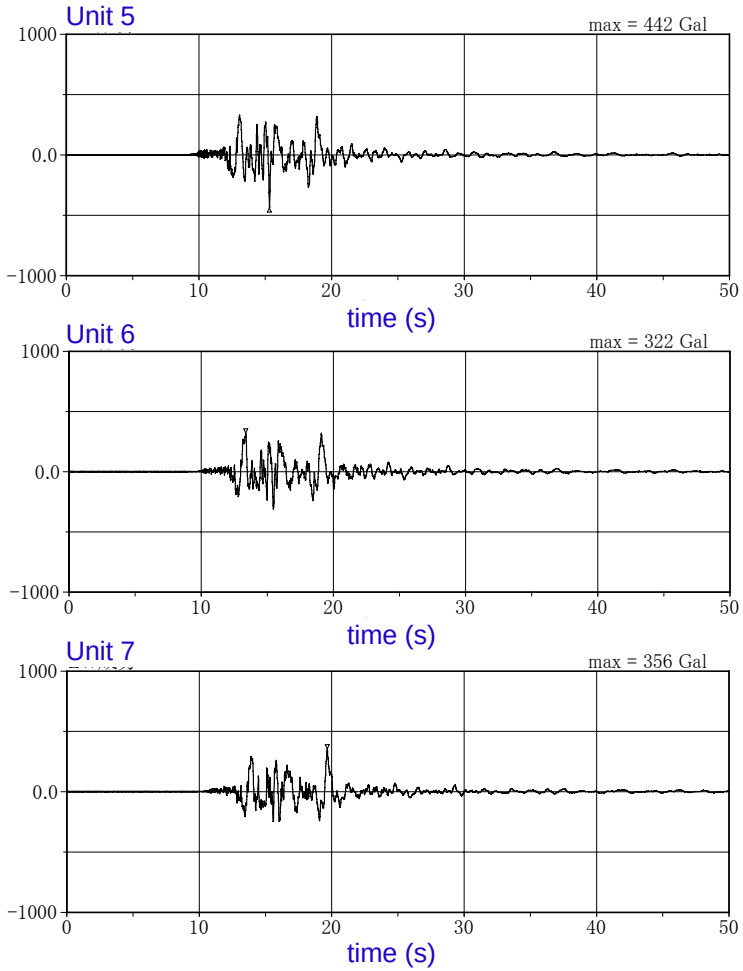

Time history of acceleration

（At the base mat of the reactor buildings：EW component）

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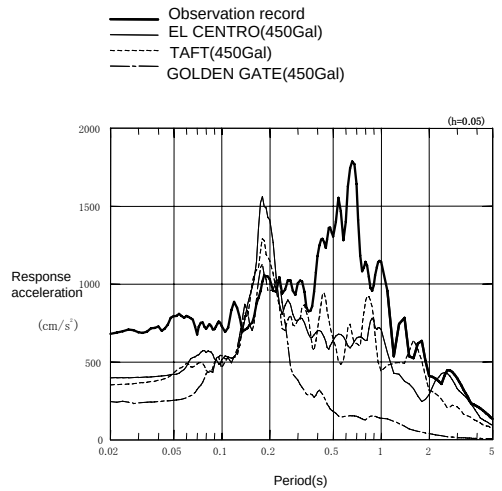
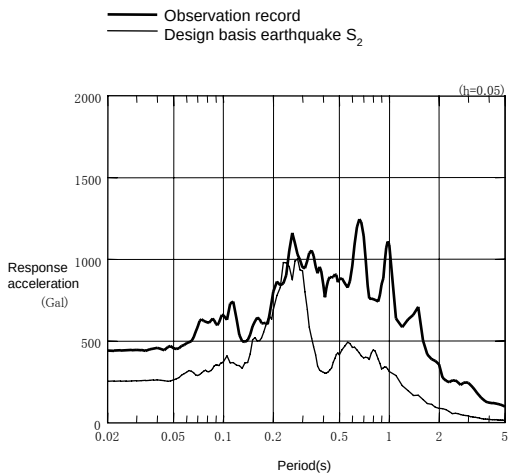
Observation records on the base mat of reactor buildings

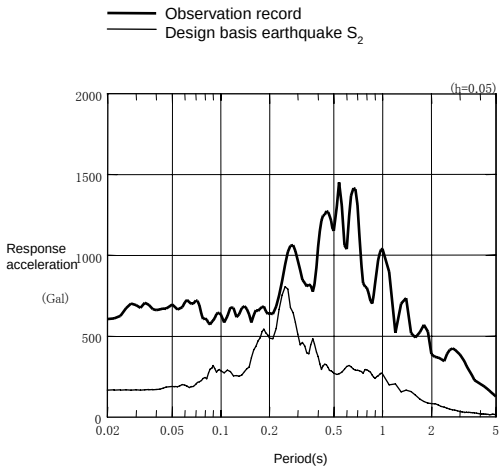
Unit 1



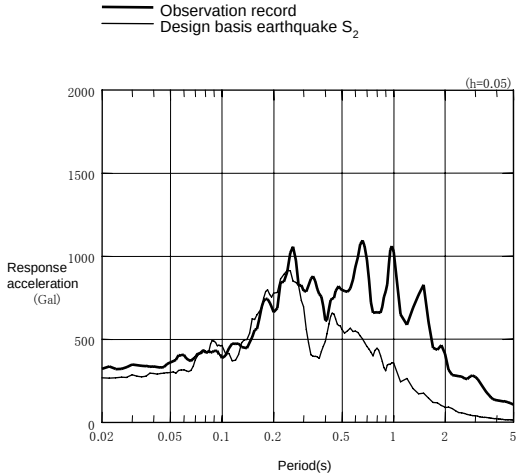
Unit 5



Unit 2



Unit 6



Acceleration Response Spectrum at the Base Mat EW

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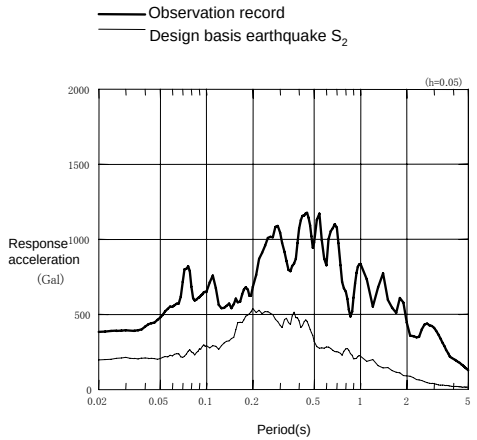
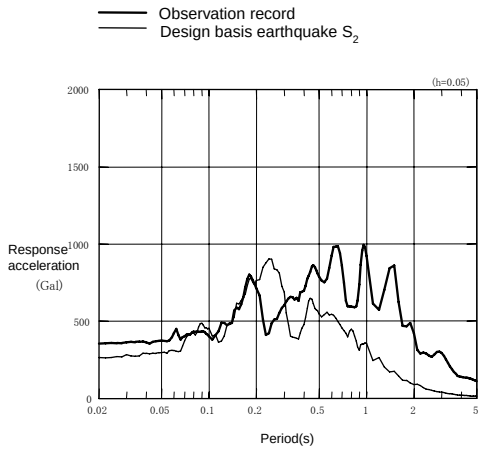
Observation records on the base mat of reactor buildings

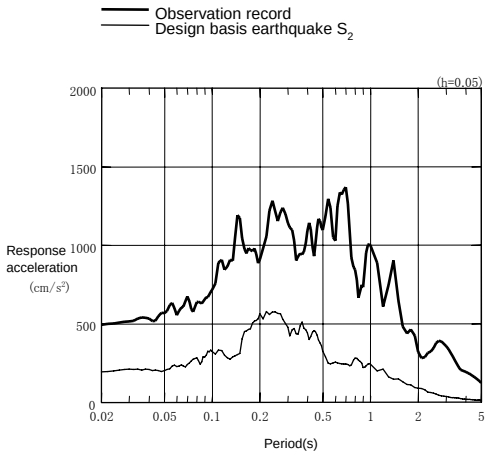
Unit 3



Unit 7



Unit 4



Acceleration Response Spectrum at the Base Mat EW

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3. Situation after the earthquake

(1) Plant status

Plant status during and after the earthquake

			Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7
Status at the time of the earthquake	Operation status		Outage	Startup (Subcritical)	In operation	In operation	Outage	Outage	In operation
	Automatic shutdown		–	Yes	Yes	Yes	–	–	Yes
	Reactor status	Fuel position	All fuel retrieved (in the fuel storage pool)	In the reactor	In the reactor	In the reactor	In the reactor	In the reactor	In the reactor
		Pressure vessel's top lid	Open	Closed	Closed	Closed	Closed	Closed	Closed
		Containment vessel's top lid	Open						
		Well cover	Open					Open	
Status after the earthquake	Operation status		Cold shutdown	Cold shutdown	Cold shutdown	Cold shutdown	Cold shutdown	Cold shutdown	Cold shutdown
	Overflow of fuel storage pool		Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Release of radioactive substances		–	–	–	–	–	Overflowed fuel pool water released to the external environment via cable cavities	Released from the exhaust stack via the turbine shaft seal
	Other events		Fire protection system's water flooding in the annex area of the reactor combination building 2,000m^3	–	House transformer fire	Seawater leakage at the turbine building 24m^3	–	–	–
Power sources	Off-site power		2 out of 4 lines were maintained during and after the earthquake						
	Diesel generator		Good (Stand-by)	Good (Stand-by)	Good (Stand-by)	Good (Stand-by)	Good (Stand-by)	Good (Stand-by)	Good (Stand-by)

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Seismic Design and Status of Power Station Facilities

Seismic importance		Major equipments/systems	Seismic design force	Major damage identified through visual observation
As	Facilities especially important among seismic class A	Reactor pressure vessel Primary containment vessel Control rod, CRD mechanism Residual heat removal system	Basic earthquake ground motion S_2	None
A	Facilities containing radioactive materials by themselves or related directly to Facilities containing radioactive materials, whose loss of function might lead to the diffusion of radioactive materials to the environment, Facilities required to prevent the occurrence of those events and Facilities required to mitigate the consequences resulting from the diffusion of radioactive materials in the occurrences of those accidents, and also whose influences are very significant	Emergency core cooling system Reactor internal structures	Basic earthquake ground motion S_1 or three times of the seismic force in building code, whichever is greater	None
B	Facilities of the same functional categories as above A Class, however whose influences are relatively small	Turbine Radioactive waste disposal sys. Reactor water clean-up sys.	One half of the seismic force in building code	Breakage of the drive axis of the overhead crane (KK-6) (The function of preventing from falling was maintained.)
C	Facilities except for A or B Class, and ones required to ensure equal safety as general industrial facilities	Main generator Transformer Turbine auxiliary cooling sys. Laundry waste disposal sys.	The seismic force in building code	House transformer fire (KK-3) Ground subsidence and displacement of oil fences (KK-1,2,4,7) Displacement of exhaust duct (KK-1～5)
Others	----	----	----	Breakage of glass of office building Leakage from drinking water tank

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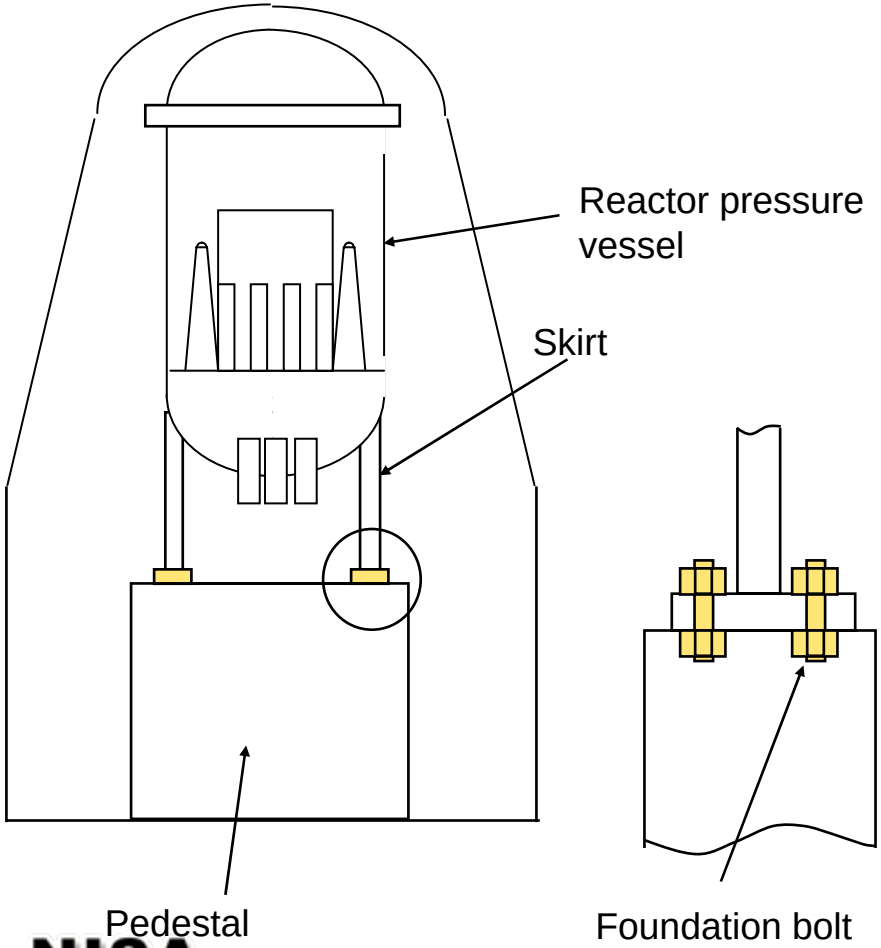
Foundation bolt for the reactor pressure vessel at Unit 1

- Visual check of the foundation bolt for the reactor pressure vessel at Unit 1 (peripheral side).



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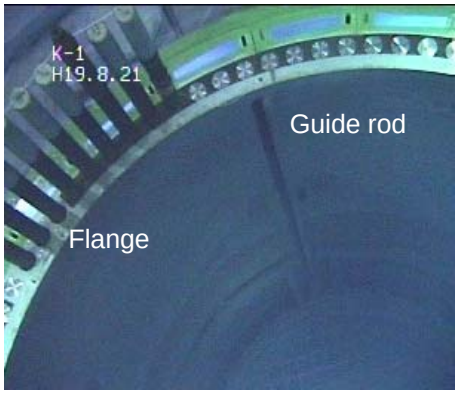
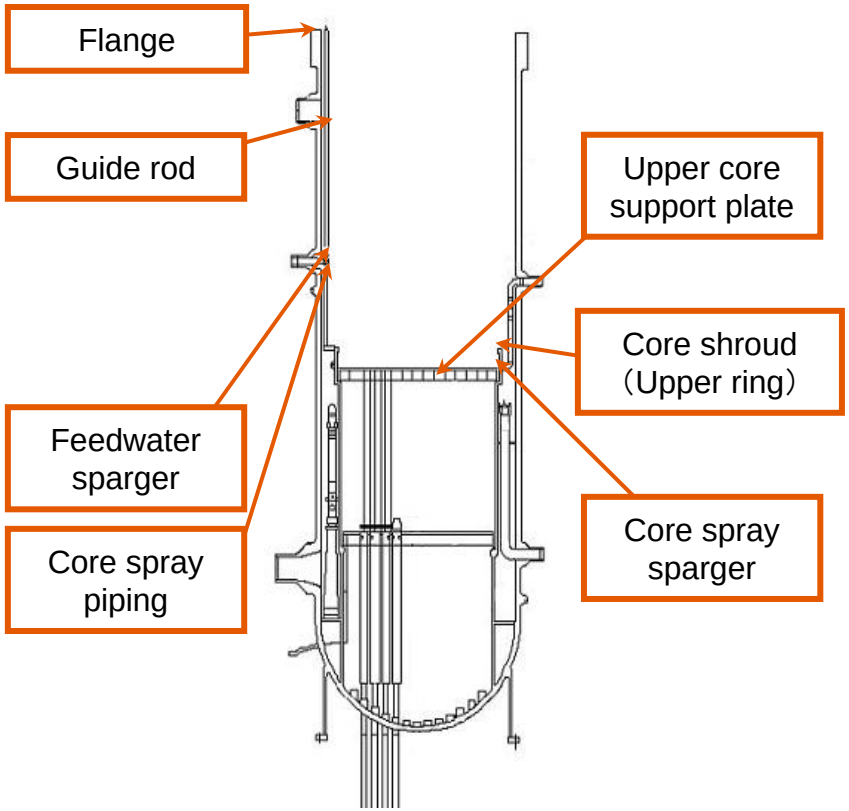
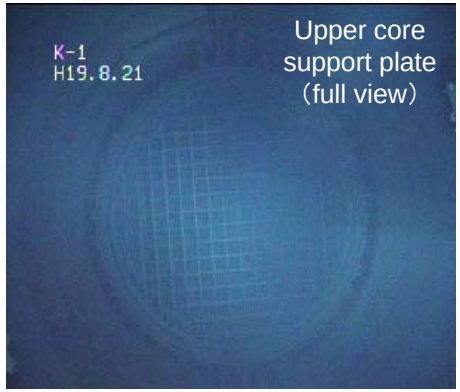
Conditions of Class A / As SSCs

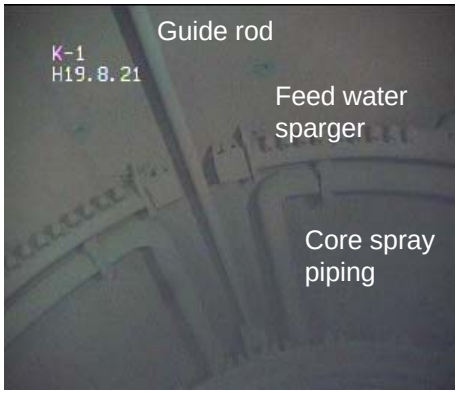
Upper reactor pressure vessel at Unit 1

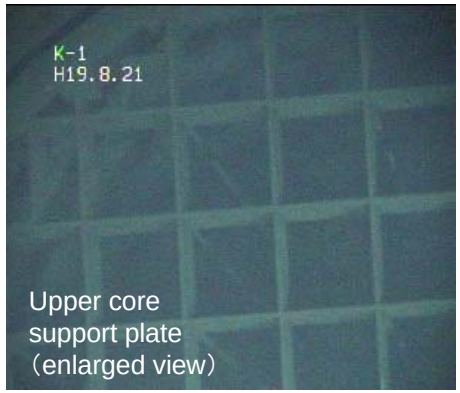
No anomaly such as damage, deformation and dropout has been identified from the inspection by under water camera.

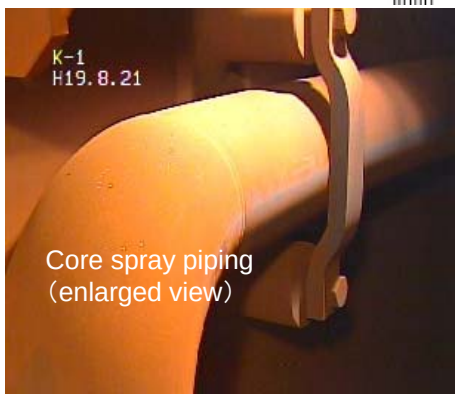


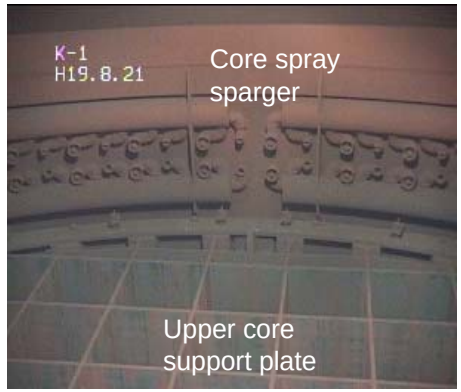


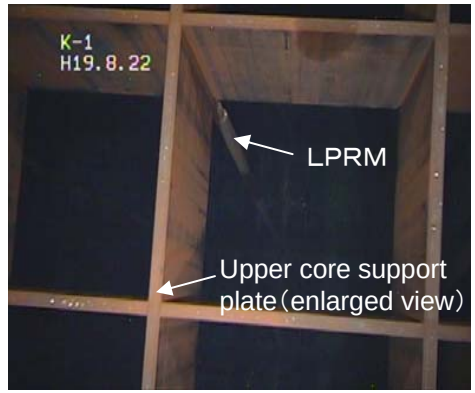












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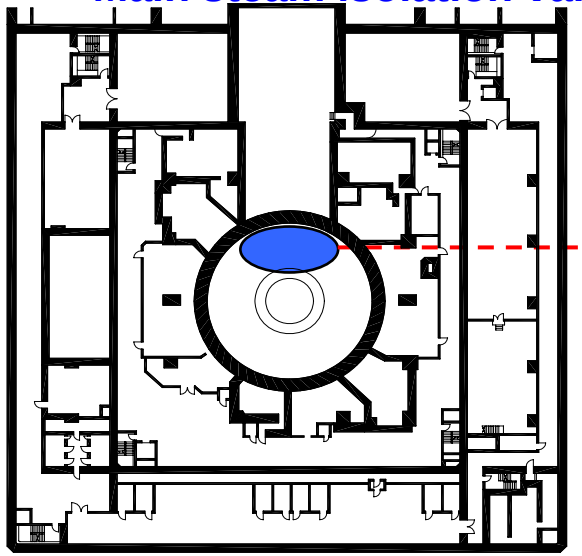
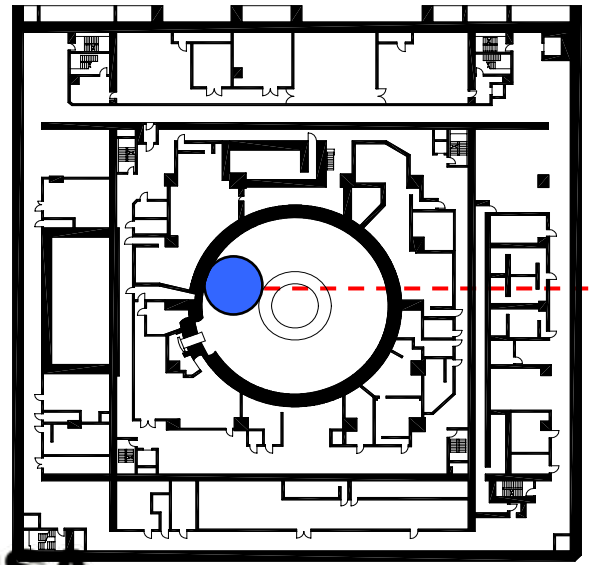
Main steam isolation valve and PLR pump at Unit 3

Main steam isolation valve (In the primary containment vessel).



PLR pump (In the primary containment vessel).



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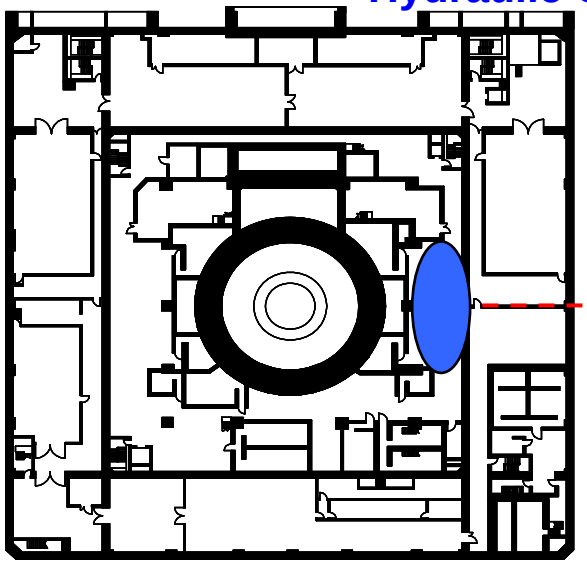
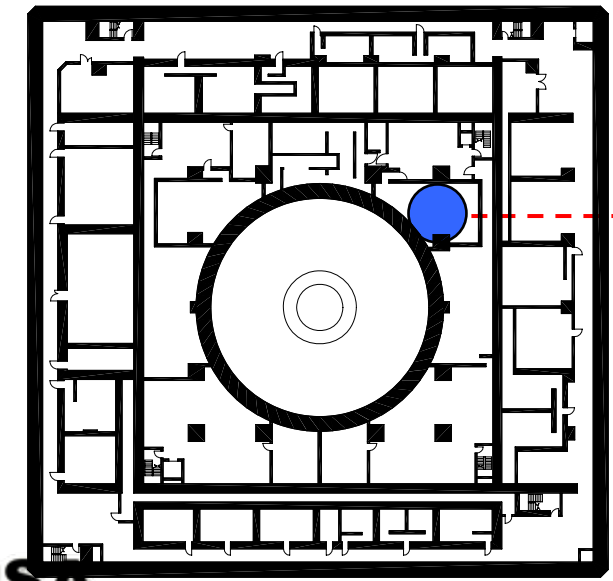
Hydraulic Control Unit and Residual Heat Removal Pump at Unit 3

Hydraulic Control Unit (B1F in the reactor building).



Residual Heat Removal Pump (B5F in the reactor building).



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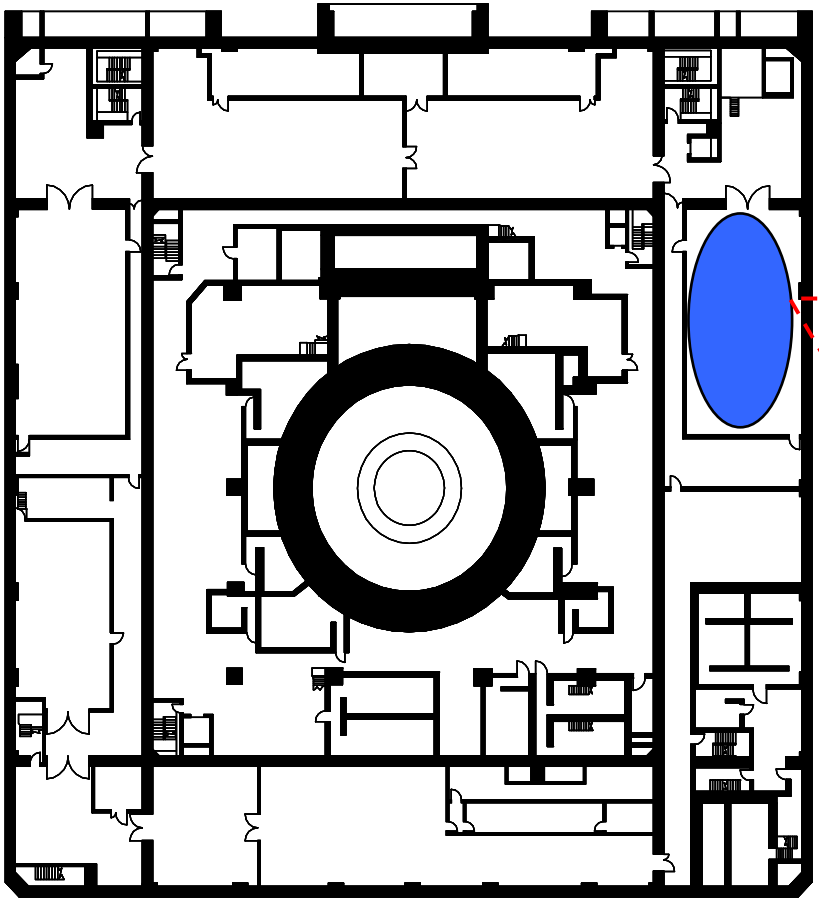
Conditions of Class A / As SSCs
Emergency diesel generator at Unit 3

B1F in the annex of the reactor building.



Upper side of the emergency diesel generator.

Lower side of the emergency diesel generator.

The 20 emergency diesel generators at units 1 to 7 underwent a manual startup test from July 25 to 27 to confirm their availability.

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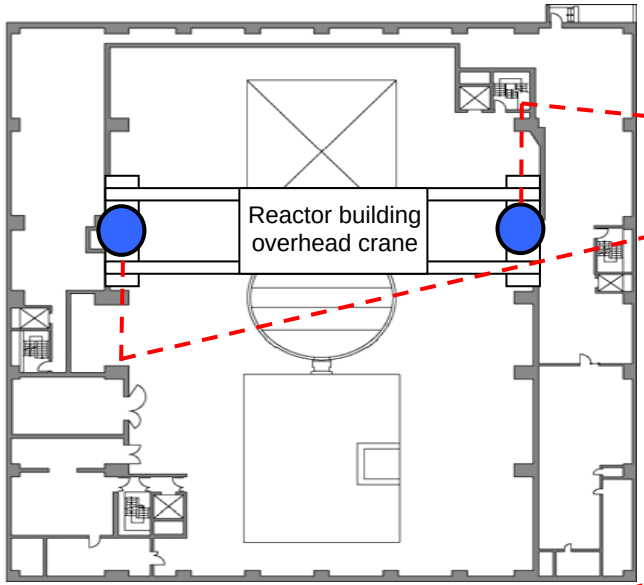
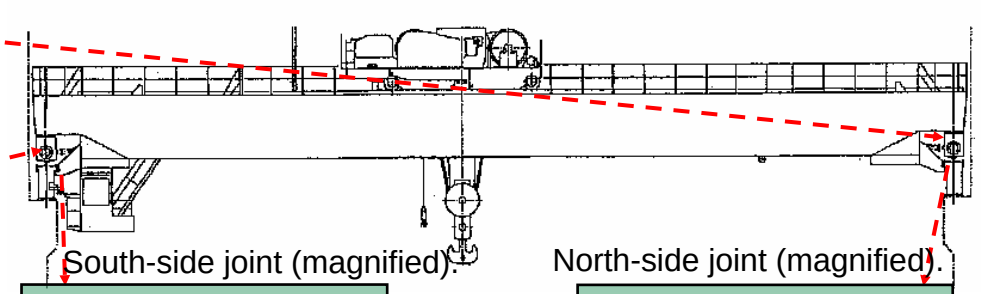
Conditions of Class B / C and other SSCs

Overhead crane of the reactor building at Unit 6

Overhead crane of the reactor building on the refueling floor (4th floor) at Unit 6.



Cross-section diagram of the reactor building's overhead crane.



Universal joint.
(on the south-side wheel)

Universal joint.
(on the south-side motor)

Universal joint.
(on the north-side wheel)

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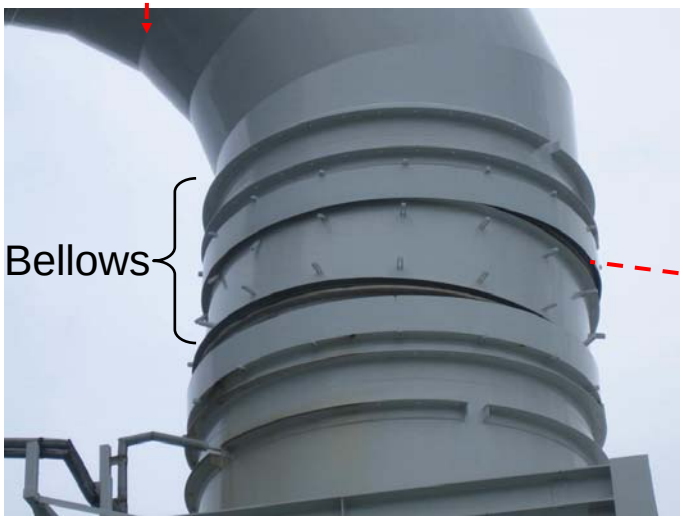
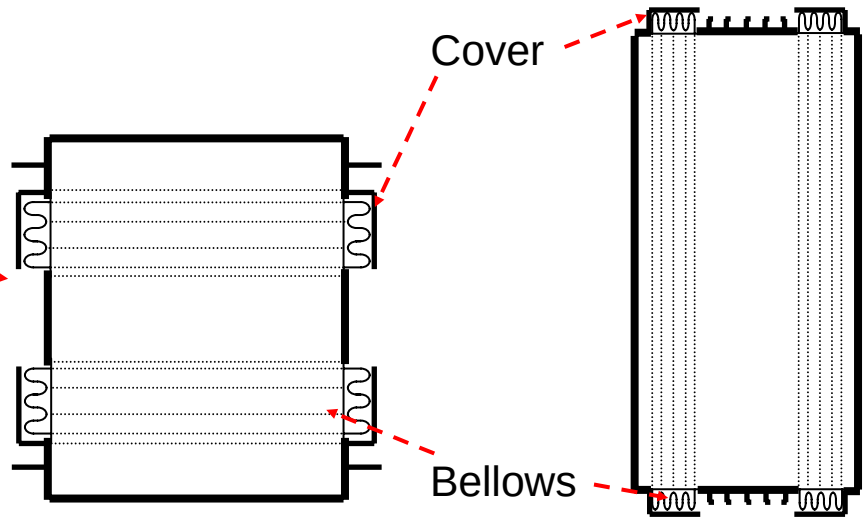
Exhaust duct at Unit 1

- Displacement of exhaust duct at Unit 1.





Duct displacement

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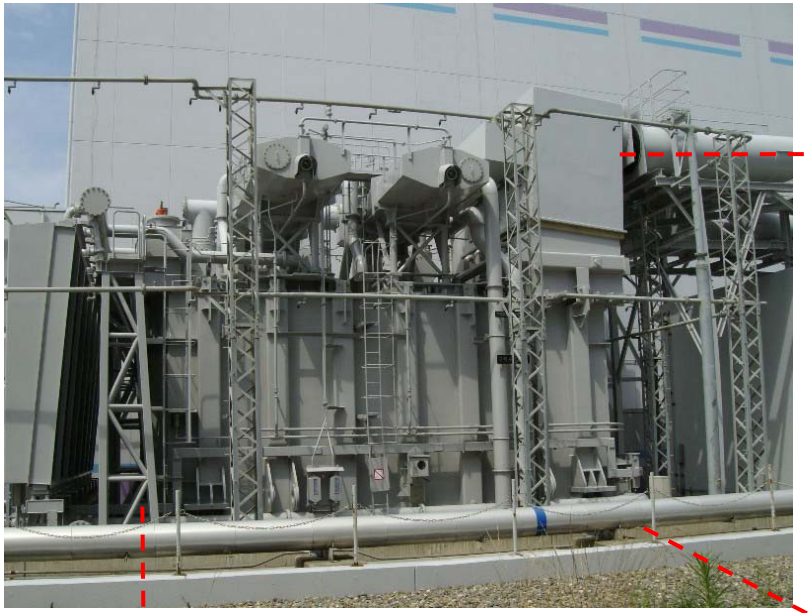
Main transformer at Unit 2

Full view of the main transformer.



- Displacement at the primary-side joint .

- Oil leakage.

- Breakage of foundation bolts.

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Status of Class B, C or Other Facilities (K1 Light Oil Tank)

- Ground subsidence around the light oil tank of Unit 1

Entire view of the light oil tank

Ground subsidence around the light oil tank

It has been confirmed that the light oil tank is free from oil leakage or deformation and any structural problems.

* July 18 From the Mayor of Kashiwazaki, according to the fire protection law, the power station received the command to cease using the dangerous facilities such as the light oil tank.
July 24 From the Mayor of Kashiwazaki, the power station received the permission to use the facilities (emergency diesel generator facilitties (including the light oil tank) and auxiliary boiler facilities) for which the power station had applied.

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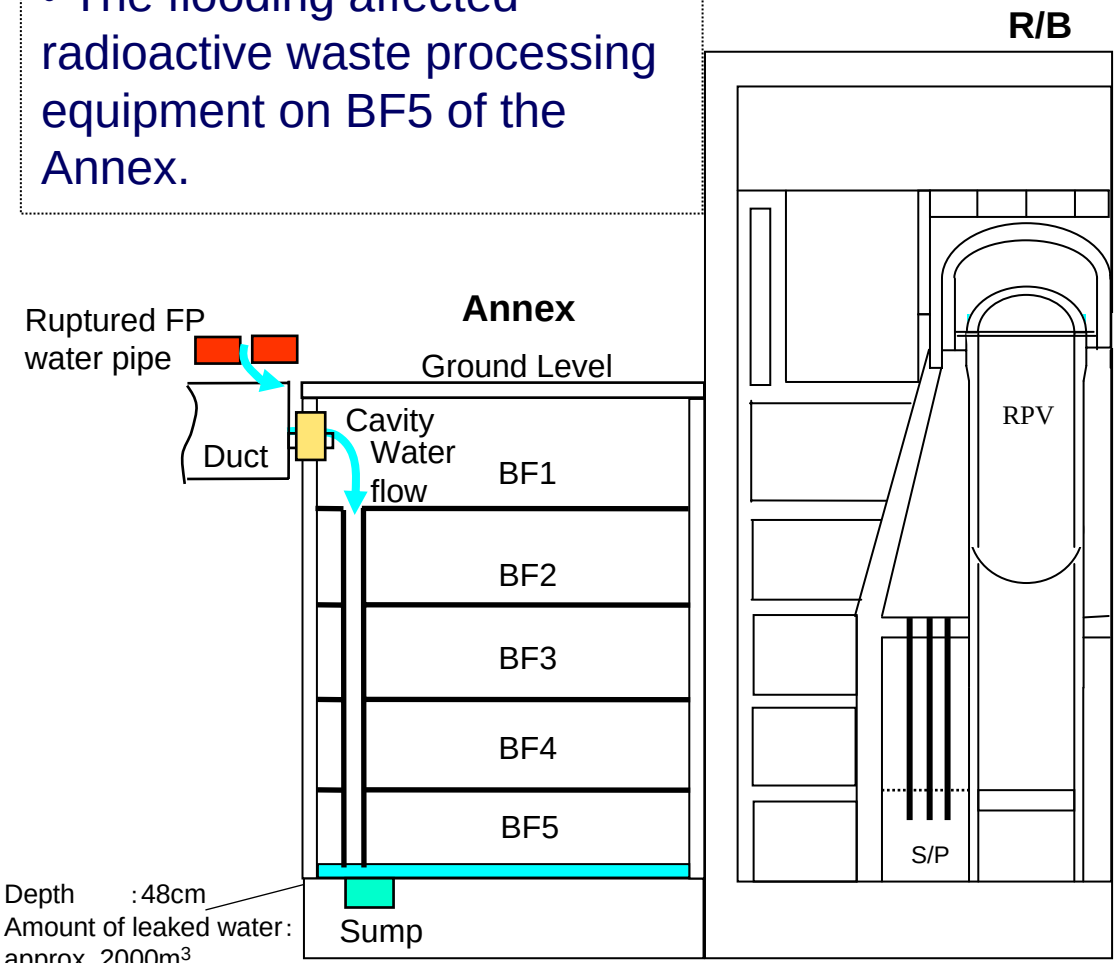
Conditions of Class B / C and other SSCs
Piping of the fire protection system at Unit 1

- Flooding caused by a fire protection pipe rupture.

Status of damage.

Status of restoration.

• The flooding affected radioactive waste processing equipment on BF5 of the Annex.



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Solid waste storage facility

- Tumbling of drums at the solid waste storage facility.
  - As of now, 438 drums are confirmed to have fallen over, and 41 of them had the lid open as a result.
  - No radioactive substances were detected in the measurement of atmospheric radioactive substance concentration in the facility. Radiation was also not detected from leaked water.

Conditions of Class B / C and other SSCs
Roads in the station compound

- Road damage near Unit 5.

- Road damage near Switch Yard.

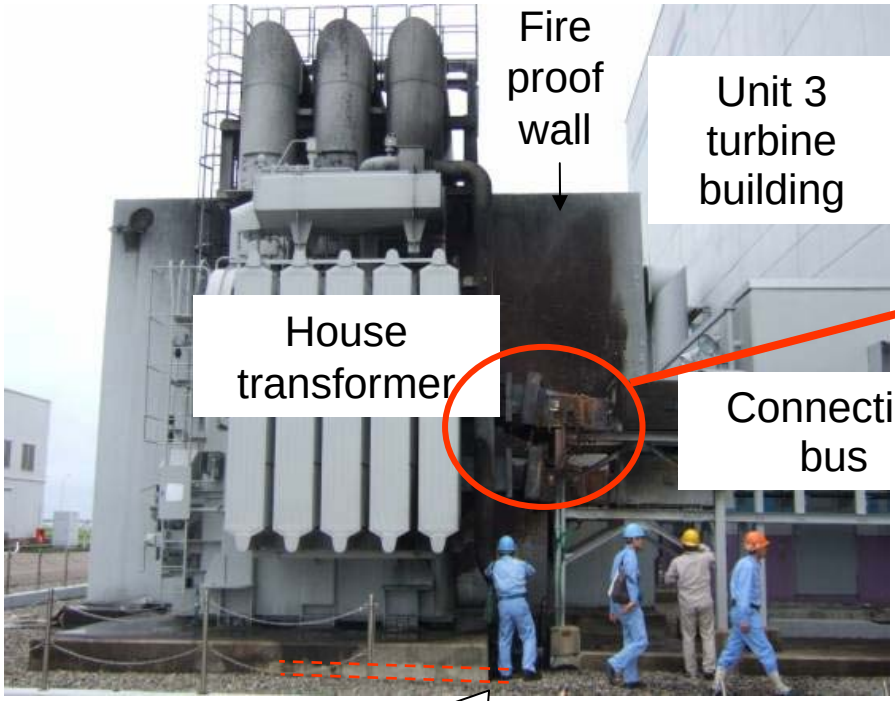
3. Post-earthquake status

(2) Major Incidents Identified

① House transformer fire at Unit 3
② Opening of blowout panel of reactor building at Unit 3
③ Radioactive leakage at Unit 6
④ Radioactive leakage at Unit 7

House transformer fire at Unit 3

- The fire continues 2 hours before extinction.



Vertical displacement between the transformer and its secondary connection bus.

Subsidence of the base of the transformer's secondary connection bus in relation to the transformer's base.

Unit 3 House Transformer Fire

- Unit 3 House Transformer Fire
  - Time line

    July 16

    10:13 Earthquake occurred

    10:15 Post-earthquake plant walk-down discovered the fire.
    Initial efforts to extinguish the fire (4 people).

    10:27 Shift supervisor contacted the fire station but was asked to use in-house self defense fire brigade.

    11:23 Shift supervisor contacted the fire station again.

    11:27 The fire station entered the Kashiwazaki-Kariwa NPS.

    11:33 Fire fighting by the fire station was started.

    12:10 Fire was extinguished.

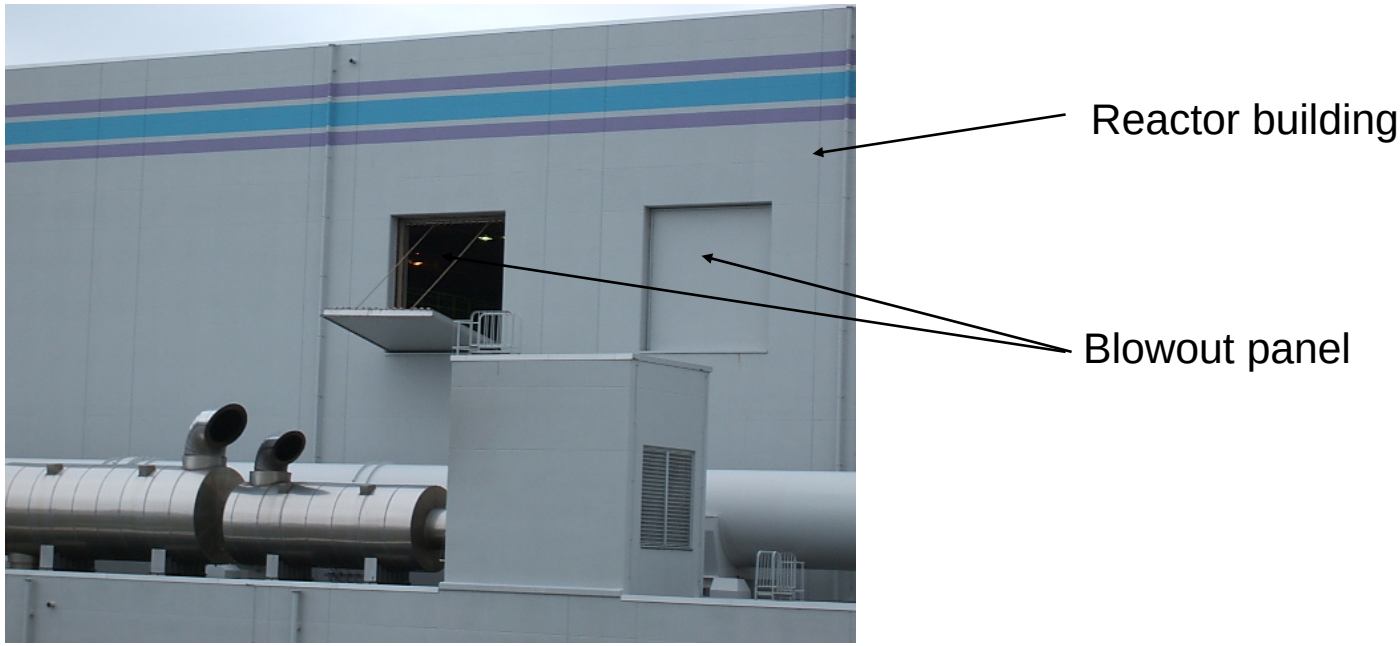
Water could not be sprayed from the fire hydrant due to pipe breakage.

Since oil fire was suspected and difficult to extinguish with water, the workers retreated to a safe area, reported to the emergency H/Q and waited for the arrival of the fire department.

  - Damage and causes
    - The fire protection wall prevented the fire from spreading to other areas.
    - The cause is presumed to be such that: Because of soil deformation, the duct dropped and came in contact with the connecting terminals and the bushing was damaged and caused oil leakage. In such a situation, oil was ignited by sparks generated by the contact.

Displacement of Reactor Building Blowout Panel

- Opening of a Unit 3 blowout panel
  - It is presumed that the reactor building blowout panel came off due to the earthquake.

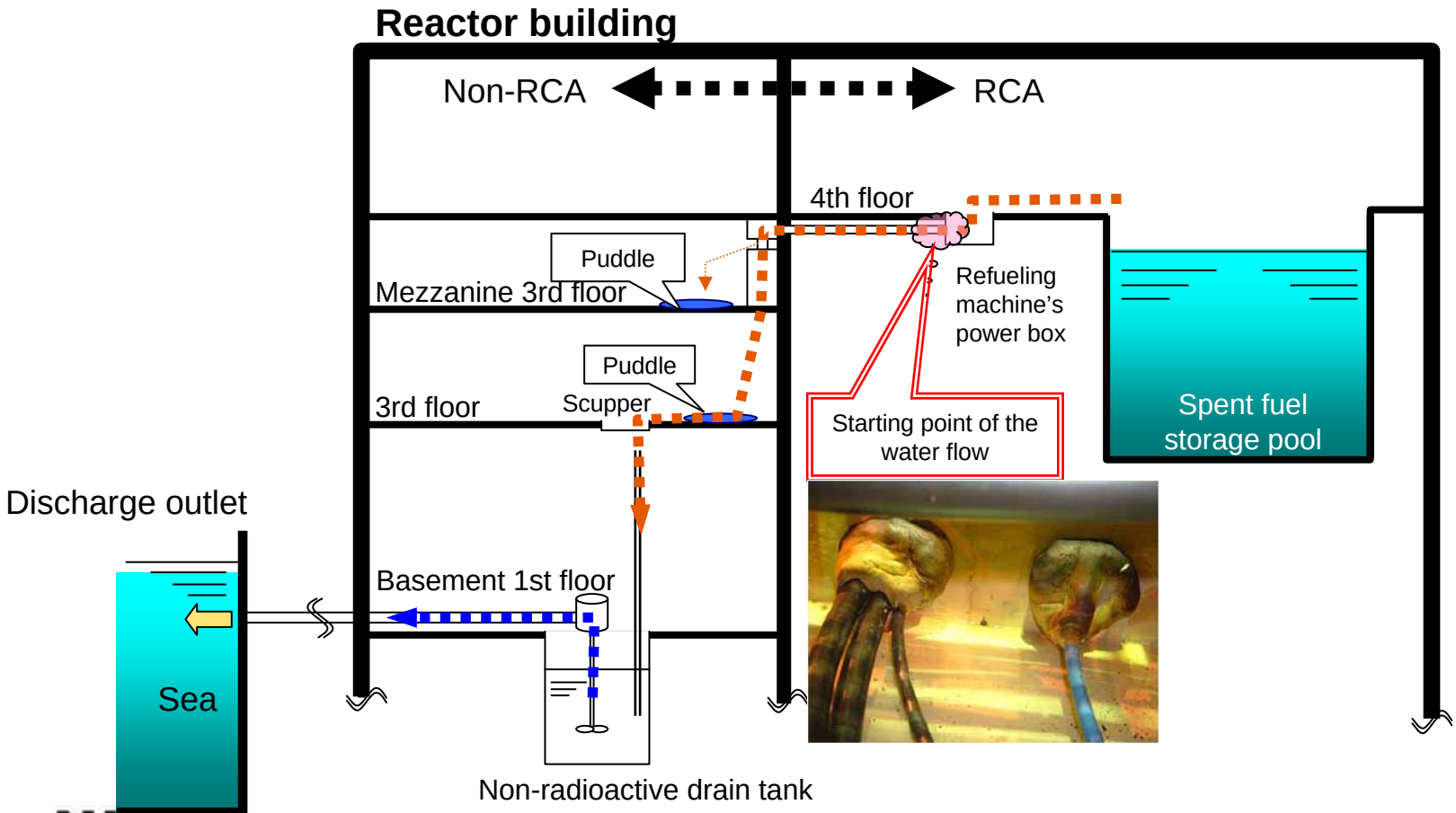


  - Departure from the LCO* due to displacement of the reactor building blowout panel was declared (15:37) and returning to within the LCO was declared (23:07) after the unit came to a cold shutdown condition.
    (Departure from the LCO was declared since it was considered that the negative pressure would not be maintained. Actually, however, the negative pressure remained maintained.)
  - The blowout panel will be restored prior to fuel transfer work.

*LCO: Limiting Condition of Operation, as specified Fitness-for-Safety Program for reactor facilities

Radioactive leakage at Unit 6

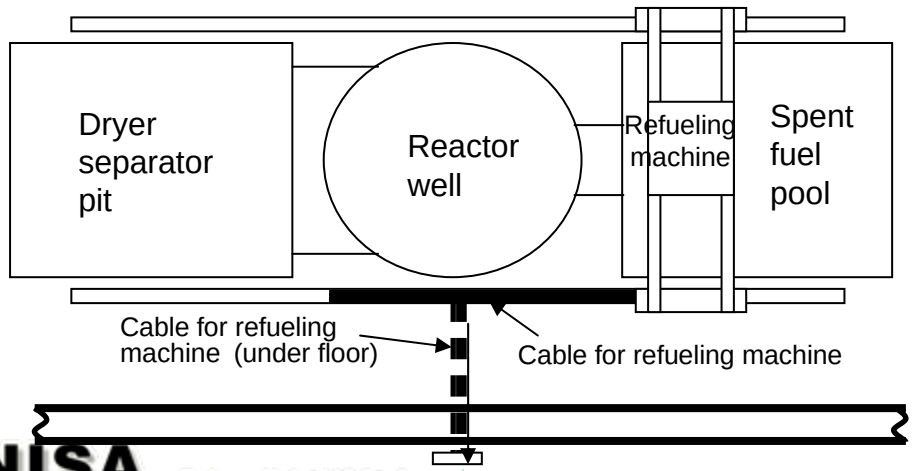
- Water leakage and subsequent release of radioactive substances into the sea.
  - Amount of water discharged: 1.2 m3.
  - Radiation dose: 2×10^{-9} mSv << 1 mSv (public dose limit).

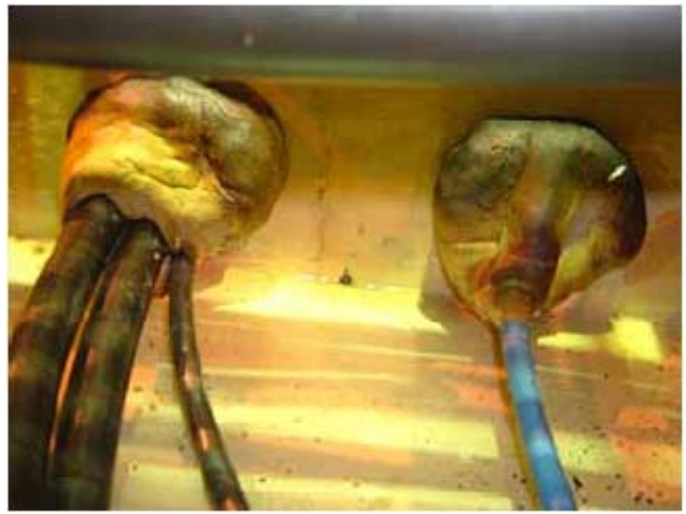


Leakage path at unit 6

- Water leakage and subsequent release of radioactive substances into the sea

Cable for refueling machine





Cable for refueling machine (under floor)

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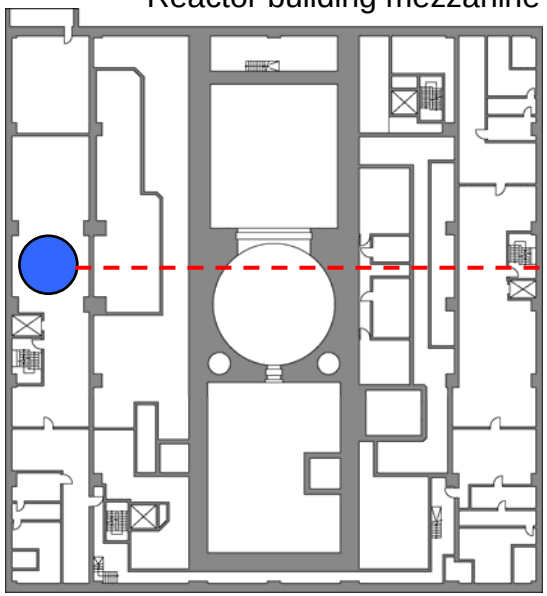
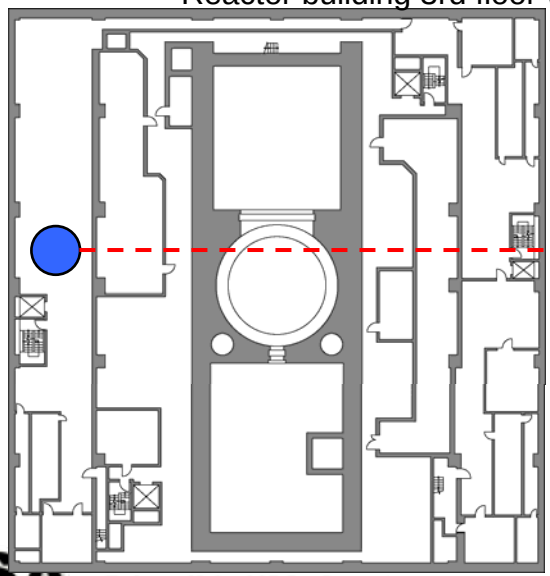
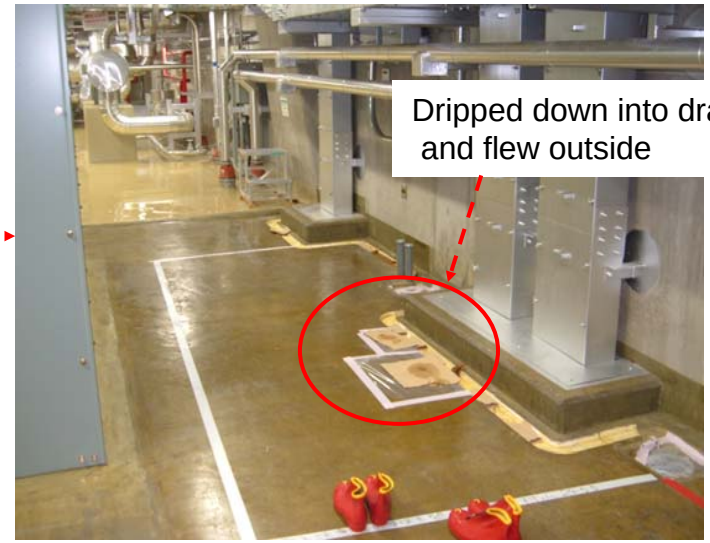
Leakage path at unit 6

Reactor building mezzanine 3rd floor where leakage water dripped down (non controlled area)



Reactor building 3rd floor where leakage water dripped down (non controlled area)





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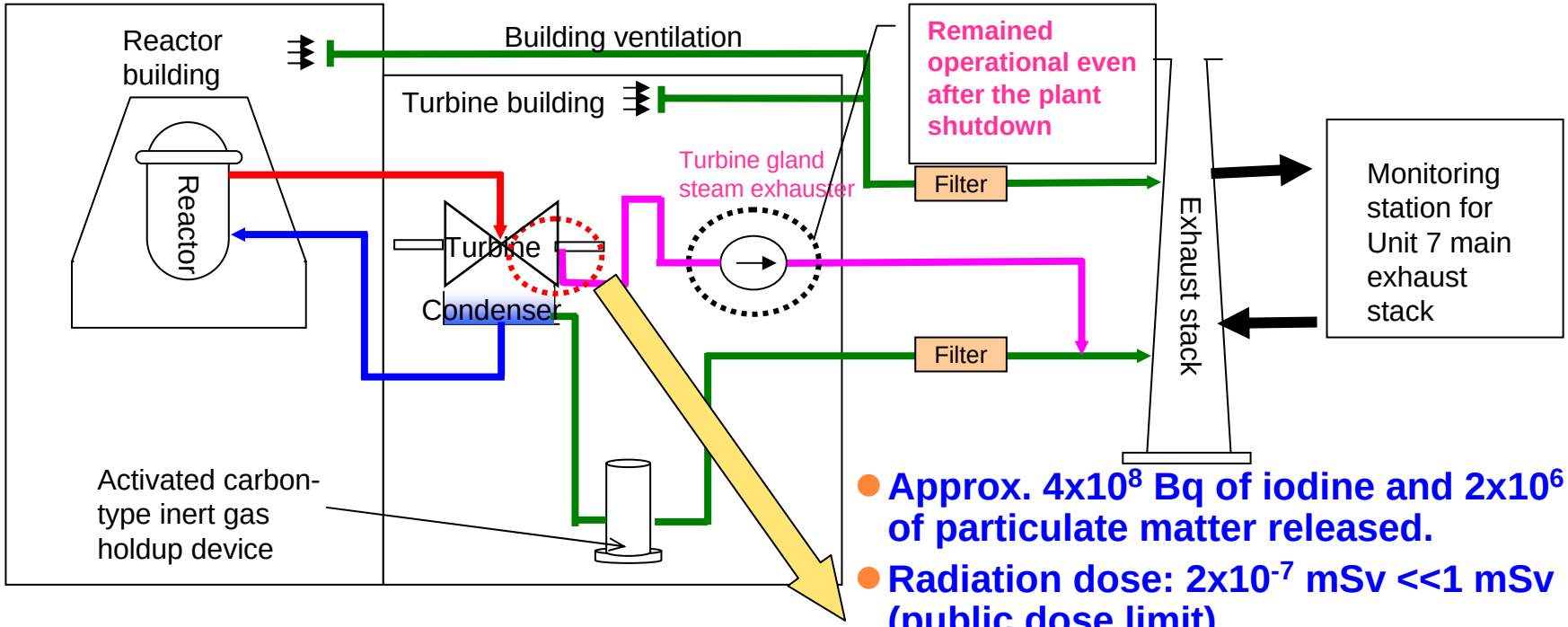
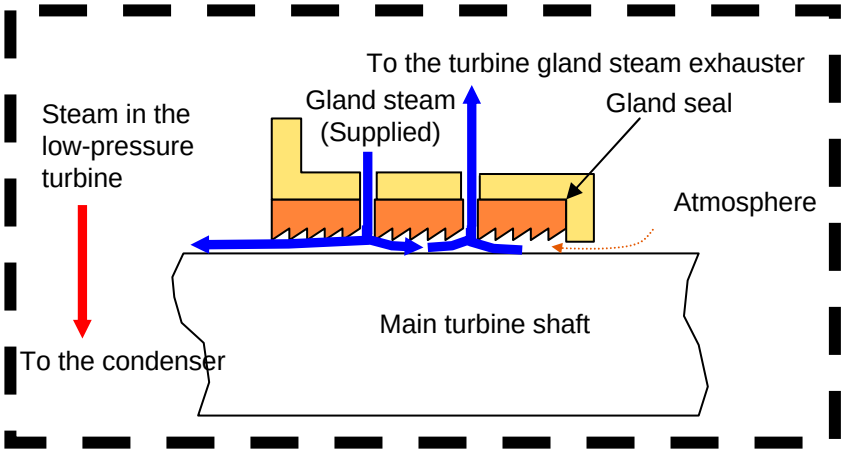
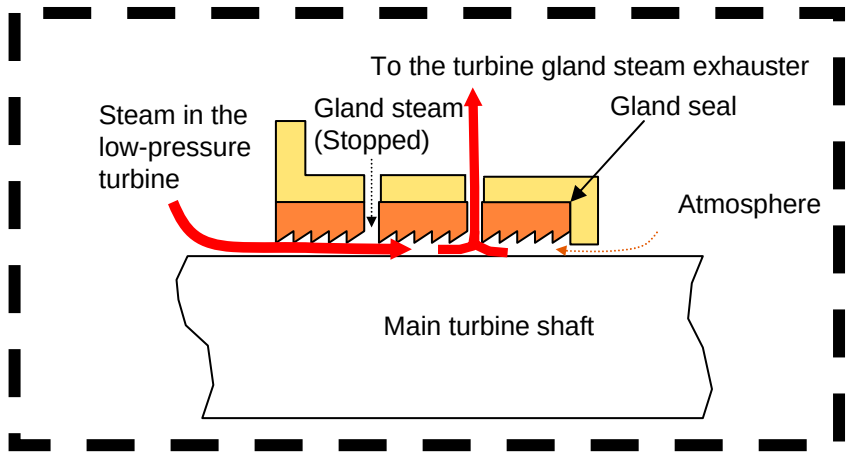
Radioactive leakage at Unit 7



- **Approx. 4×10^{8} Bq of iodine and 2×10^{6} Bq of particulate matter released.**
- **Radiation dose: 2×10^{-7} mSv <<1 mSv (public dose limit).**



Normal condition



Condition after the earthquake

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3. Situation after the earthquake

3-1 Three fundamental functions of safety

- Shut down (reactivity control)
- Cooling
- Confinement

Three fundamental functions of safety ensured

1. Shut down

- ■Time history of neutron flux（IRM／APRM、SRM／SRNM）
- ■CR position after scram
  （Ref.）CR insertion speed during scram (measured value)

2. Cooling

- ■Reactor water transition as a function of time
- ■Reactor pressure transition as a function of time
- ■Reactor water level change as a function of time

3. Confinement

- ■I131 concentration in the reactor water
- ■Monitoring at main exhaust stack as a function of time
- ■Data on the monitoring post
- ■Data on the seawater monitor

1. **Shut down**

Situation of each plant at the time of the earthquake

2007.07.16 10:13

	Before quake	After quake
KK1	Outage	←
KK2	Start-up (sub critical)	Automatic scram
KK3	Rated thermal operation	Automatic scram
KK4	Rated thermal operation	Automatic scram
KK5	Outage	←
KK6	Outage	←
KK7	Rated thermal operation	Automatic scram

(1) Neutron flux history

■KK2：Maintained sub critical

■KK3,4 and 7：APRM signal fell zero immediately

(2) CR position after scram

Scram set value; 120 gal horizontally, 100 gal vertically

■Full insertion confirmed by the process computer log

Note：CR insertion speed at the time of scram (measured values)

○KK2 ：0.905～0.955s（75% insertion） < 1.62s (design value)

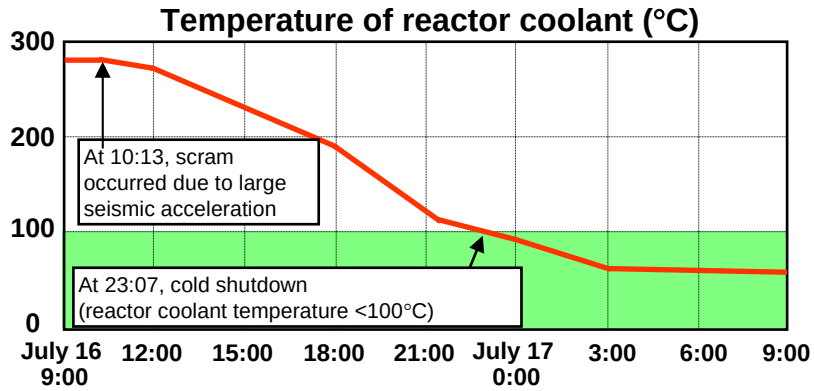
○KK7 ：0.714～0.807s（60% insertion） < 1.44s (design value)

○KK3 ：Scram time recorder failed already before the quake（7/15)

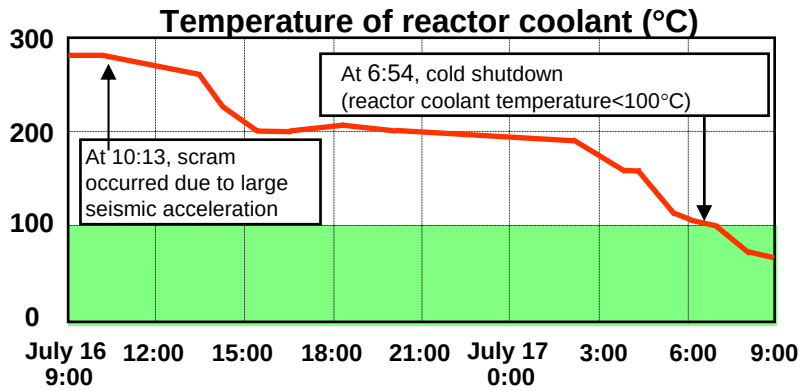
○KK4 ： Scram time recorder failed at the quake

（For KK4 Process computer log confirmed the scram signal at 10:13:27 and full insertion at 10:13:29 and for KK3 the scram signal at 10:13 and full insertion at 10:13.)

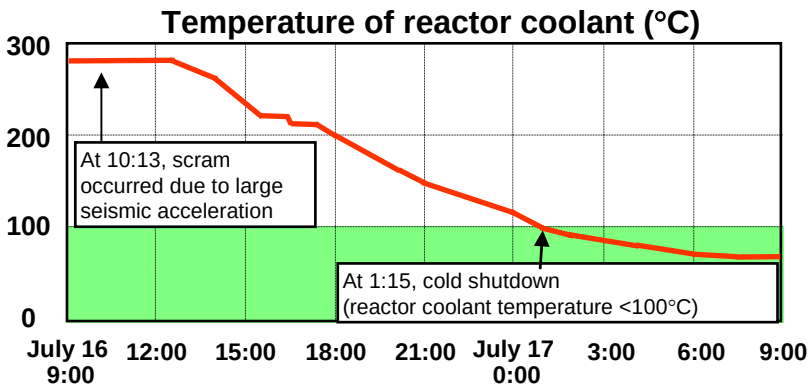
Reactor coolant was cooled below 100°C



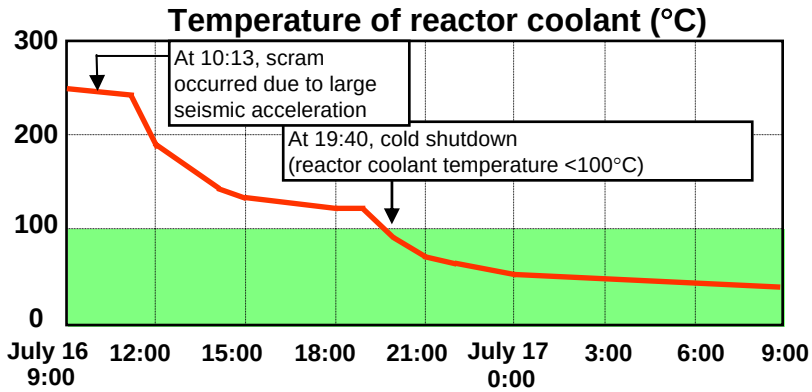
Unit 3 was in constant operation
at the rated thermal output
(cold shutdown at 23:07, July 16, 2007)



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)

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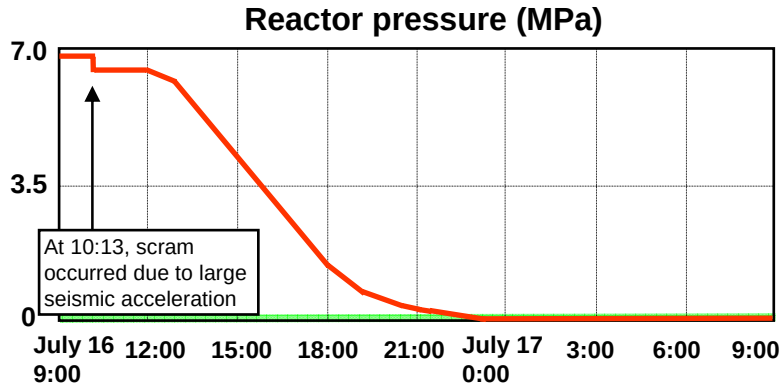
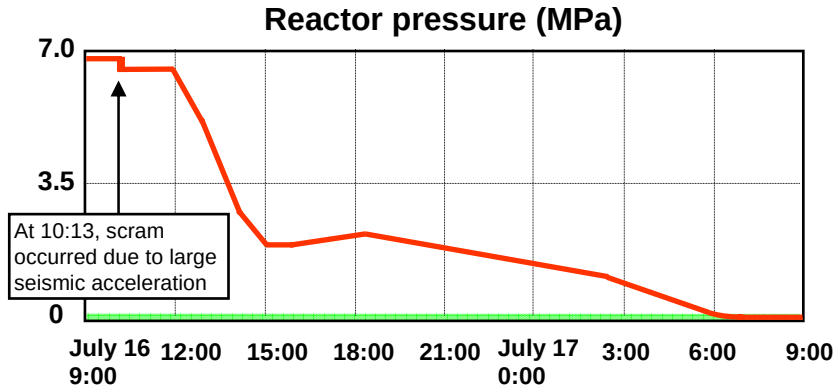
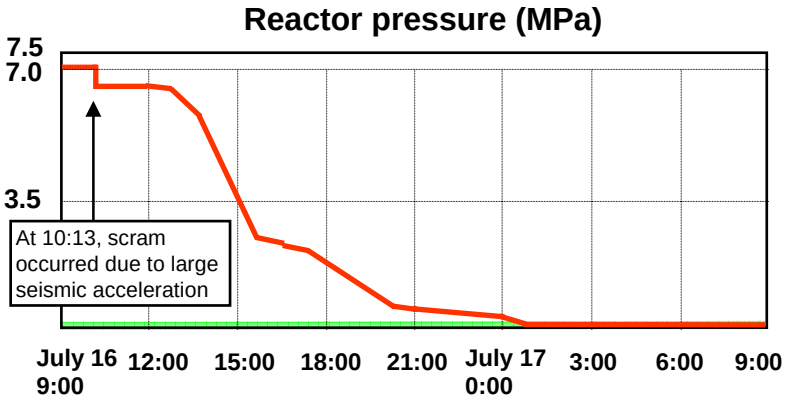
Reactor depressurized to atmospheric pressure



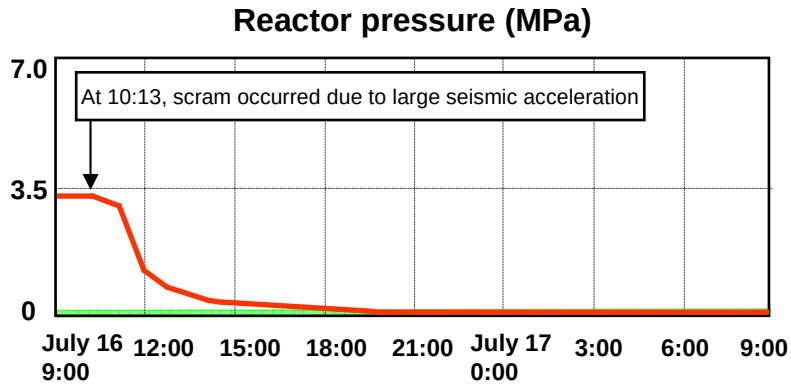
Unit 3 was in constant operation at the rated thermal output (depressurization completed at 23:07, July 16, 2007)



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)

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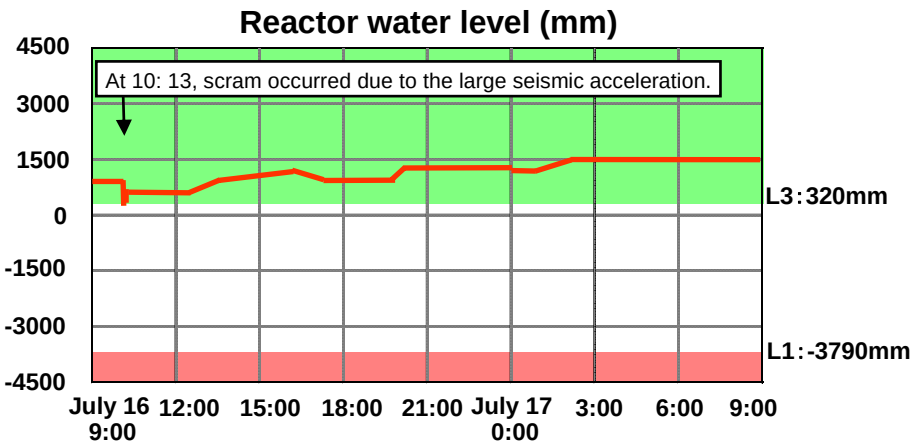
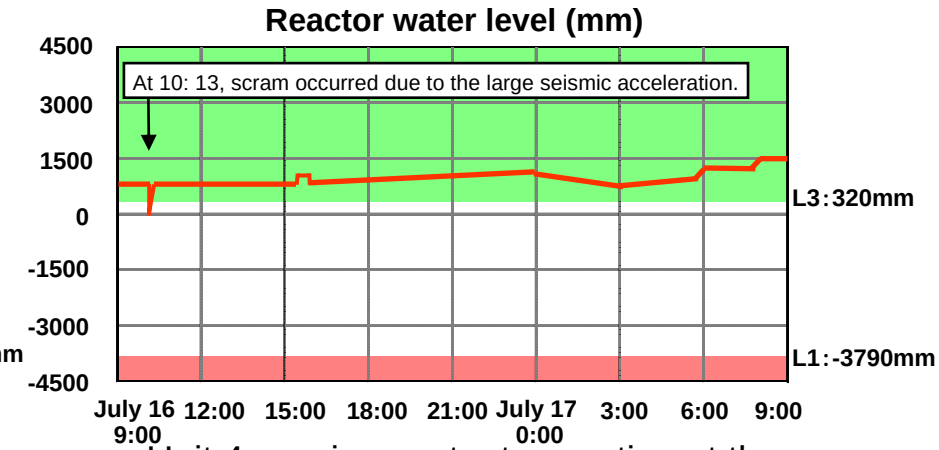
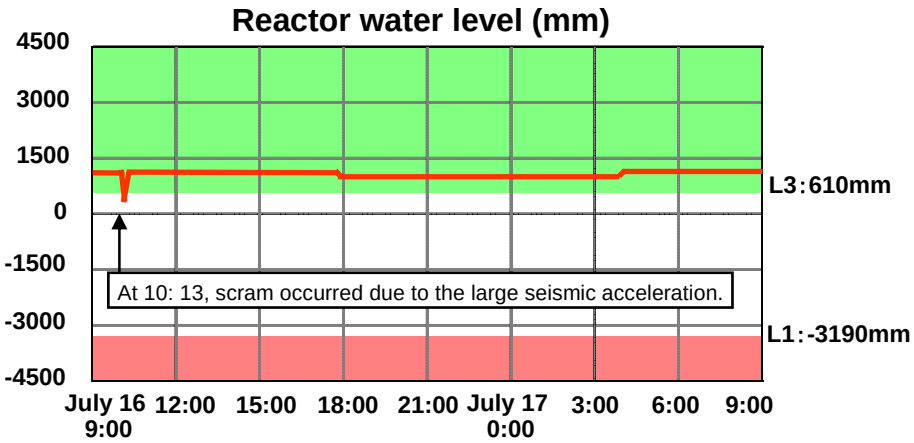
Reactor water level maintained properly



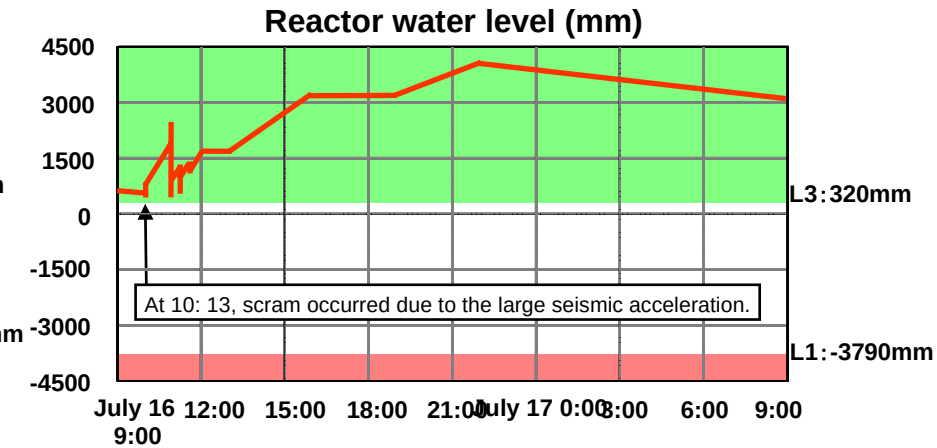
Unit 3 was in constant operation at the rated thermal output.



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).

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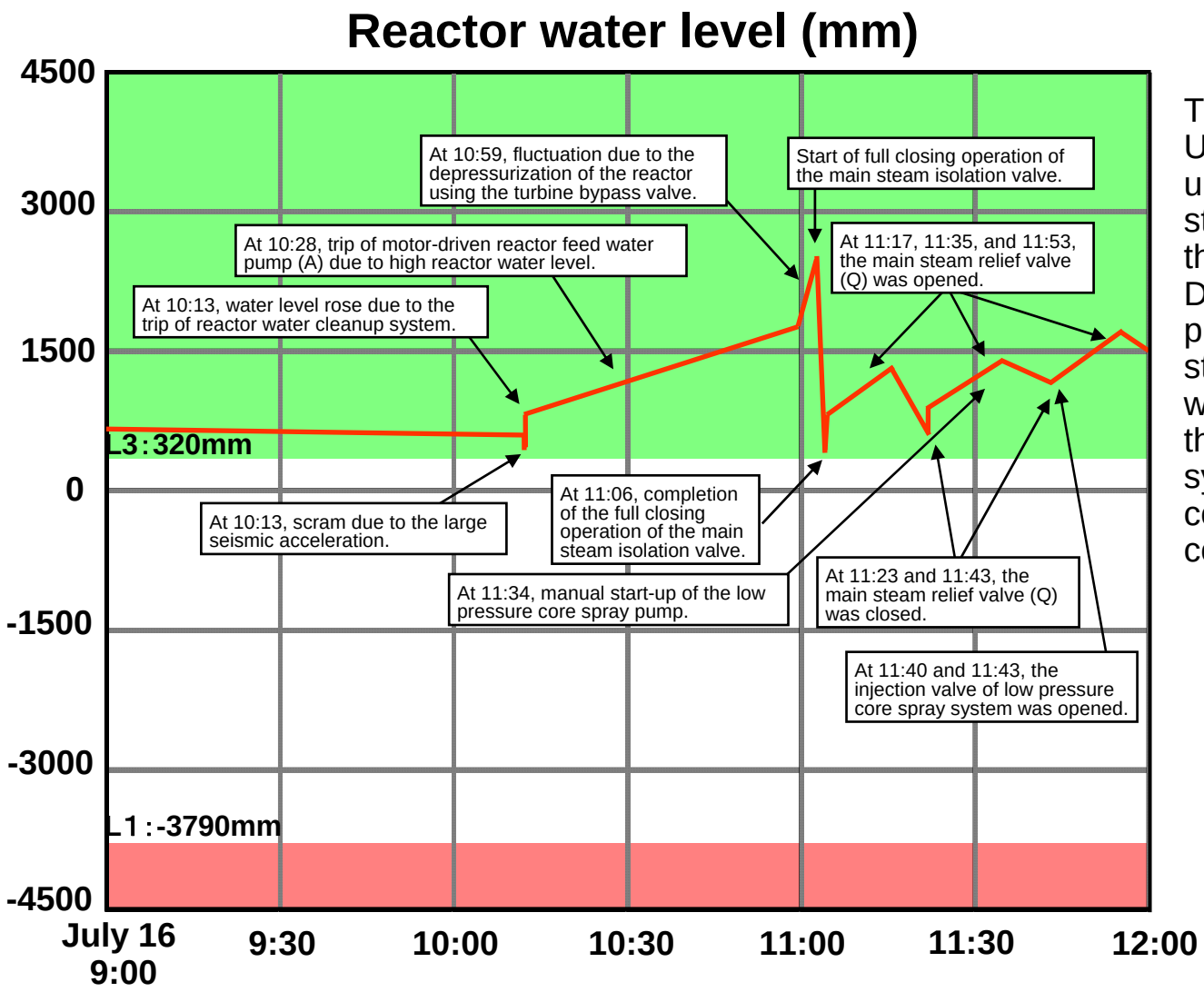
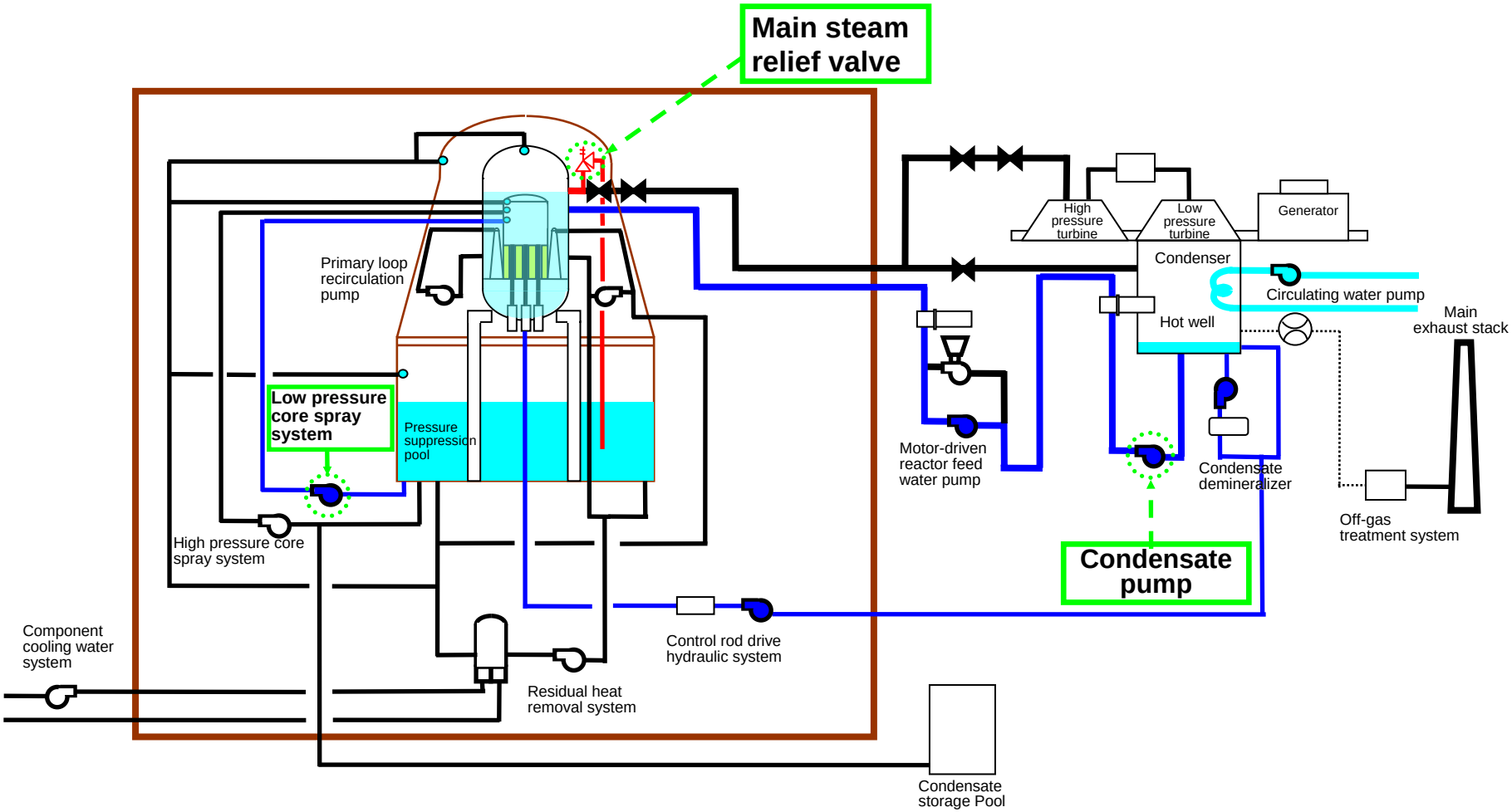
Behaviors of water level at Unit 2



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.

Water injection at KK2



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3. Confinement

No changes in iodine concentration in the reactor coolant and spent fuel pool water indicating that the fuels of all units are intact.

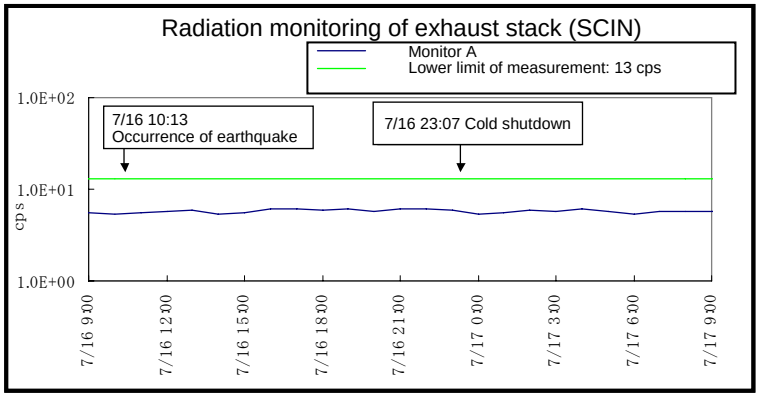
Iodine concentration at the time of quake

（Bq／cm3）

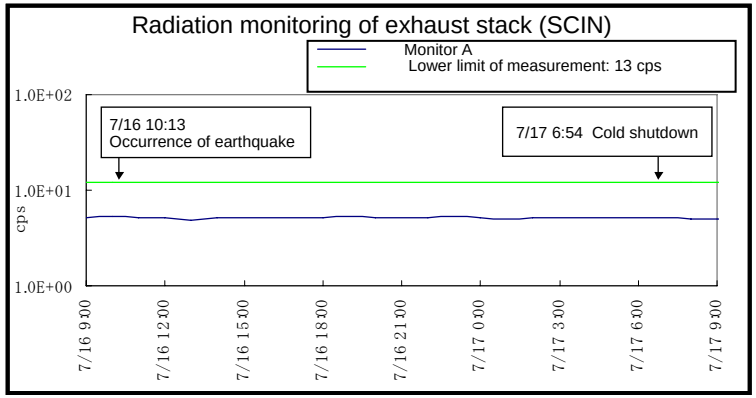
Plant situation at quake	Operational limit (Operational Safety Program)	Before quake	After quake
KK1 (Outage)	4.6×10^{3}	—	— *1
KK2 (Start Up)	4.6×10^{3}	—	Not detected Sampled July 20
KK3 (Operation)	1.5×10^{3}	1.6×10^{-2} Sampled July 9	Not detected Sampled July 18
KK4 (Operation)	1.5×10^{3}	1.8×10^{-2} Sampled July 9	Not detected Sampled July 18
KK5 (Operation)	4.6×10^{3}	—	Not detected Sampled July 20
KK6 (Operation)	1.3×10^{3}	—	Not detected Sampled July 20
KK7 (Operation)	1.3×10^{3}	3.6×10^{-2} Sampled July 11	Not detected Sampled July 18

*1. No measurement (Full core was discharged for outage)

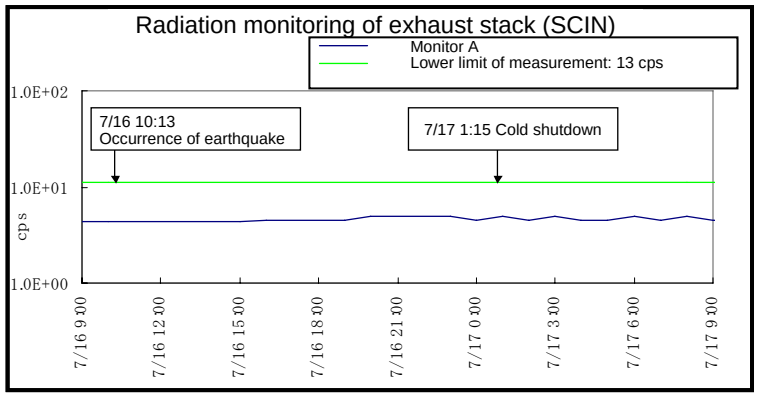
The main exhaust stack monitoring.



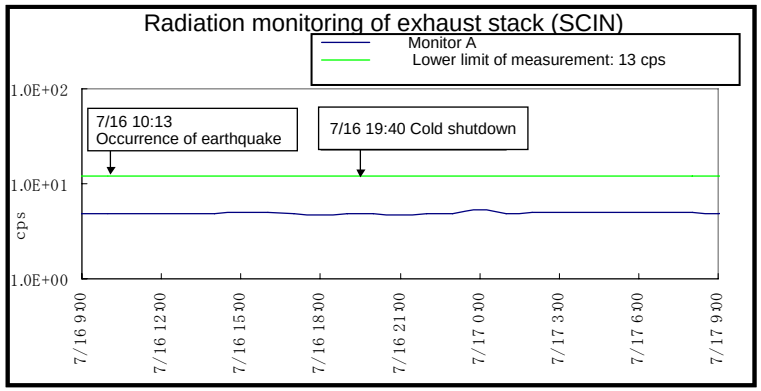
Unit 3 was in constant operation at the rated thermal output.



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

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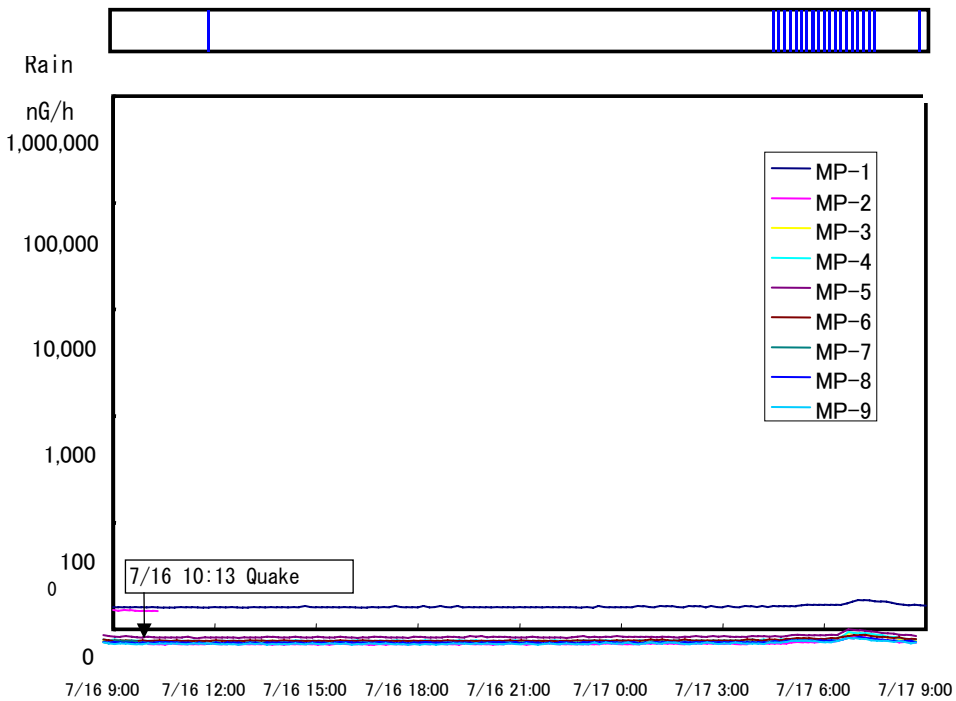
Monitoring Post

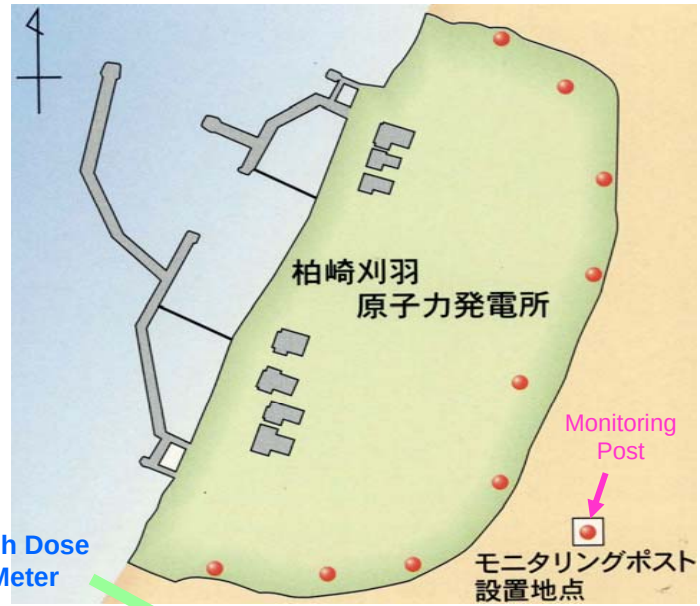
Kashiwazaki-Kariwa NPP

Actual Data from the Post (7/16 9:00～7/17 9:00)



Max. value reached with rainfall

Note：Past reference (1982.4 2006.3) 5～174hGy/h

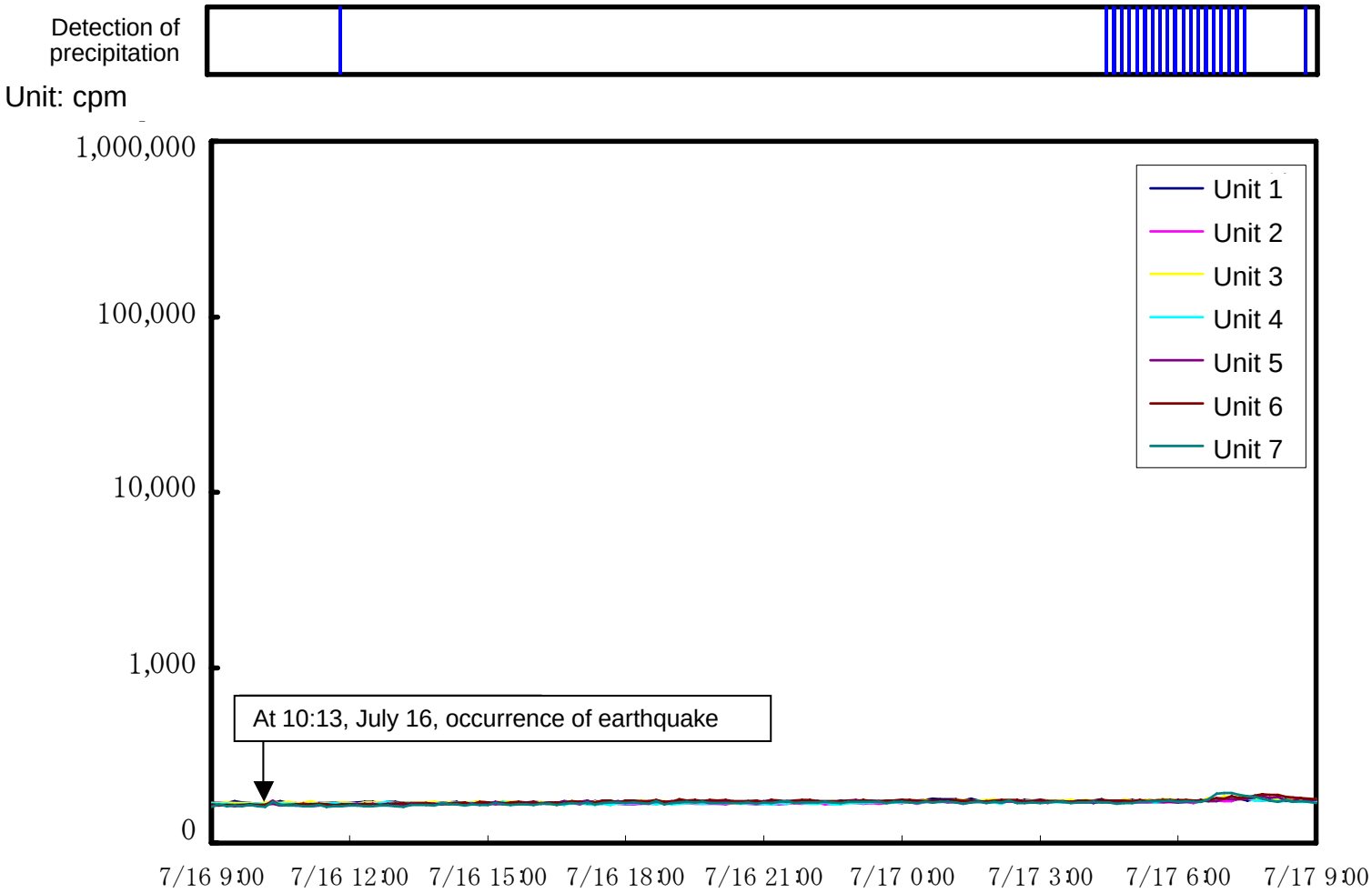


High Dose Meter

Low Dose Meter

Seawater monitoring

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



NISA Nuclear and Industrial Safety Agency

4. IAEA expert mission

IAEA expert mission (August 6 – 10)

– Conducting the joint observation of NISA and IAEA

http://www.iaea.org/NewsCenter/News/PDF/kashiwazaki060807.pdf

IAEA Review Team:

- JAMET, Philippe IAEA/NSNI/Director, Team Leader
- GODOY, Antonio R. IAEA/NSNI/ESS, Deputy Team Leader.
- GUNSELL, Lars SKI, Sweden
- GÜRPINAR, Aybars Consultant, Turkey
- JOHNSON, James J. James J. Johnson & Associates, USA
- KOSTOV, Marin Risk Engineering Ltd, Bulgaria

IAEA Mission Report – Outline

1. The trip of all the reactors which were at full power or increasing power was performed without problem and the installation behaved in a satisfactory manner during and after the earthquake.

   The three fundamental safety functions (reactivity control, removal of residual heat and confinement) were insured.

2. Although an extremely small amount of radioactive material was released, the resulting individual dose was estimated well below the authorized limits.
3. Although the safety related structures, systems and components of the plant suffered from the large earthquake, they seem to be in a much better general condition than expected. This is probably due to the conservatisms taken into account at different stages of the design process.
4. In the seismic re-evaluation complying with the September 2006 guidelines issued by NSC, the investigations are also to address the issue of the potential existence of active faults under the site.
5. The possibility should be considered that the systems and components remain functionally available under normal operating conditions but sustain hidden damage.

Specific issues indicated in the report

- Exceeding of the Design Basis Ground Motion by the Observed Earthquake
- Re-evaluation of the Seismic Hazard
- Off-Site Power
- Common-Cause Failure
- Fire Safety
- Seismic System Interaction
- Soil Failures
- Anchorage Failures
- Operational Safety Management
- Releases

5. Actions taken by NISA

Actions taken by NISA (1)

- July 16 - Minister's Order to TEPCO

  (First two were also ordered to all other operators.)

  - Analyze the acquired seismic data of the earthquake
  - Check the seismic safety on nuclear reactors' important systems, structures and components with seismic data of the earthquake
  - Suspend the plant operation until its safety is confirmed.
- July 20 - Minister's Order to all licensees
  - Reinforce self-employed fire brigade
  - Establish quick and accurate accident reporting system
  - Confirm seismic safety, prioritizing public safety

Actions taken by NISA (2)

- July 26 - received reports on the plan for the improvement concerning to
  - Self-employed fire brigade
  - Accident reporting system
- July 31 - Set up a new Advisory Committee
- August 20 - received reports on the revised implementation plan of the back-check by licensees against new “Seismic Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities”, which was recently revised and issued by Nuclear Safety Commission of Japan.
- August 23 – established Fire Prevention and Protection Office at NISA dedicated to cope with fire related issues

Renewed schedule for seismic back-check

Utilities reporting on August 20 confirming the following actions until end of March, 2008

①Finish geological survey and establish the design ground motions

②Assess the safety-important systems for one unit per one nuclear power plant site

（Excluding the Kashiwazaki-Kariwa site and Hamaoka site already submitting back-check report)

Confirmation of safety-maintenance functions with other nuclear power stations (1)

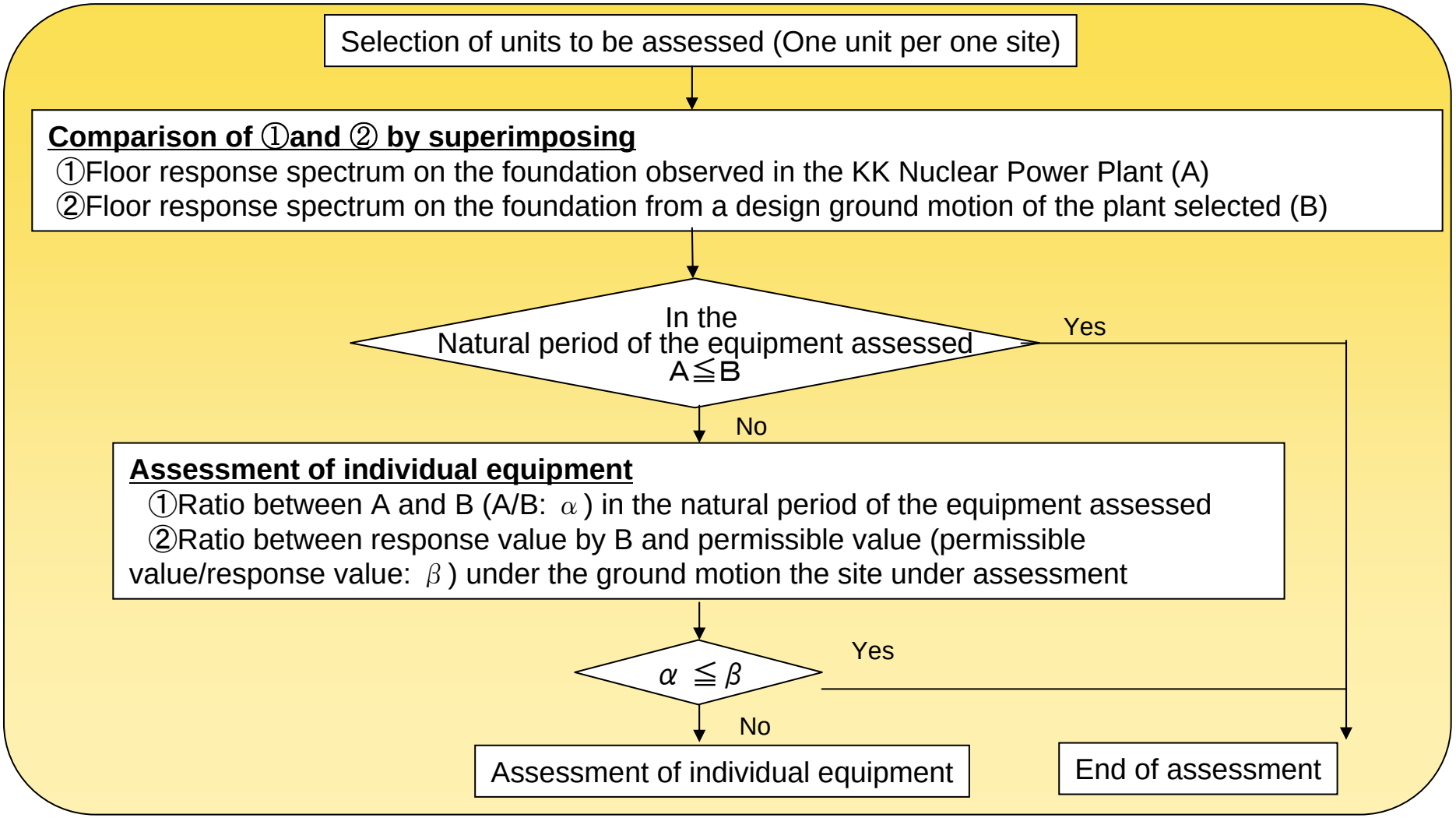
1) Seismic back-check for other nuclear power plants as utilities' voluntary actions
2) Confirmation of the Safety-maintenance functions of "shut down", "cooling" and "confinement" for others reactors ordered by NISA to other utilities in case of equivalent ground motion observed at the reactor building foundation of the KK Nuclear Power Plant.

Equipment subject to the assessment

BWR : CR, core support structure, RHR pump, RHR piping, RPV, main steam piping, reactor containment, reactor building

PWR : CR, core support structure, RHR pump, RHR piping, RV, primary coolant piping, reactor containment, reactor building, SG

Confirmation of safety-maintenance functions with other nuclear power stations (2)



NISA Nuclear and Industrial Safety Agency

Way forward by NISA

– Licensees' on-site fire-fighting system, reporting system and public relations in case of earthquake

①Self-employed fire brigade system

②Licensees' information supply system

③Supply of information to the local governments and the public in case of disasters

（Report to be ready around the mid-November 2007）

– Evaluation the seismic safety based on the Chuetsu- oki earthquake data

(1) Investigation of the causes where observed values exceed the design values at each unit making use of the research results, data collected by various organizations, field data

(2) Investigation of the effect of earthquake to the KK plant

(3) Identification of the items to be further considered for seismic safety of KK site

(4) Assessment of the seismic safety derived from the future finding on the ground motion at KK site

(5) Identification of the items to be forwarded to other nuclear power plans in terms of seismic safety

NISA Nuclear and Industrial Safety Agency

Way forward by NISA

– Reactor management at the earthquake, intactness of the facilities and necessary measures for earthquake

（1）Operation management immediately after the earthquake disaster

①Evaluation of measures for operation management conducted by the licensee immediately after the earthquake disaster; extraction of problems; and demanding the licensee to reflect the problems in their manuals when needed.

（Finishing of examination of (1) above by around the end of 2007 ）

（2）Examination of equipment integrity

①Examination of necessary inspection matters through understanding the equipment conditions of the power plant, and evaluation of equipment inspection plans conducted by the licensee and their results

②Examination of an evaluation method for equipment integrity, and judgment criteria for necessity of maintenance and repair

Way forward by NISA

③Examination of a method for maintenance and repair, based on the results of inspection and evaluation

④Extraction of items to be reflected in guidelines and criteria in the courses of individual examinations
（Formulation of “judgment criteria for the necessity of maintenance and repair by around the end of March 2008）

NISA will separately confirm the integrity of the equipment based on the judgment criteria. For the equipment whose stress exceeds the elastic range, NISA will confirm said equipment in accordance with the judgment criteria and carefully examine replacement and reinforcement and repair plans. At the same time, NISA will strictly evaluate the safety of the equipment through inspections including the nondestructive test.

– Hold Work Shop by the international specialists for the purpose of information sharing (schedule unfixed)

（Reference）
Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities

Revision of the Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (1/2)

○ History of revision of the regulatory guide for reviewing seismic design

- Regarding the policy for seismic design of nuclear power plants in Japan, examination is performed according to the “Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities” (hereinafter referred to as the “Seismic Guide”) established by the Nuclear Safety Commission (NSC).

- To make it more reasonable by reflecting the latest knowledge, the NSC has set up the Seismic Guide Review Subcommittee under the Special Committee for Nuclear Safety Standards and Guides in July, 2001, and released the revision of the Seismic Guide on September 19, 2006.

Revision of the Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (2/2)

○ Efforts in response to the revision of the Seismic Guide by the NSC

- Main points of the revision of the Seismic Guide by the NSC (Revised on September 19, 2006).
  (i) More severe level
  (ii) More careful investigation
  (iii) More sophisticated methodology

- On September 20, 2006, the Nuclear and Industrial Safety Agency (NISA) instructed the following two points to utilities:
  (i) Reactors under review: The new guide will be applied for review.
  (ii) Reactors in operation or under construction: Seismic safety will be reviewed in the context of the new Guide.

- From now on, NISA will confirm acceptability of the evaluation results by licensees sequentially. (On January 25th of this year, Chubu EPC submitted the evaluation report of seismic safety for Hamaoka NPS Unit 4, and NISA is confirming its acceptability. This report is the first one of 62 plants to be reviewed.)

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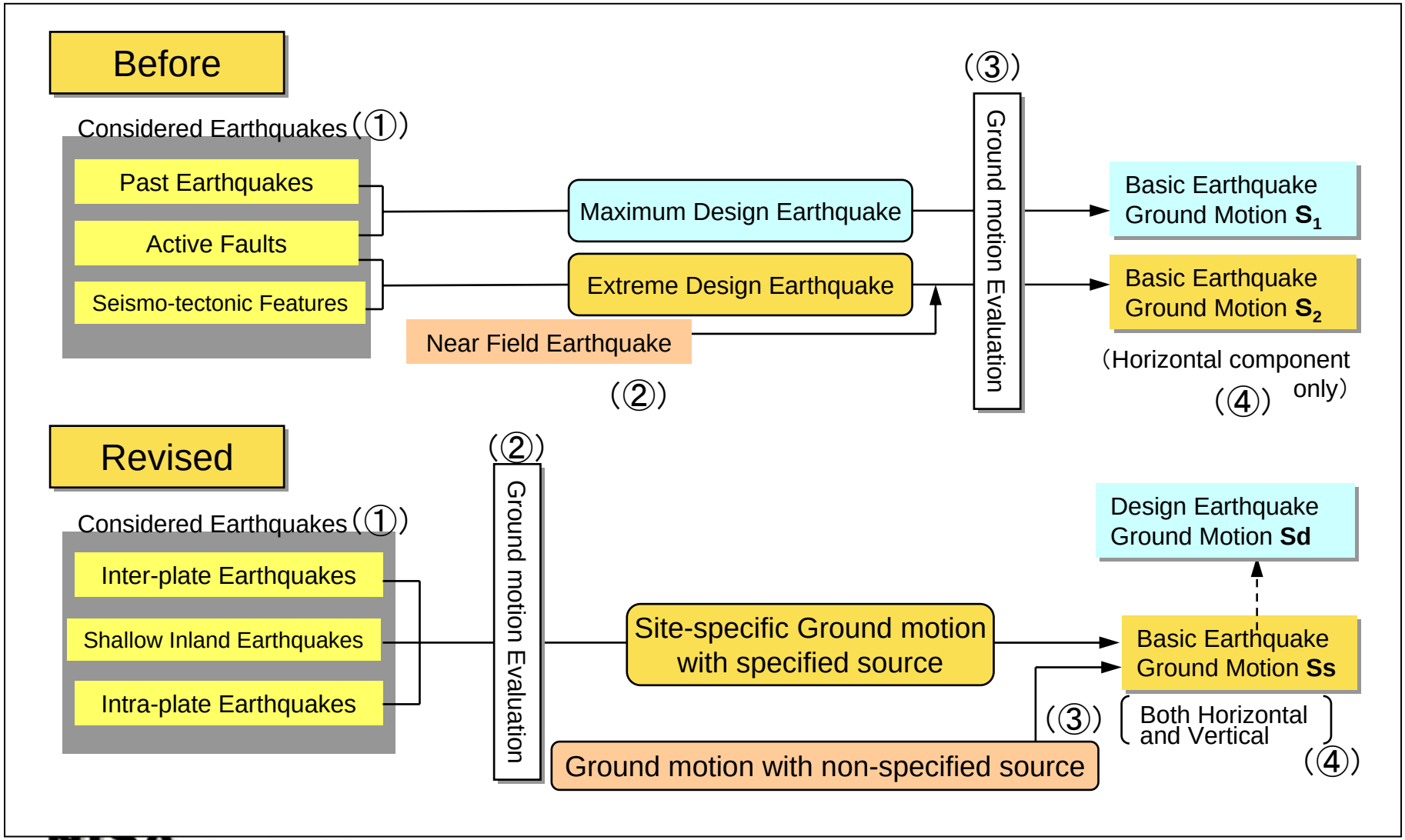
1. Main points of the revision

Item	Before	Revised
Design Base Earthquake Definition	・S1: Return period less than 10000y Stay in elastic region＊ ・S2: Return period less than 50000y Keep function＊ ＊ Class As、A component	・One DBE Ss: Consider active fault hereafter late Pleistocene (80000-130000y before) Keep function＊ ・Sd for design (Not earthquake) to stay in elastic region＊ Sd=$\alpha \times$Ss ; $\alpha \geqq 0.5$ ＊ Class S component
Geological Survey		Use most updated knowledge and technique
Consideration of Vertical Seismic Force	Fv= 1/2 FH (Static)	Define Fv dynamically
Over DBE Earthquake		Possibility of over DBE earthquake cannot be denied. Risk by over DBE is to be assessed for reference
Seismic Classification	As, A, B, C	S (old As and A), B, C → Old A class ranked up to As
Phenomena accompanying earthquake		Consider the effect of; ・Tsunami, ・Collapse of around inclined plane

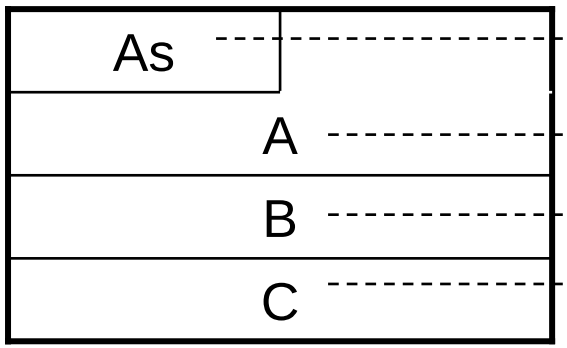
1.1 DBE Definition - Earthquake Research Flow



2. Seismic Classification

Before

4 classes



RPV, PCV etc.

ECCS, RHRS etc.

Main Turbine System etc.

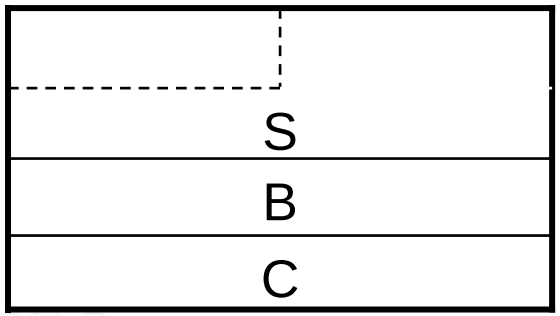
Other Facilities

As … Designed with S_2
（Maintains Safety Function）
also designed with S_1
（Remains within Elastic limit）

A … Designed with S_1
（Remains within Elastic limit）

Revised

3 classes



◆ A and As classes are integrated into S class

S … Designed with Ss
（Maintains Safety Function）
also designed with Sd
（Remains within Elastic limit）

$Sd = \alpha \times Ss$, $\alpha \geqq 0.5$

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Summary of Results of Back-check for Hamaoka Units 3 and 4

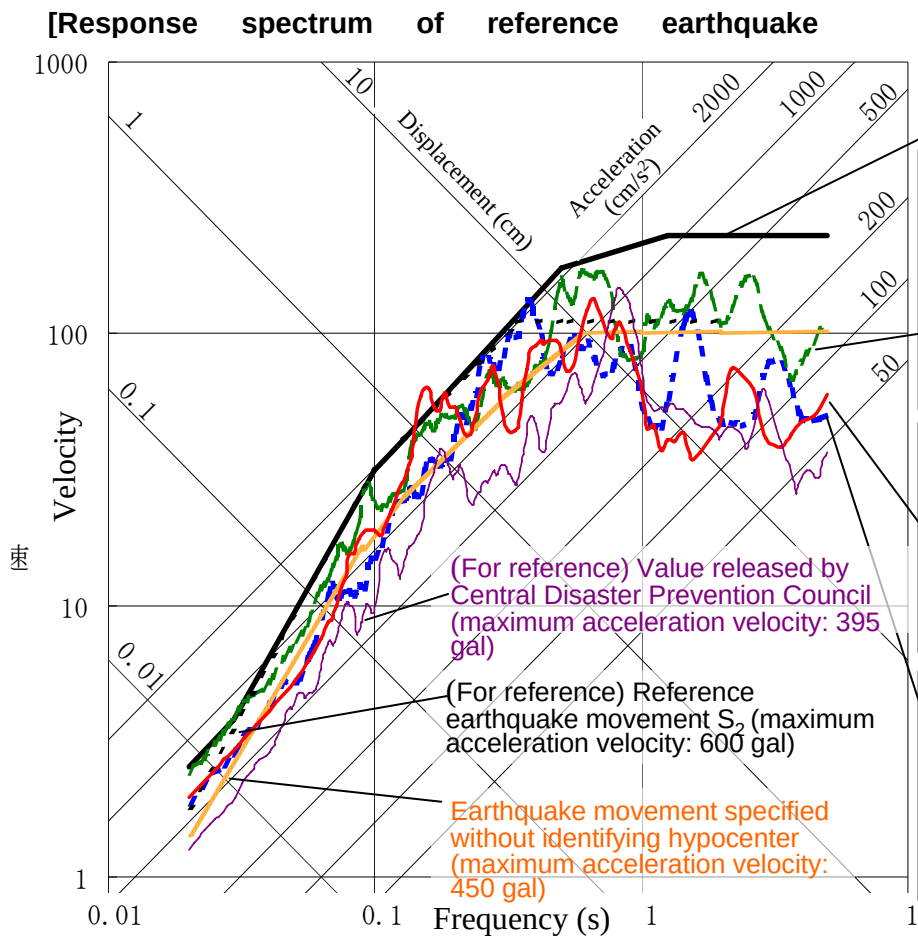
Hamaoka NPS is located in the hypocentral region of Tokai earthquake.

(i) Regarding the earthquake between plates which possibly occurs directly below the site, the reference earthquake movement is specified by performing the following sophisticated and detailed evaluation on earthquake movement:

- To apply the latest method for evaluating earthquake movement (method of using the Fault Model),
- To consider the breakdown region of hypocenter and the uncertainty of breakdown process.

(ii) For important facilities, the seismic response analysis is performed for horizontal and vertical directions based on the specified reference earthquake movement, and the behavior during earthquake is evaluated in detail, and then their safety functions are confirmed to be ensured.

(iii) As an accompanying event of earthquake, a safety evaluation for tsunami is performed.



Reference earthquake movement S_s by the method based on the response spectrum (maximum acceleration velocity: 800 gal)

Reference earthquake movement S_s by the method using Fault Model (hypothetical Tokai-Higashinankai-Nankai Earthquake, statistical GF method) (maximum acceleration velocity: 766 gal)

Reference earthquake movement S_s by the method using the Fault Model (hypothetical Tokai Earthquake, empirical GF method) (maximum acceleration velocity: 617 gal)

Reference earthquake movement S_s by the method using the Fault Model (hypothetical Tokai Earthquake, statistical GF method) (maximum acceleration velocity: 588 gal)

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Defining the design basis ground motion *Ss*

Work flow for defining the design basis ground motion Ss and conducting design assessment.