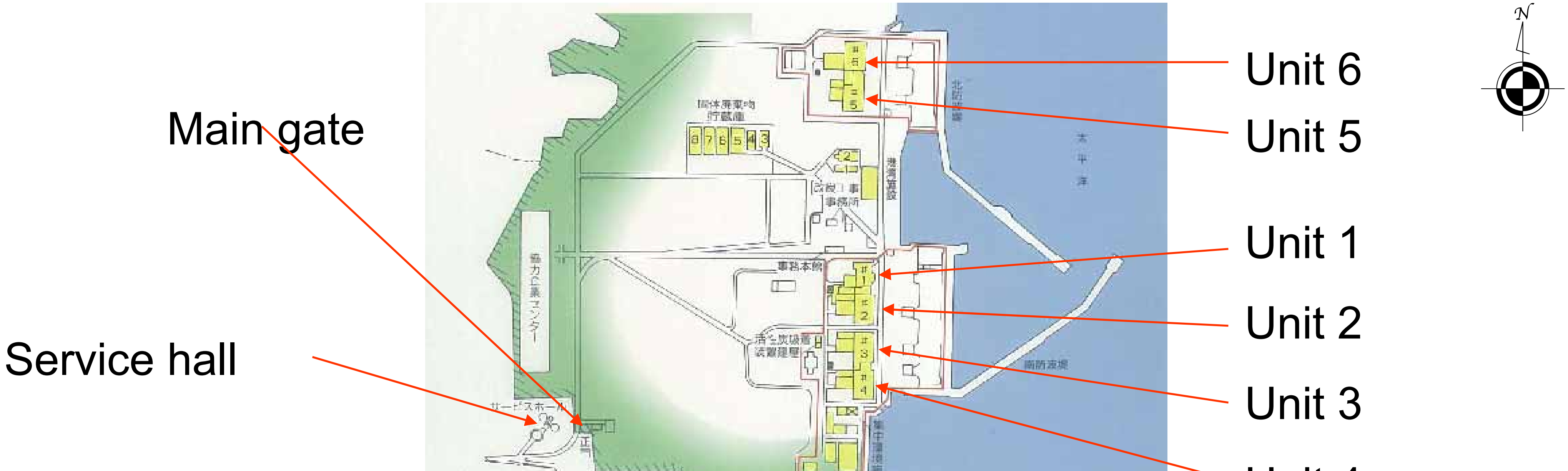
Fukushima Nuclear Accidents Investigation Report

Attachment

Summary of Fukushima Daiichi Nuclear Power Station

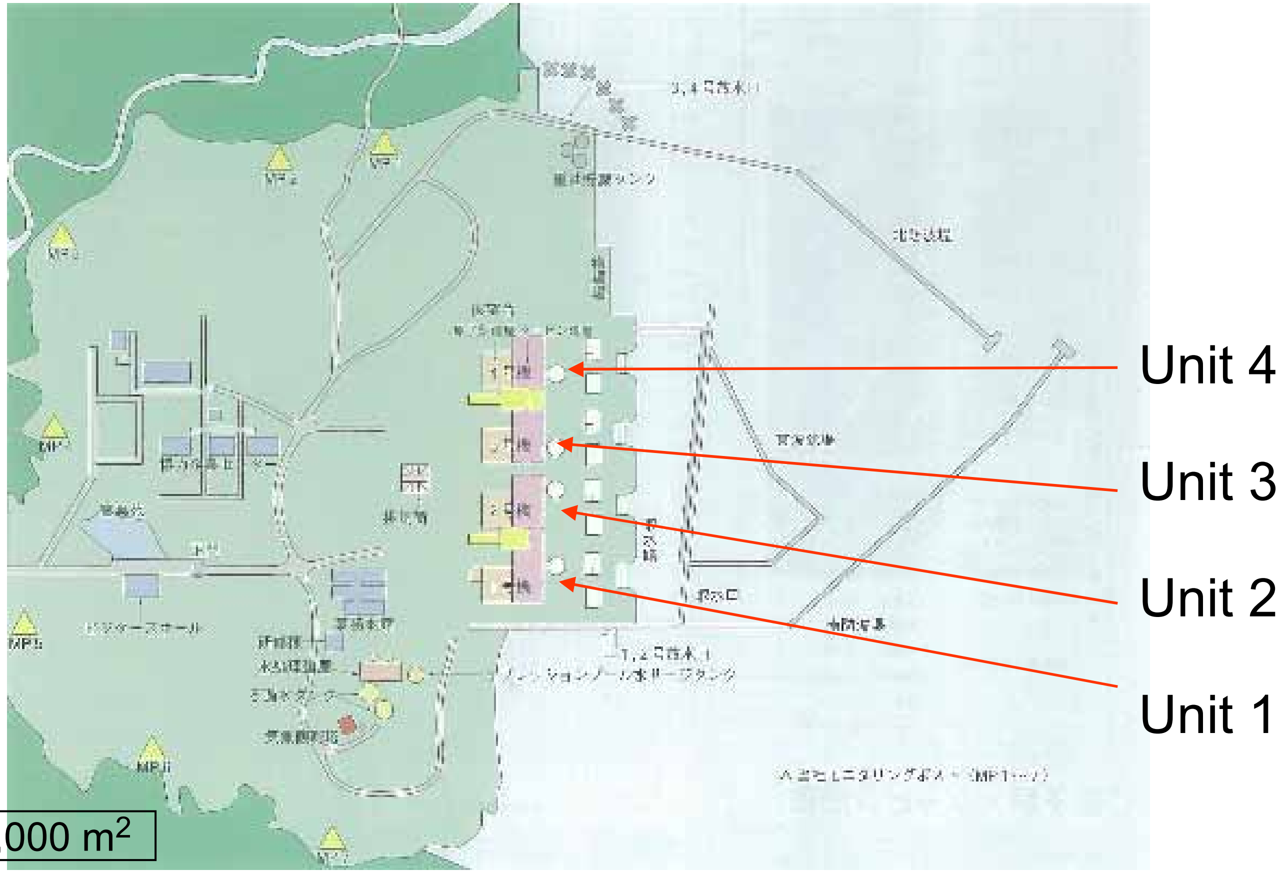


Site area: Approx. 3,500,000 m^2

<table>
<tr><th>Address</th><th>Unit</th><th>Start of operation</th><th>Type</th><th>Output
(x 10,000 kW)</th><th>Main contractor</th><th colspan="2">Status when the earthquake struck</th></tr>
<tr><td rowspan="4">Okuma Town</td><td>Unit 1</td><td>March 1971</td><td>BWR3</td><td>46.0</td><td>GE</td><td colspan="2">In rated output operation</td></tr>
<tr><td>Unit 2</td><td>July 1974</td><td>BWR4</td><td>78.4</td><td>GE/Toshiba</td><td colspan="2" rowspan="2">In rated power operation</td></tr>
<tr><td>Unit 3</td><td>March 1976</td><td>BWR4</td><td>78.4</td><td>Toshiba</td></tr>
<tr><td>Unit 4</td><td>October 1978</td><td>BWR4</td><td>78.4</td><td>Hitachi</td><td rowspan="3">Outage</td><td>All fuel removed, pool gate closed (core shroud replacement work under way)</td></tr>
<tr><td rowspan="2">Futaba Town</td><td>Unit 5</td><td>April 1978</td><td>BWR4</td><td>78.4</td><td>Toshiba</td><td rowspan="2">Reactor pressure vessel top lid closed</td></tr>
<tr><td>Unit 6</td><td>October 1979</td><td>BWR5</td><td>110</td><td>GE/Toshiba</td></tr>
</table>

Reference 2-1

Summary of Fukushima Daini Nuclear Power Station

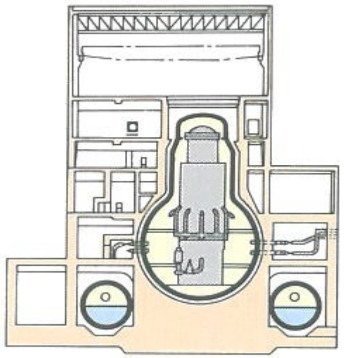
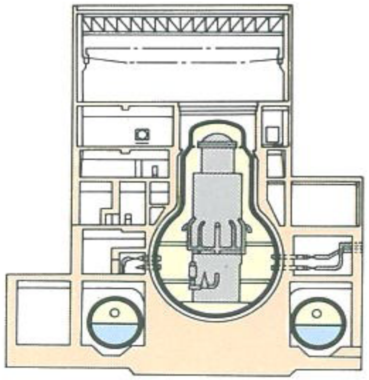
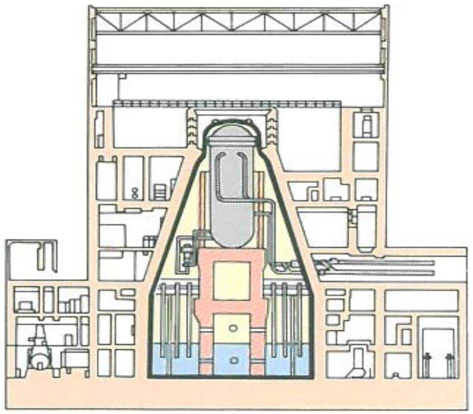
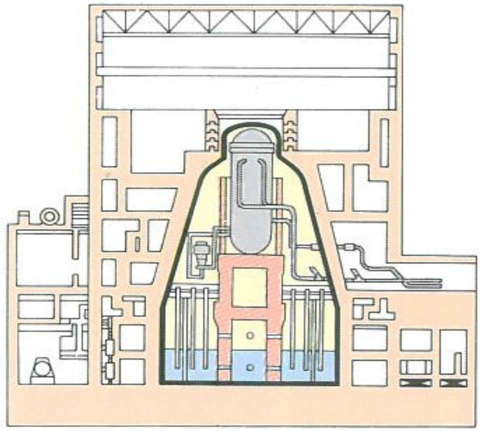


Site area: Approx. 1,500,000 m^2

Address	Unit	Start of operation	Type	Output (x 10,000 kW)	Main contractor	Status when the earthquake struck
Naraha Town	Unit 1	April 1982	BWR5	110	Toshiba	In rated power operation
	Unit 2	February 1984			Hitachi	
Tomioka Town	Unit 3	June 1985			Toshiba	
	Unit 4	August 1987			Hitachi	

Reference 2-2

Shape of Primary Containment Vessel of Fukushima Daiichi and Fukushima Daini Nuclear Power Stations

Type	BWR3	BWR4	BWR5	BWR5
Plant	Fukushima Daiichi Unit 1	Fukushima Daiichi Unit 2 to 5	Fukushima Daiichi Unit 6 Fukushima Daini Unit 1	Fukushima Daini Unit 2 - 4
Electrical output	460,000 kW	784,000 kW	1,100,000kW	1,100,000kW
Containment type	Mark I type (Flask type)	Mark I type (Flask type)	Mark II type (Cylinder type)	Mark II Advanced (Bell type)
				
	 Source: NRC website		 Fukushima Daini Unit 1	 Fukushima Daini Unit 3

Reference 2-3 (1)

Design of the Mark I Primary Containment Vessel

1. Difference between Mark I and Mark II primary containment vessel (PCV) capacity
   - In a boiling water reactor (BWR), the pressure suppression type PCV is used, which is designed to restrain pressure build-up by passing the steam escaping into the PCV, when a piping rupture occurs through the suppression chamber (S/C) water pool, where it is condensed and pressure is relieved. There is no problem here.
   - Both Mark I and Mark II PCVs are the pressure suppression type, and are designed in such a way that the larger the power output, the larger the PCV capacity.
   - Taking a look at the capacity-to-output comparison, which is a suitable indicator in comparing the size, the Mark I and Mark II are very nearly the same, and thus Mark I is not especially small.

Table: comparison of PCV capacity to reactor output

reactor	1F-1	1F-2~5	1F-6,2F-1	2F-2~4	KK-6/7 (ref)
PCV	Mark I	Mark I	Mark II	Mark II Improved	RCCV
comparison of capacity to output※1,※2	approx. 4.4	approx. 3.1	approx. 3.0	approx. 4.3	approx. 3.4

※1 ratio of PCV capacity [m^3] to reactor thermal power [MW t]
※2 Reactor thermal power according to Application for Establishing Permit documents. PCV capacity according to Establishing Permit document attachment No. 8 dry well (D/W) capacity (including vent pipe) plus suppression chamber empty space capacity.

2. Anti-explosion measures when hydrogen is produced inside the suppression chamber due to an accident
   - By controlling the oxygen level to within a fixed limited value by enclosing nitrogen inside the PCV, hydrogen burn-up or explosion inside the PCV is prevented even if a large volume of hydrogen is produced.
   - A flammability control system (FCS) installed inside the reactor building (R/B) has a heating recombination design so as to control the level of hydrogen and oxygen density inside the PCV after an accident occurs.

3. Increased load on the pressure suppression chamber (S/C) when accidents occur
   - When the Mark III PCV was being developed in the United States, necessary measures were taken (installation of facility to mitigate the load transfer: facility (quencher) that spews steam out evenly in four directions rather than in only one direction)) in answer to the problem of the load created when high pressure steam is transferred to the S/C when piping ruptures occur.

- Similar measures based on the measures taken in the US have been implemented in Japan. In regard to the investigation of load, the Nuclear Safety Commission (NSC) compiled the guideline entitled “BWR. Mark I type PCV Pressure-Suppression System Evaluation Guidelines on Added Load Transfer.” (Similar guidelines have been worked out for the Mark II)

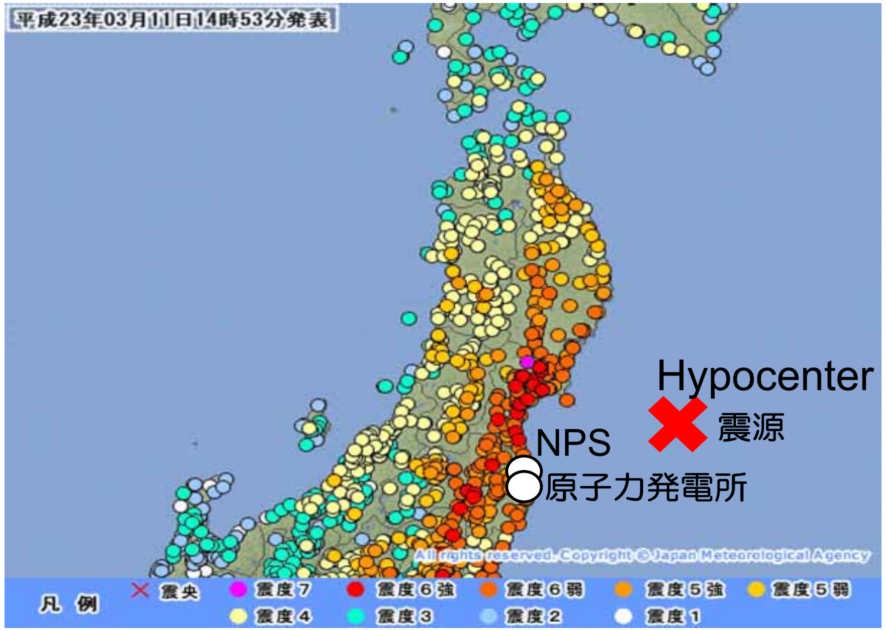
4. Improvement of Mark I PCV efficiency (vent)

- The Nuclear Regulatory Commission (NRC) of the United States established that installing a PCV hardened vent on the Mark I PCV reduced the risks of reactor core damage. Investigation through probabilistic safety assessment carried out in Japan confirmed the viability of this PCV hardened vent facility as being effective in preventing reactor core damage and impact mitigation, and the PCV hardened vent is also installed on the Mark II PCV.

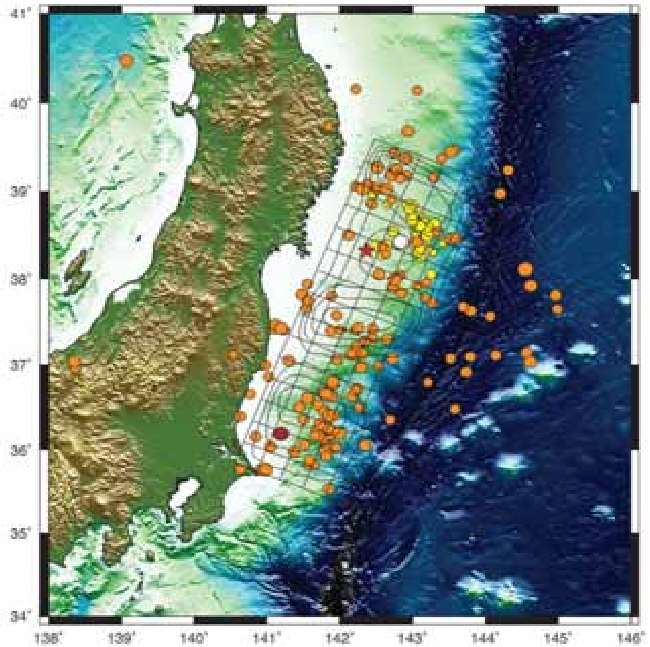
End

Overview of the Tohoku-Chihou-Taiheiyou-Oki Earthquake

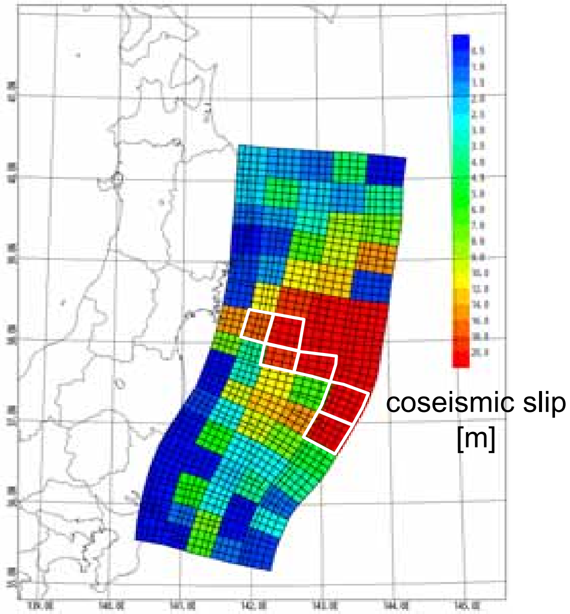
Date/Time: Friday, March 11, 2011 at 2:46 p.m.
Location: Offshore Sanriku (latitude 38 degrees, 06.2 minutes, longitude 142 degrees, 51.6 minutes), depth of hypocenter 24 km
Scale : magnitude 9.0
Intensity around Japan : Intensity 7 : Miyagi Prefecture: Kurihara City
Intensity **6 (upper) Fukushima Prefecture: Naraha Town,TomiokaTown,Okuma Town, FutabaTown**
Intensity 6 (lower) Miyagi Prefecture: Ishinomaki City, Onagawa Town, Ibaraki Prefecture: Tokai-mura
Intensity 5 (lower) Niigata Prefecture: Kariwa-mura
Intensity 4: Aomori Prefecture: Rokkasho-mura, Higashidori-mura, Mutsu City, Oma-machi,
Niigata Prefecture: Kashiwazaki City



Distribution of earthquake intensity



Local area of earthquake
(source: Earthquake Research Institute of the University of Tokyo)



Wave source of tsunami
(source: TEPCO)

attachment 3-1

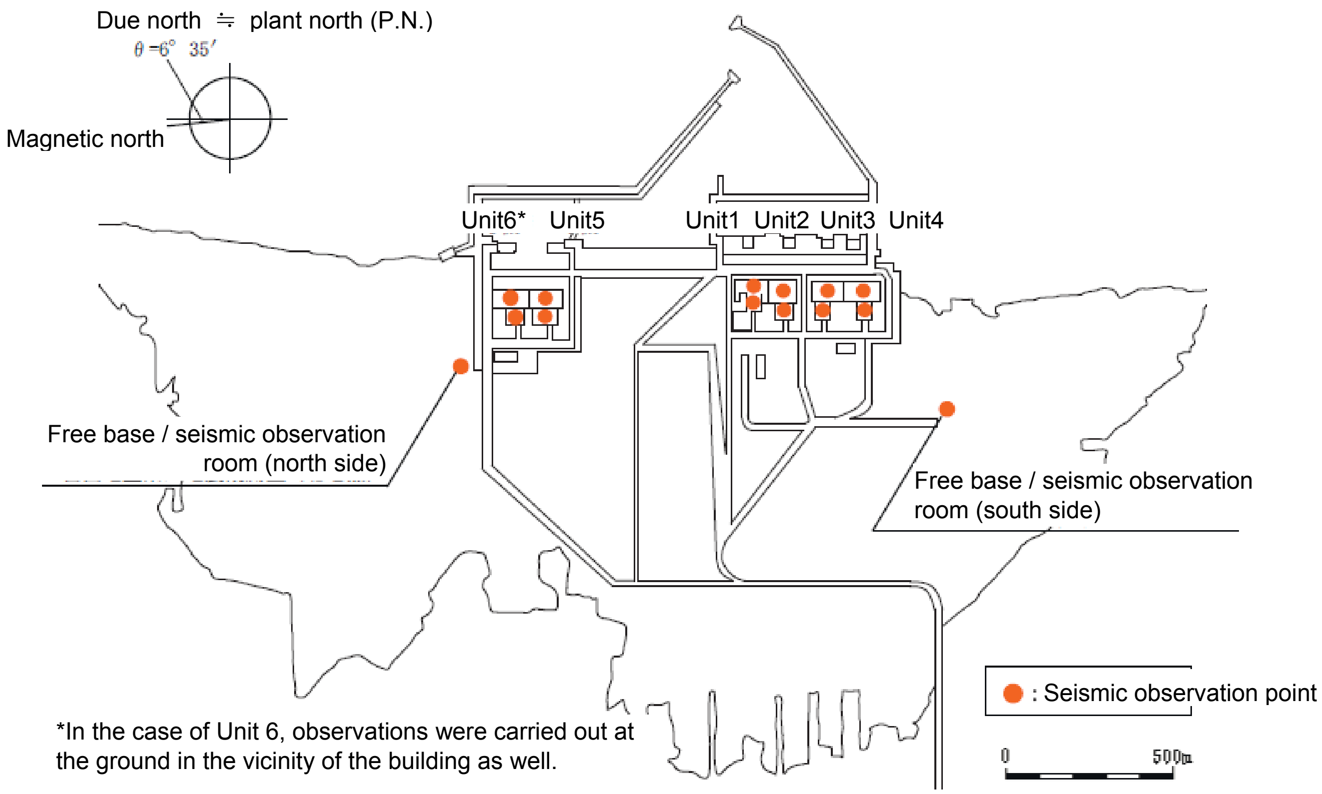
The scale of the tsunami-earthquake was the fourth largest ever observed in the world.

Comparison between the seismic observation records and the design seismic motion at the Fukushima Daiichi Nuclear Power Station

Comparison of the observation records at Fukushima Daiichi NPS from the Tohoku-Chihou-Taiheiyo-Oki Earthquake and the response spectrum against design basis seismic ground motion (DBSGM) Ss

Observation point (R/B base mat)		Observation records Maximum acceleration (Gal)			maximum acceleration response against DBSGM Ss (Gal)		
		NS direction	EW direction	UD direction	NS direction	EW direction	UD direction
Fuku-shima Daiichi	Unit 1	460	447	258	487	489	412
	Unit 2	348	550	302	441	438	420
	Unit 3	322	507	231	449	441	429
	Unit 4	281	319	200	447	445	422
	Unit 5	311	548	256	452	452	427
	Unit 6	298	444	244	445	448	415

Legend: NS: North-South, EW: East-West, UD: Up-Down



*In the case of Unit 6, observations were carried out at the ground in the vicinity of the building as well.

Locations of Fukushima Daiichi NPS seismic observation points

Figures 1-1 through 1-6 show the acceleration transient wave forms observed above the base mat of all reactor buildings at Fukushima Daiichi NPS Unit 1 through Unit 6 and Figures 2-1 through 2-6 show the observed spectrum with the response spectrum calculated by inputting the DBSGM Ss.

Figures 2-1 through 2-6 show that a portion of the observed response spectrum exceeds the DBSGM Ss response spectrum, but for the most part they are roughly the same.

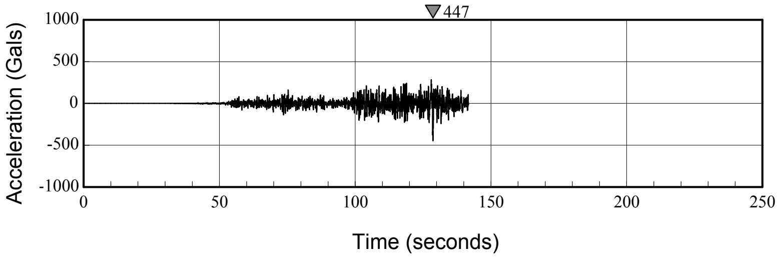


Figure 1-1 : Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 1

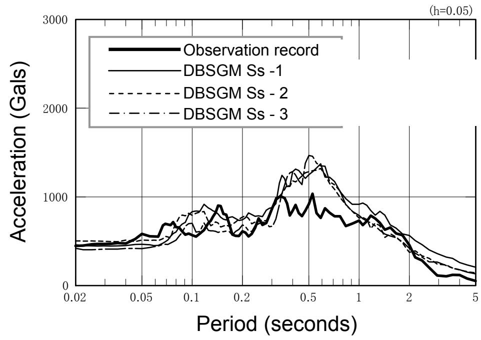


Figure 2-1 : Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 1

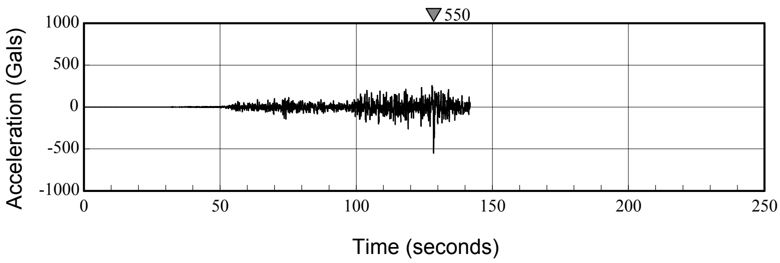


Figure 1-2 : Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 2

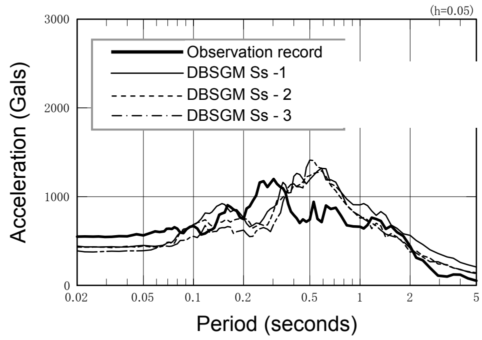


Figure 2-2 : Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 2

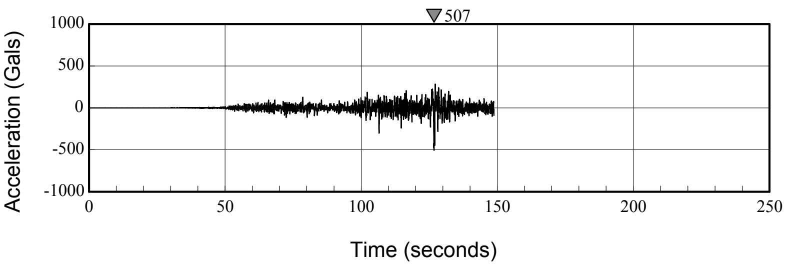


Figure 1-3 : Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 3

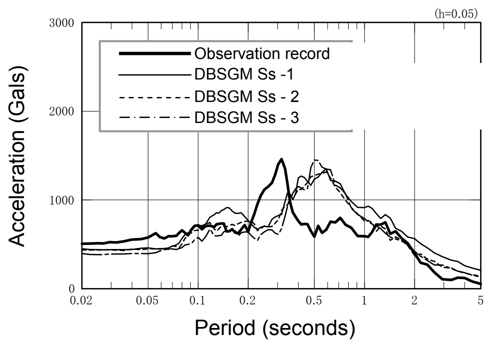


Figure 2-3 : Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 3

*The table illustrates examples of the larger direction on the horizontal plane (Fukushima Daiichi : EW direction).

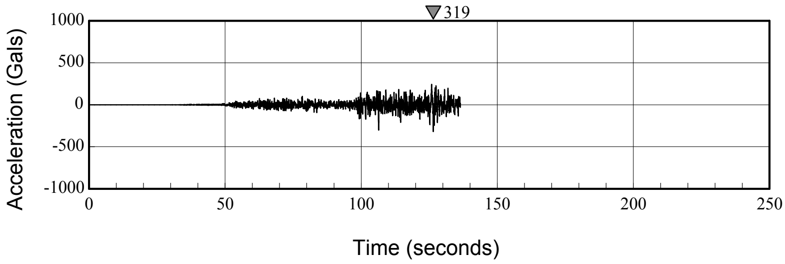


Figure 1-4: Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 4

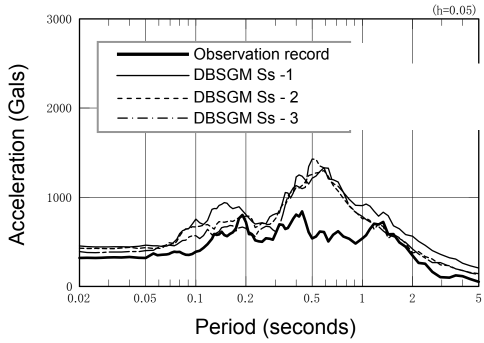


Figure 2-4: Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 4

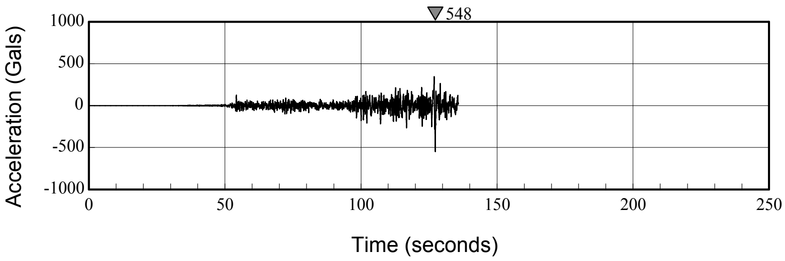


Figure 1-5: Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 5

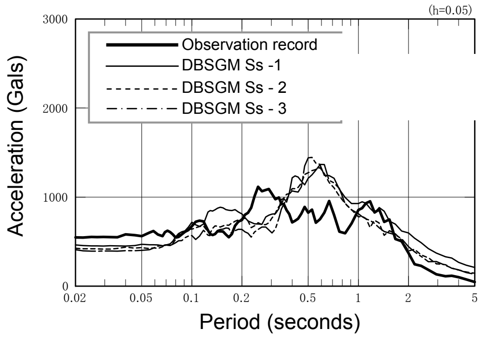


Figure 2-5: Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 5

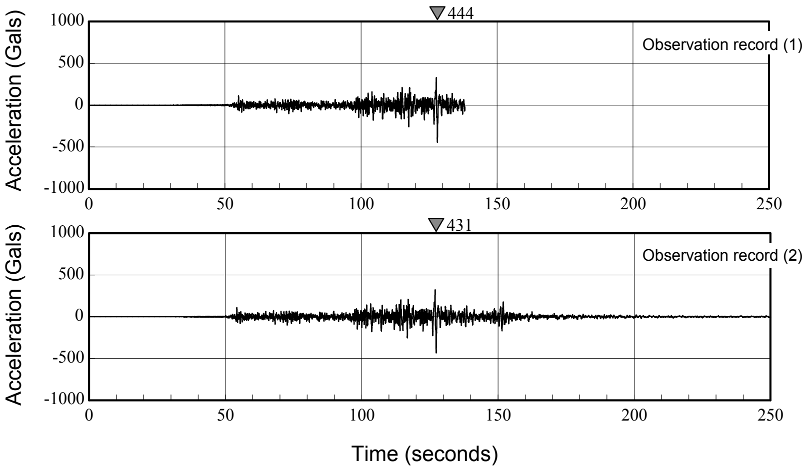


Figure 1-6: Acceleration transient wave form (EW direction) at R/B base mat of Fukushima Daiichi Unit 6

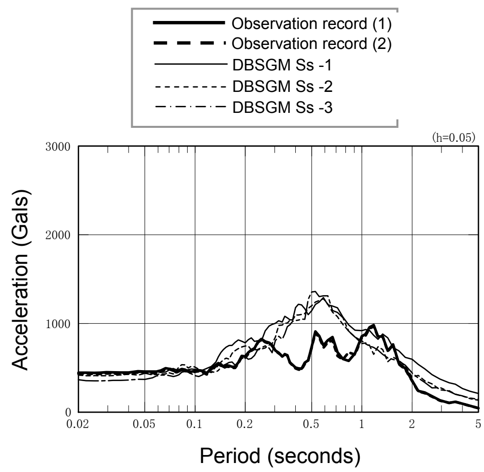


Figure 2-6: Response spectrum (EW direction) at R/B base mat of Fukushima Daiichi Unit 6

* The table illustrates examples of the larger direction on the horizontal plane (Fukushima Daiichi : EW direction).

Stripped Wave Analysis of Seismic Observation records from Fukushima Daiichi Nuclear Power Station

The base model for stripped wave analysis is estimated by making use of the observation records of the free base obtained from this earthquake, the stripped wave analysis conducted using this ground model, seismic motion evaluated for the free surface of the base stratum, and then it is compared to the design basis seismic ground motion Ss.

1. Identification of ground model

Reverse analysis is carried out on the transfer function calculated from the records obtained from this earthquake, and the ground model is estimated for the stripped wave analysis. The transfer function evaluated using the observation records is shown in Figure 1. As it is conceivable from this data that there is no great difference between the transfer function from the NS and EW directions, investigations are carried out on the average NS and EW transfer functions for the horizontal direction.

1) Identification analysis method

- By conducting reverse analysis of the ground transfer function recorded in the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake employing theoretical ground transfer characteristics based on the one-dimensional wave motion theorem which hypothesizes vertical incidence of the S wave, optimized examination of the ground model is implemented for each of the horizontal direction and the vertical direction.
- The initial model is set taking into account the results of PS logging, and all strata are identified as the ideal S wave velocity or P wave velocity and damping ratio.
- The scope of searching for S wave velocity and P wave velocity is basically based on 0.8 to 1.2 times the initial model, but the range of 0.25 to 1.2 times are taken at following area.

  South-side point: O.P.+34.9m - O.P.+26.9m

  North-side point: O.P.+14.2m - O.P.+0.2m

  Furthermore, based on past investigation results of south-side point P wave velocity, the value is set at 0.7 to 1.3 times the initial model at the range of O.P.+26.9m - O.P.-3.1m.
- Formula (1) frequency dependent function form is applied to the damping ratio h(f), the upper limit value of h(f) is set to 1 and lower limit value is set to 0, and the search range of h_0 and α are both set to 0 - 1.

  $h(f) = h_0 \times f^{-\alpha} \quad 0 \leqq h(f) \leqq 1$ ・・・ (1)
- GA (genetic algorithm) is used for the reverse analysis, and the parameters are set to population 20, generation number 100, crossover probability 0.75, and the mutation rate is set to 1/(2 x gene length). The initial random number is changed ten times and trial calculations carried out, and after checking the convergent to the solution, the ground model adopted is the one to which the minimal error is obtained.

2) Identification Results

○ South-side Point

The ground model as estimated using the south-side point records is shown together with the initial model and scope of search in Table 1 and Figure 2, whereas a comparison of the transfer function estimated from the ground model and the transfer function according to observation records is shown in Figure 3. When the records from the deepest location of the seismometer (O.P.-300.0m) is inputted into the estimated ground model, the response spectrum for O.P.-5.0m, as shown in Figure 4, is a close match to the response spectrum extrapolated from the seismic observation records obtained from the said location, and therefore the estimated ground model is believed to be appropriate.

○ North-side Point

The ground model as estimated using the north-side point records is shown together with the initial model and scope of search in Table 2 and Figure 5, whereas the transfer function estimated from the ground model is shown in Figure 6. When the records from the deepest location of the seismometer (O.P.-300.0m) is inputted into the estimated ground model, the response spectrum for O.P.-5.0m, as shown in Figure 7, is a close match to the response spectrum extrapolated from the seismic observation records obtained from the said location, and therefore the estimated ground model is believed to be appropriate.

The relationship of the above with the ground model for stripped wave analysis used in the seismic safety assessment for existing nuclear reactor facilities when the "Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities" was revised before the Tohoku Earthquake is shown in Reference 1.

2. Stripped Wave Analysis

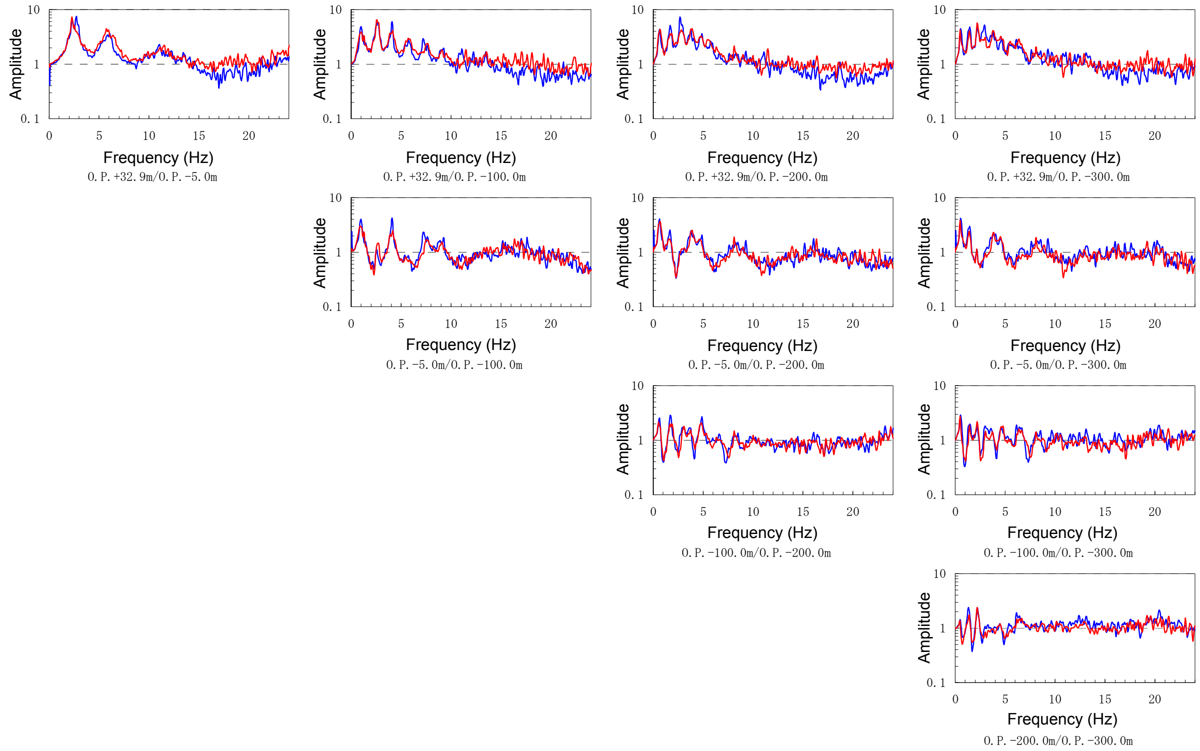
Stripped wave analysis of the records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake is conducted using the estimated ground model, and an evaluation of the seismic motion of the free surface of the base stratum (O.P.-196,0m) is made. The observation records used are the records of a location at O.P.-200.0m near the free surface of the base stratum.

Figure 8 shows a comparison of the acceleration transient wave forms for the free surface of the base stratum calculated by the stripped wave analysis with the observation records at a location O.P.-200.0ms. Furthermore, a comparison of pseudo-velocity response spectrum with the design basis seismic ground motion Ss is shown in Figure 9.

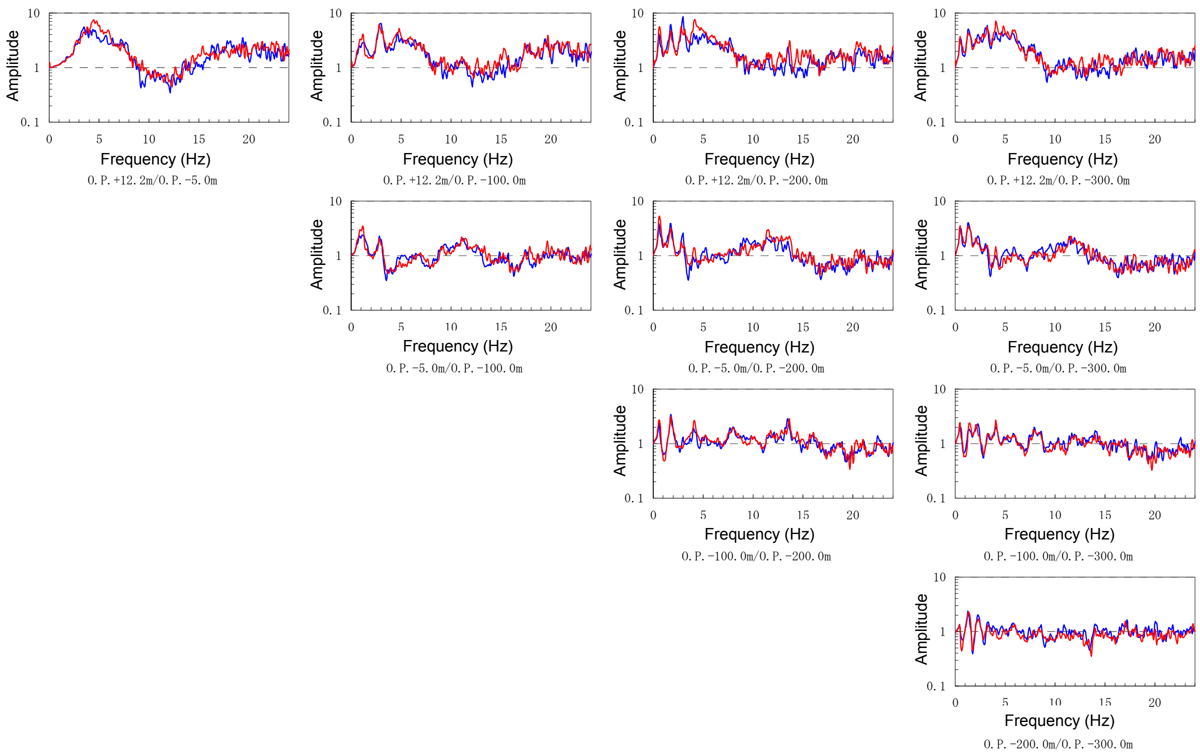
From the above, it is confirmed that the level of the seismic motion of the free surface of the base stratum is around the same level as the design basis seismic ground motion Ss.

3. Conclusion

Through investigations using the seismic observation records, the seismic motion of the Tohoku Earthquake free surface of the base stratum was evaluated and compared to the design basis seismic ground motion Ss. As the result of the examination, it is believed that the free surface of the base stratum seismic motion and the design basis seismic ground motion Ss are approximately the same level.



a. Fukushima Daiichi : south-side point



b. Fukushima Daiichi : north-side point

Fig. 1 comparison of NS direction (blue) and EW direction (red) transfer function (amplitude spectrum)

Table 1 - (1) Fukushima Daiichi : south-side point : horizontal direction ground model

Fixed parameters			Initial model	Scope of search						Identification results		
O.P.	Layer thickness	density	S wave velocity	S wave velocity (m/s)		damping $h(f)=h_0 \times f^{-\alpha}$				S wave velocity	damping $h(f)=h_0 \times f^{-\alpha}$	
						h_0		α				
(m)	(m)	(g/cm³)	(m/s)	lower end	upper end	lower end	upper end	lower end	upper end	(m/s)	h_0	α
+34.9	2.0	2.10	440	110	528	0	1	0	1	285	0.291	0.25
+32.9	● 6.0	2.10										
+26.9	8.0	2.00	280	224	336	0	1	0	1	252	0.274	1.00
+18.9	22.0	1.73	460	368	552					400		
-3.1	1.9	1.73	520	416	624	0	1	0	1	486	0.107	0.67
-5.0	● 44.1	1.73										
-49.1	24.0	1.80										
-73.1	24.0	1.80	590	472	708					592		
-97.1	2.9	1.77										
-100.0	● 9.1	1.77										
-109.1	46.0	1.77	650	520	780	0	1	0	1	659	0.063	1.00
-155.1	40.0	1.76										
-195.1	0.9	1.76	730	584	876					740		
-196.0	4.0	1.76										
-200.0	● 10.1	1.76										
-210.1	89.9	1.81										
-300.0	● —	1.81										

● : Seismometer

* : Fixed parameters are according to PS logging results.

Table 1 - (2) Fukushima Daiichi : south-side point : vertical direction ground model

Fixed parameters: O.P. (m)	Fixed parameters: Layer thickness (m)	Fixed parameters: density (g/cm³)	Initial model: S wave velocity (m/s)	Scope of search: S wave velocity (m/s) lower end	Scope of search: S wave velocity (m/s) upper end	Scope of search: damping $h(f)=h_0 \times f^{-\alpha}$, h_0 lower end	h_0 upper end	α lower end	α upper end	Identification results: S wave velocity (m/s)	Identification results: damping $h(f)=h_0 \times f^{-\alpha}$, h_0	α
+34.9	2.0	2.10	800	200	960	0	1	0	1	366	0.139	0.55
+32.9 ●	6.0	2.10										
+26.9	8.0	2.00	1200	840	1560	0	1	0	1	1042	1.000	0.71
+18.9	22.0	1.73	1730	1211	2249					1502		
-3.1	1.9	1.73		1384	2076	0	1	0	1	1823	0.627	1.00
-5.0 ●	44.1	1.73										
-49.1	24.0	1.80										
-73.1	24.0	1.80										
-97.1	2.9	1.77										
-100.0 ●	9.1	1.77										
-109.1	46.0	1.77	1810	1448	2172	0	1	0	1	1907	0.252	1.00
-155.1	40.0	1.76										
-195.1	0.9	1.76	2000	1600	2400					2108		
-196.0	4.0	1.76										
-200.0 ●	10.1	1.76										
-210.1	89.9	1.81										
-300.0 ●	—	1.81										

● : Seismometer

* : Fixed parameters are according to PS logging results.

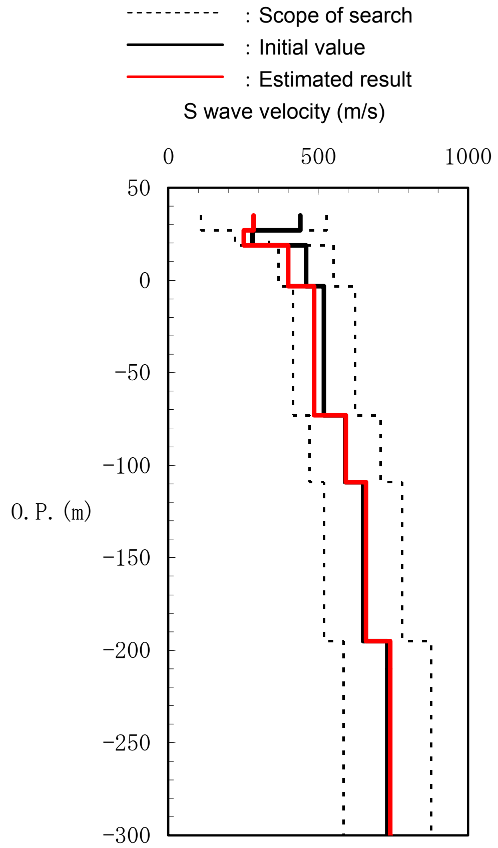


Fig. 2 - (1) Scope of search and estimated results
(Fukushima Daiichi, south-side point, horizontal direction)

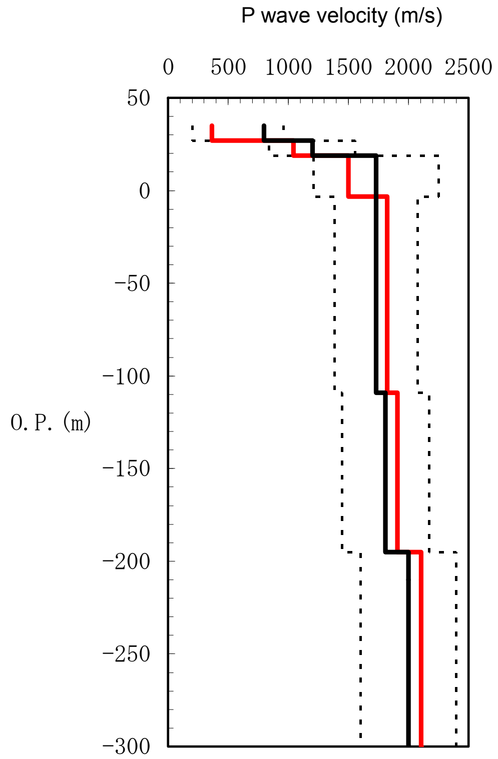
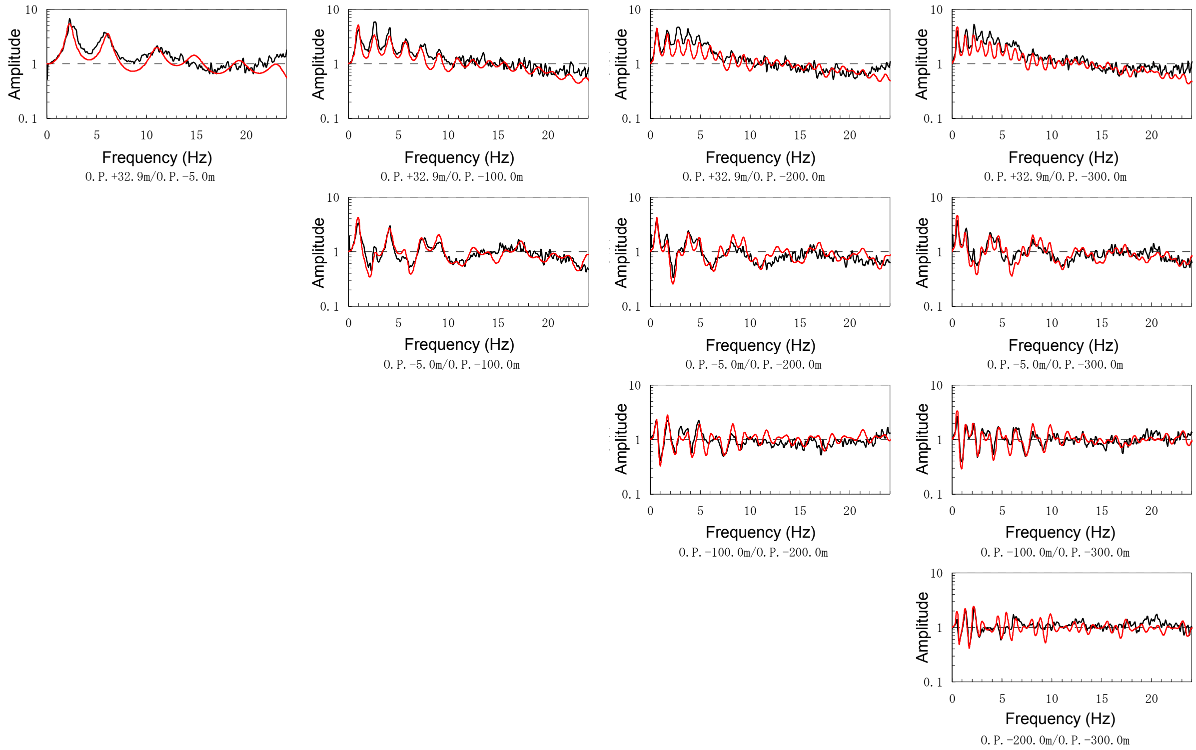
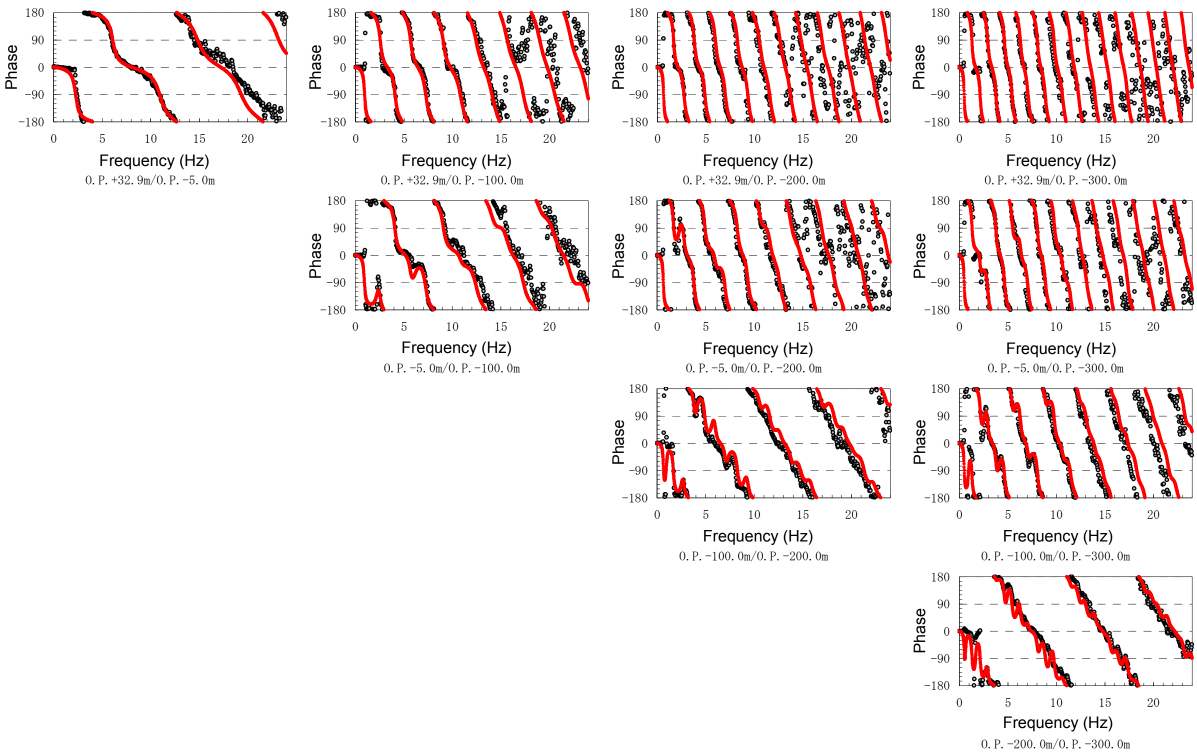


Fig. 2 - (2) Scope of search and estimated results
(Fukushima Daiichi, south-side point, vertical direction)

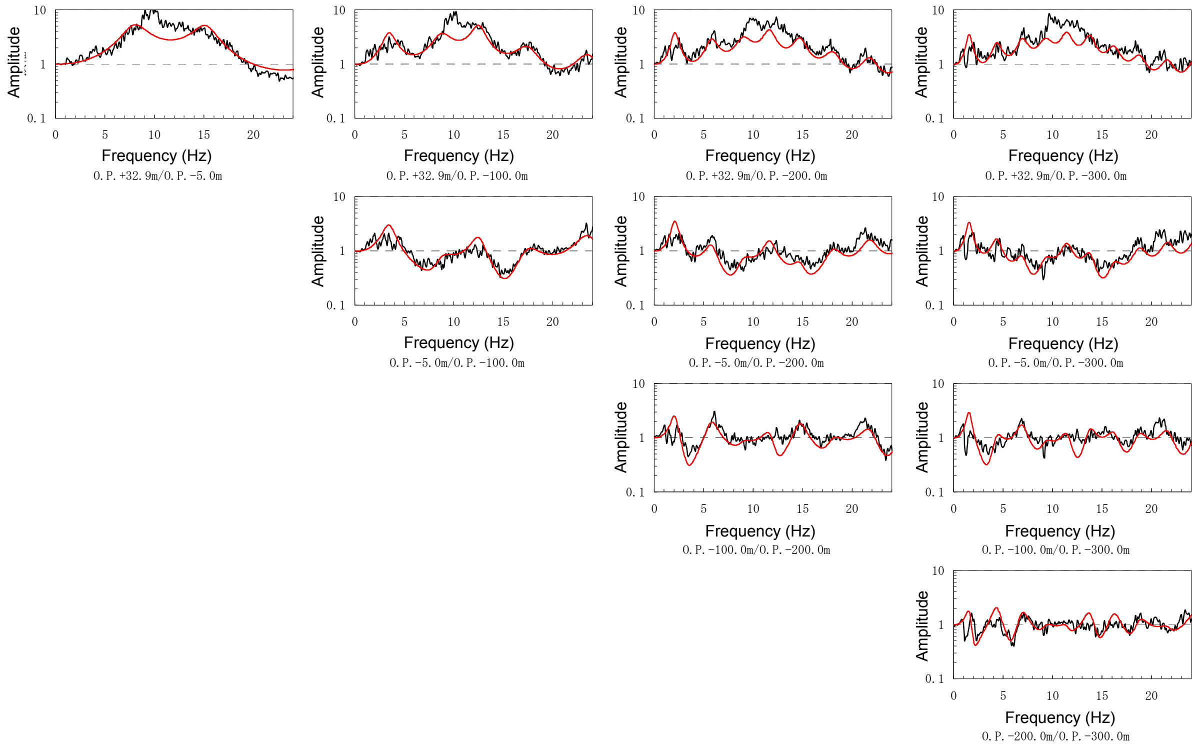


a. Amplitude spectrum

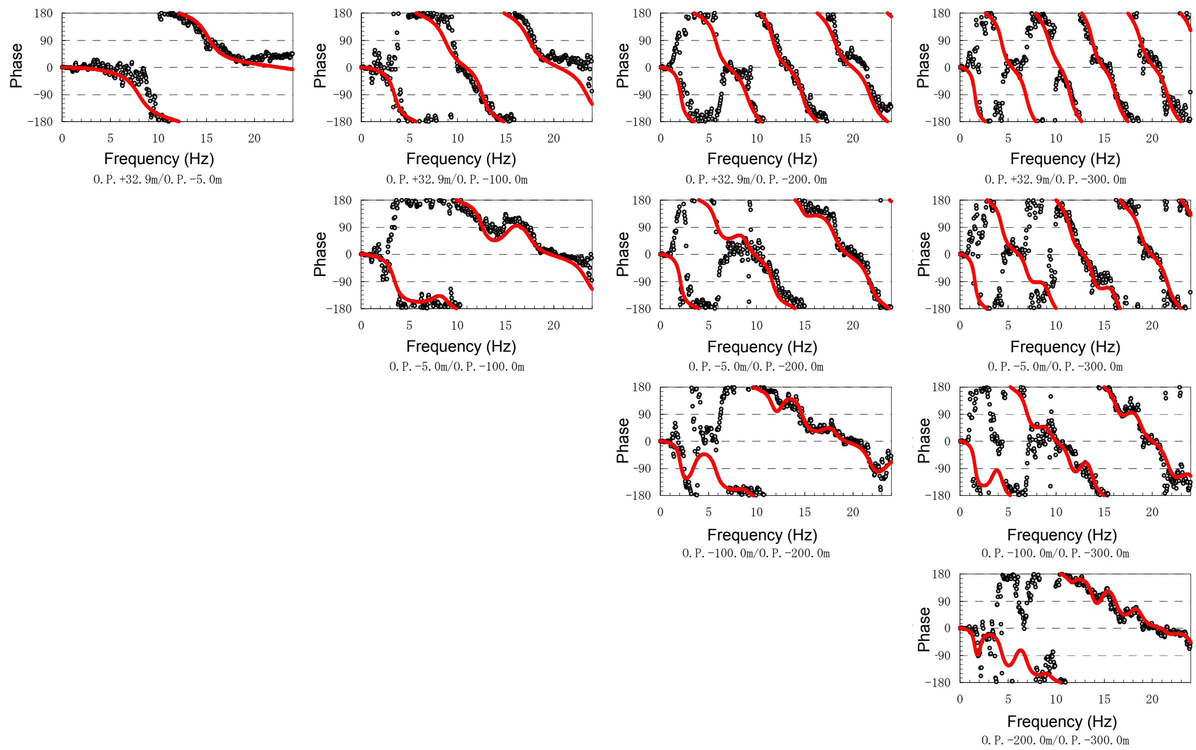


b. Phase spectrum

Fig. 3-(1) Fukushima Daiichi, south-side point, transfer function of the estimated ground model for the horizontal direction (red) and transfer function according to observation records (black)

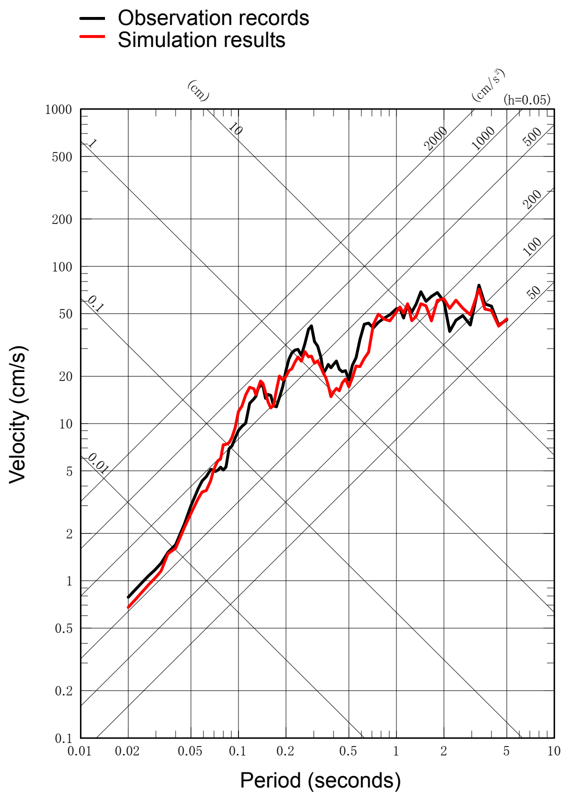


a. Amplitude spectrum

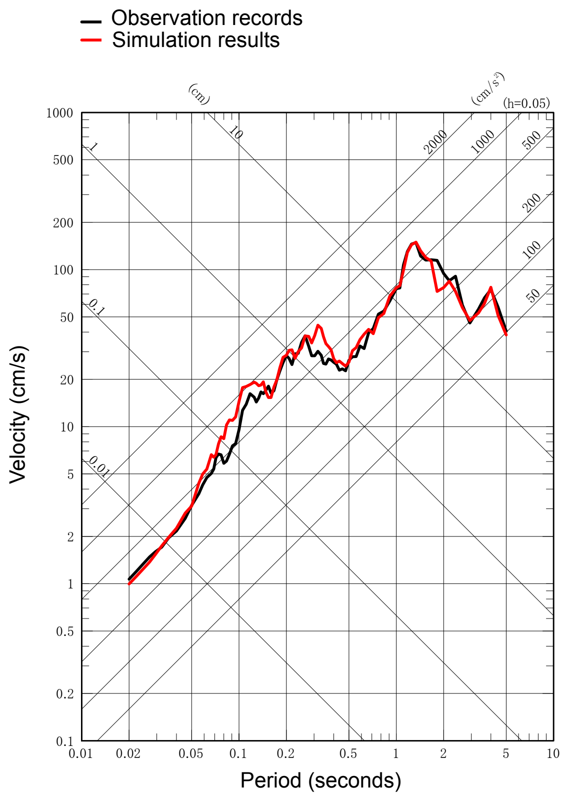


b. Phase spectrum

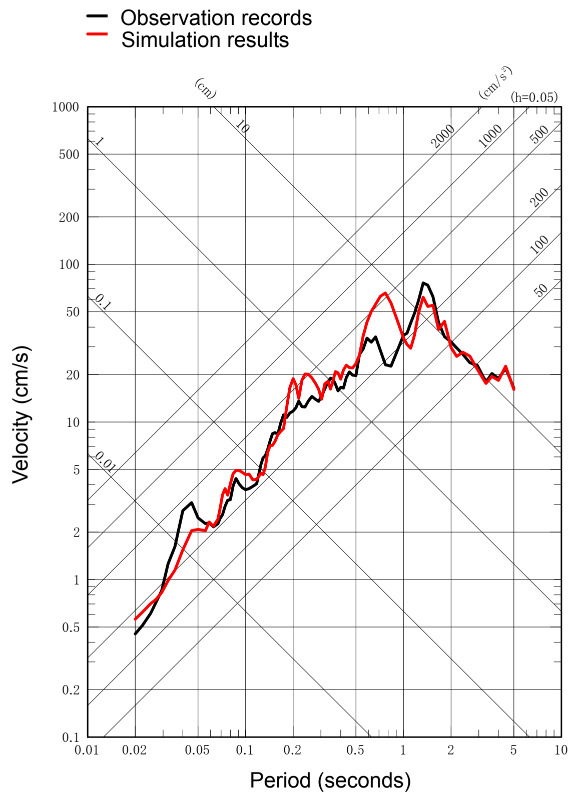
Fig. 3-(2) Fukushima Daiichi, south-side point, transfer function of the estimated ground model for the vertical direction (red) and transfer function according to observation records (black)



(1) NS direction



(2) EW direction



(3) Vertical direction

Fig. 4 Ground response simulation results (Fukushima Daiichi, south-side point, O.P.-300.0m to O.P.-5.0m)

Table 2 - (1) Fukushima Daiichi: north-side point: horizontal direction ground model

fixed parameters			initial model	scope of search						identification results		
O.P.	layer thickness	density	S wave velocity	S wave velocity		damping $h(f)=h_0 \times f^{-\alpha}$				S wave velocity	damping $h(f)=h_0 \times f^{-\alpha}$	
				(m/s)		h_0		α				
(m)	(m)	(g/cm^3)	(m/s)	lower end	upper end	lower end	upper end	lower end	upper end	(m/s)	h_0	α
+14.2												
	2.0	1.70	150	38	180	0	1	0	1	103	1.000	0.59
+12.2 ●												
	12.0	1.80	430	108	516	0	1	0	1	294	0.363	0.53
+0.2												
	5.2	1.68	470	376	564	0	1	0	1	471	0.127	1.00
-5.0 ●												
	66.8	1.68										
-71.8												
	22.0	1.70	570	456	684	0	1	0	1	515	0.070	0.94
-93.8												
	6.2	1.78	610	488	732					551		
-100.0 ●												
	85.8	1.78										
-185.8												
	10.2	1.83	780	624	936					746		
-196.0												
	4.0	1.83										
-200.0 ●												
	100.0	1.83										
-300.0 ●												
	—	1.83										

● : Seismometer

* : Fixed parameters are according to PS logging results

Table 2 - (2) Fukushima Daiichi: north-side point: vertical direction ground model

fixed parameters: O.P. (m)	fixed parameters: layer thickness (m)	fixed parameters: density (g/cm^3)	initial model: P wave velocity (m/s)	scope of search: P wave velocity (m/s) lower end	scope of search: P wave velocity (m/s) upper end	scope of search: damping $h(f)=h_0 \times f^{\alpha}$, h_0 lower end	scope of search: damping, h_0 upper end	scope of search: damping, α lower end	scope of search: damping, α upper end	identification results: P wave velocity (m/s)	identification results: damping $h(f)=h_0 \times f^{\alpha}$, h_0	identification results: damping, α
+14.2	2.0	1.70	1250	313	1500	0	1	0	1	1229	0.382	0.40
+12.2 ●	12.0	1.80										
+0.2	5.2	1.68	1730	1384	2076	0	1	0	1	1803	0.582	1.00
-5.0 ●	66.8	1.68										
-71.8	22.0	1.70										
-93.8	6.2	1.78	1850	1480	2220	0	1	0	1	1879	0.266	1.00
-100.0 ●	85.8	1.78										
-185.8	10.2	1.83	1900	1520	2280	0	1	0	1	1982	0.196	1.00
-196.0	4.0	1.83										
-200.0 ●	100.0	1.83										
-300.0 ●	—	1.83										

● : Seismometer

* : Fixed parameters are according to PS logging results

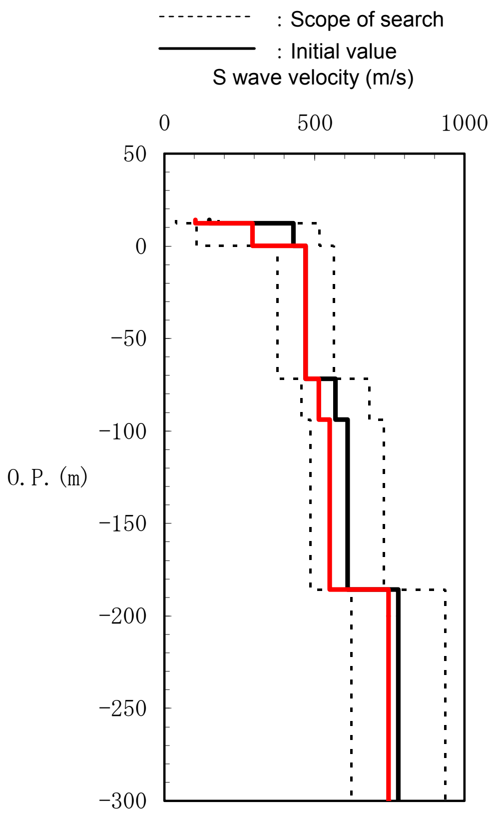


Fig. 5 - (1) scope of search and estimated results
(Fukushima Daiichi, north-side point, horizontal direction)

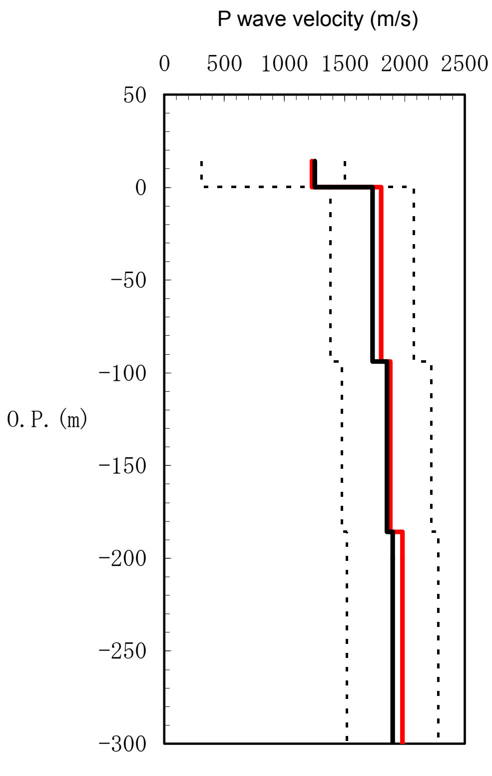
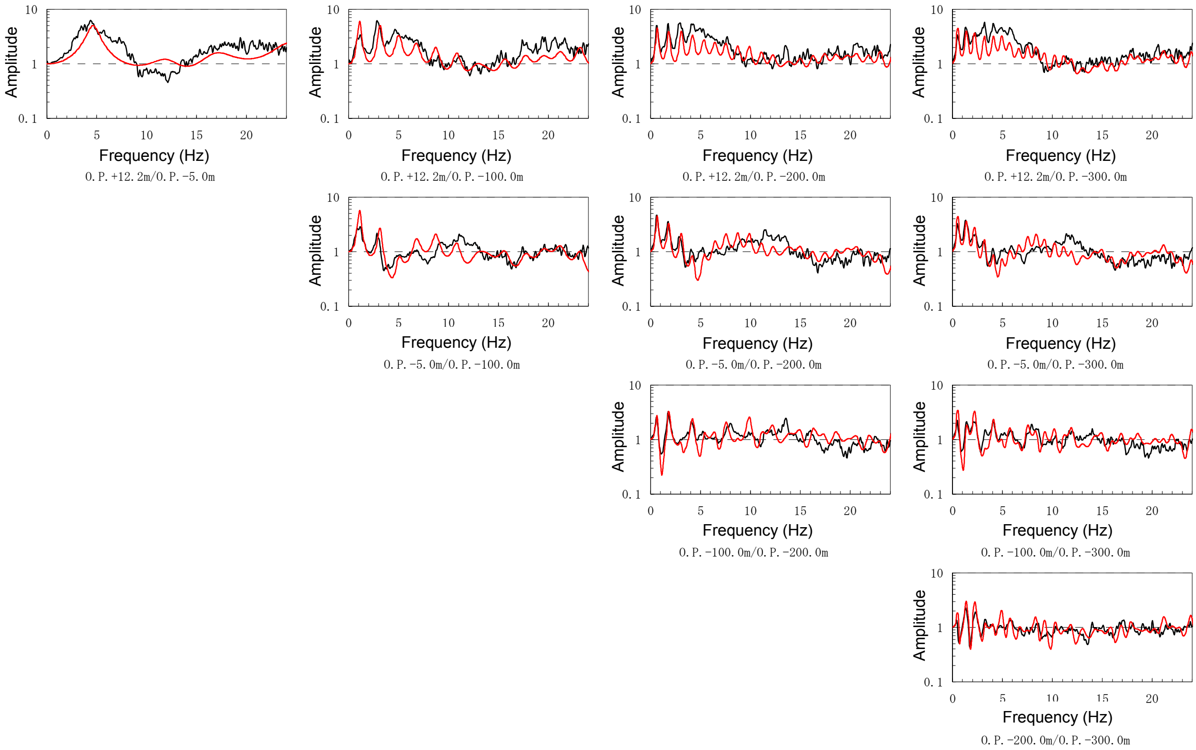
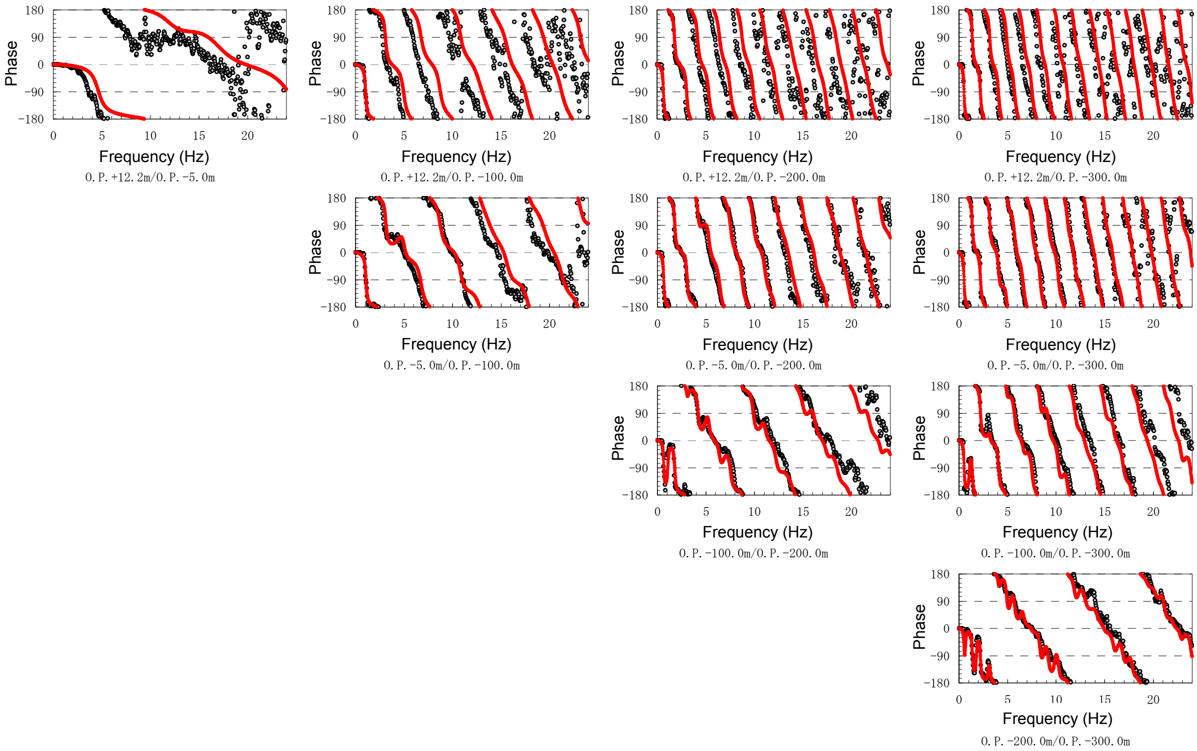


Fig. 5 - (2) Scope of search and estimated results
(Fukushima Daiichi, north-side point, vertical direction)

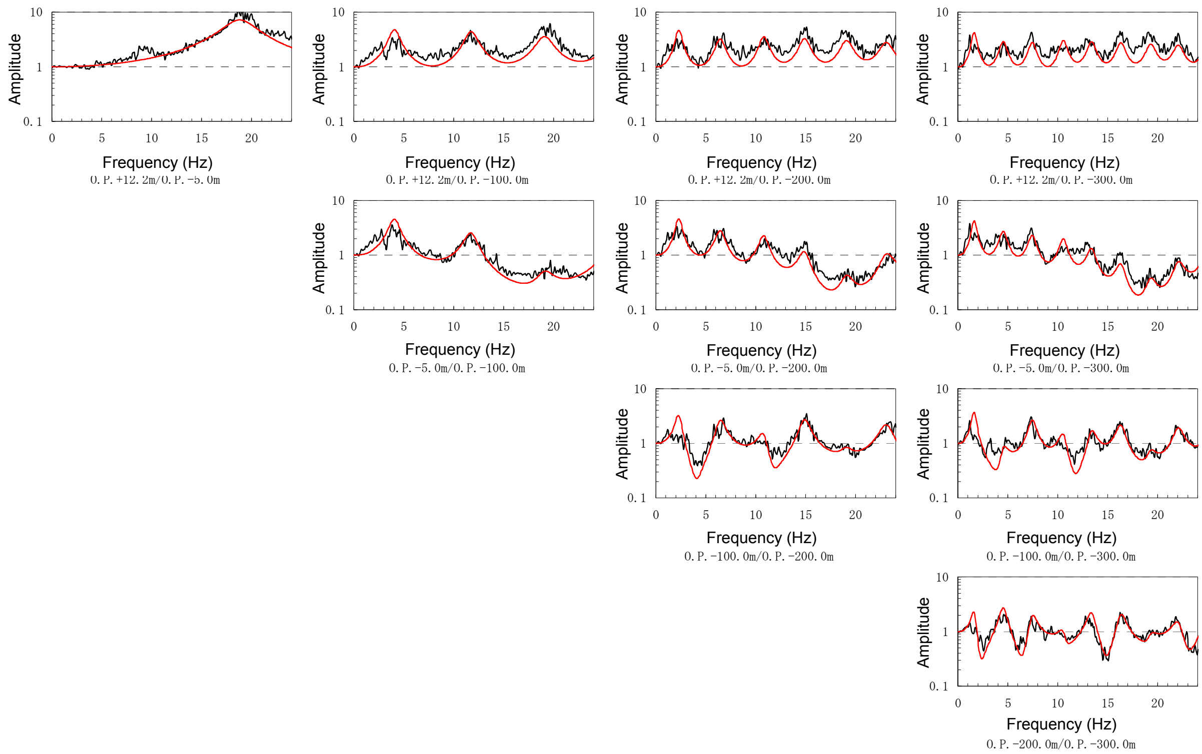


a. Amplitude spectrum

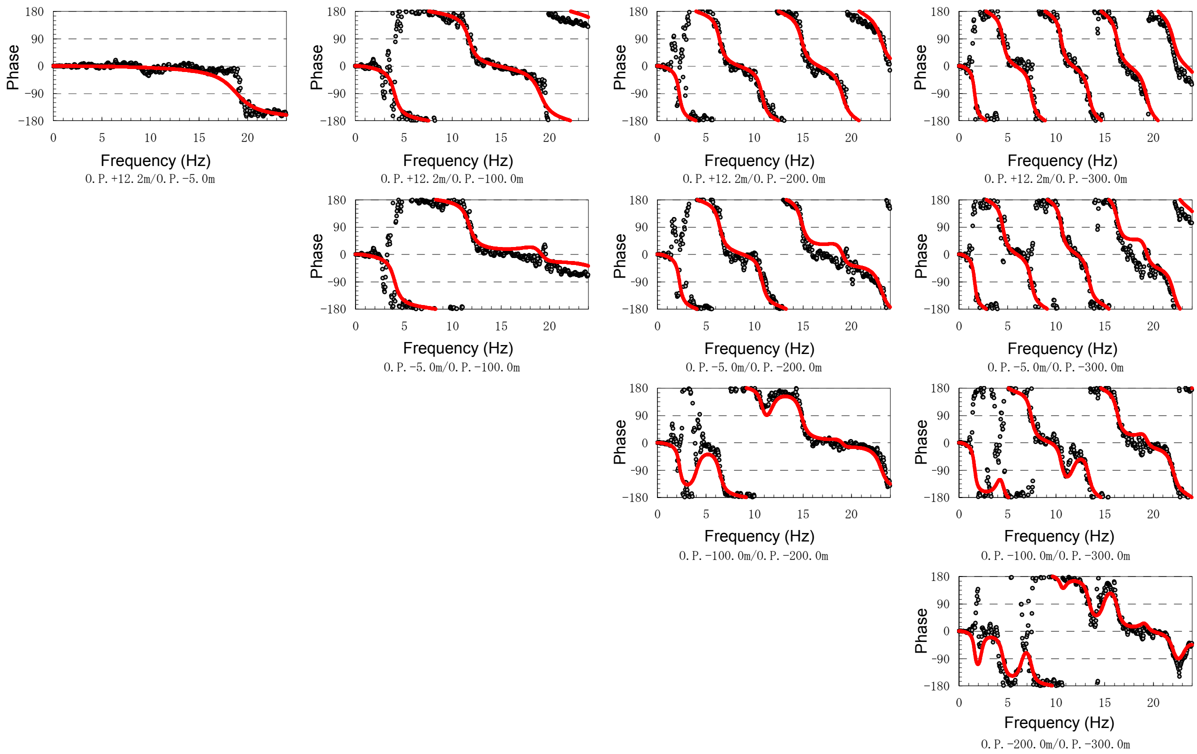


b. Phase spectrum

Fig. 5 - (1) Fukushima Daiichi north-side point, transfer function of the estimated ground model for the horizontal direction (red) and transfer function according to observational records (black)

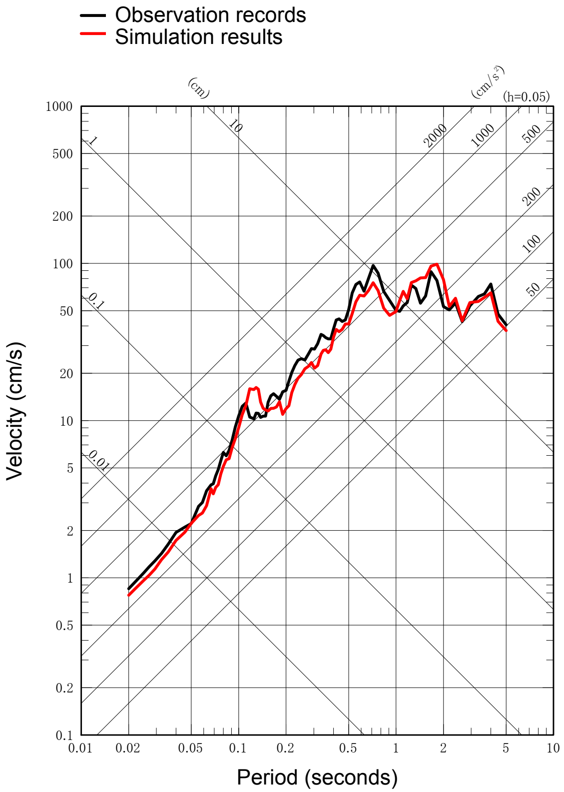


a. Amplitude spectrum

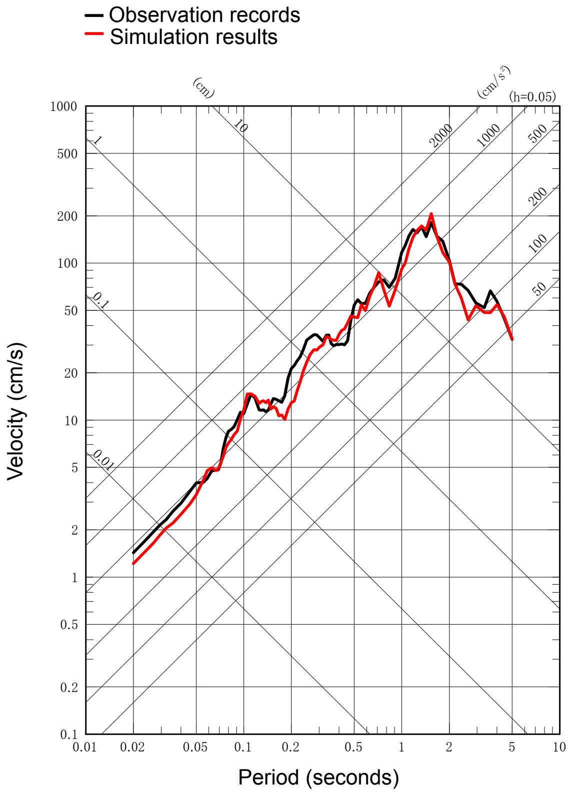


b. Phase spectrum

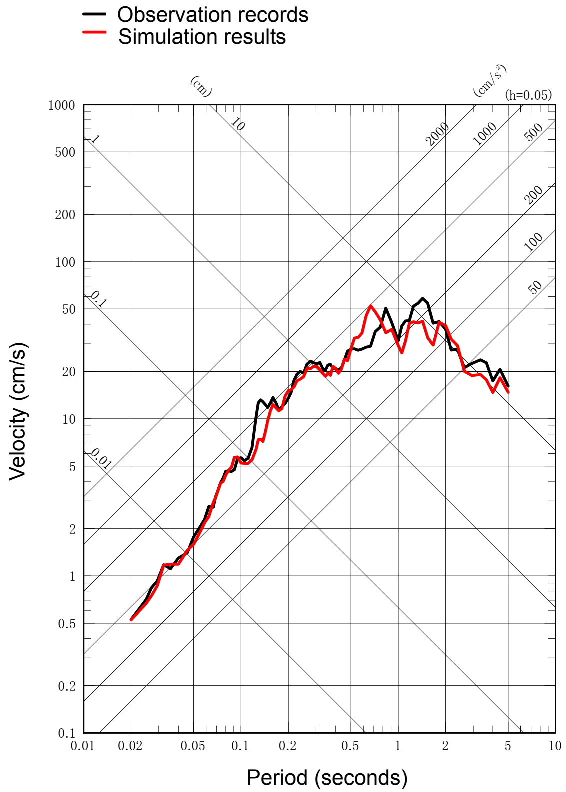
Fig.6 - (2) Fukushima Daiichi, north-side point, transfer function of the estimated ground model for the vertical direction (red) and transfer function according to observation records (black)



(1) NS direction

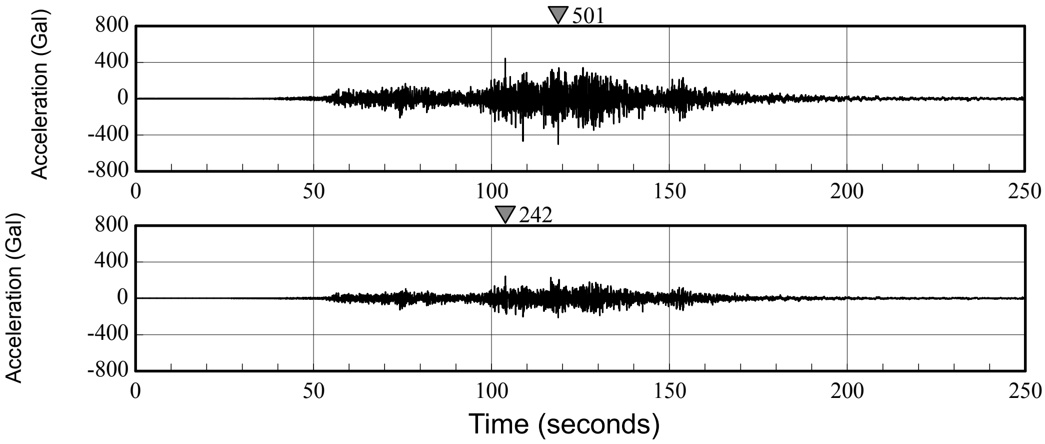


(2) EW direction

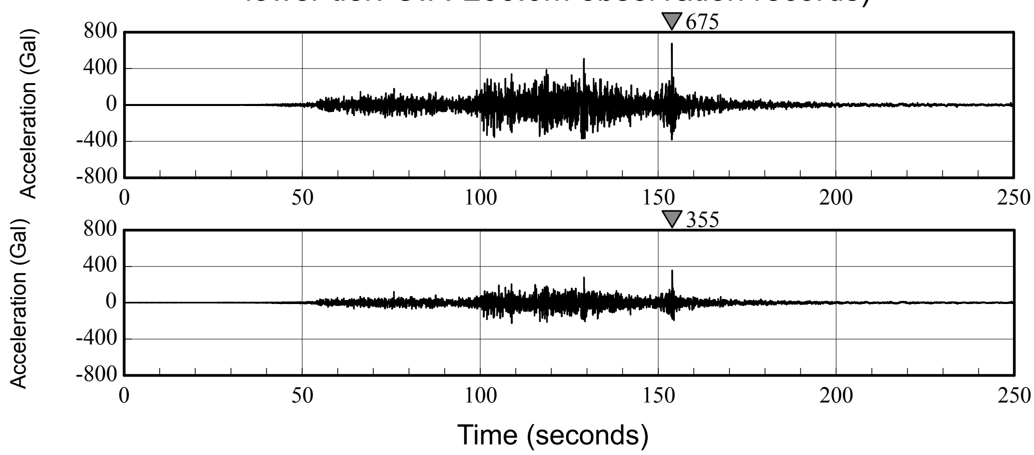


(3) Vertical direction

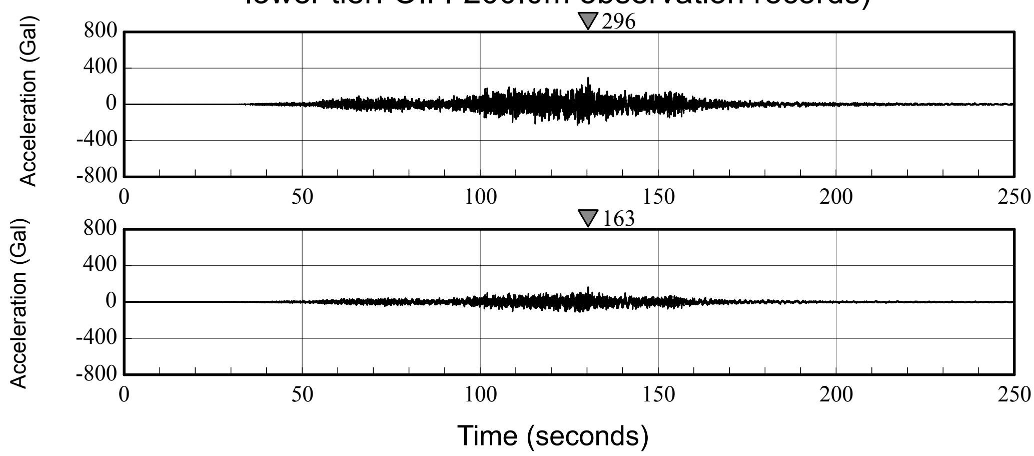
Fig. 7 Ground response simulation results
(Fukushima Daiichi, north-side point, O.P.-300.0m to O.P.-5.0m)



(a) NS direction (upper tier: stripped wave analysis result,
lower tier: O.P.-200.0m observation records)

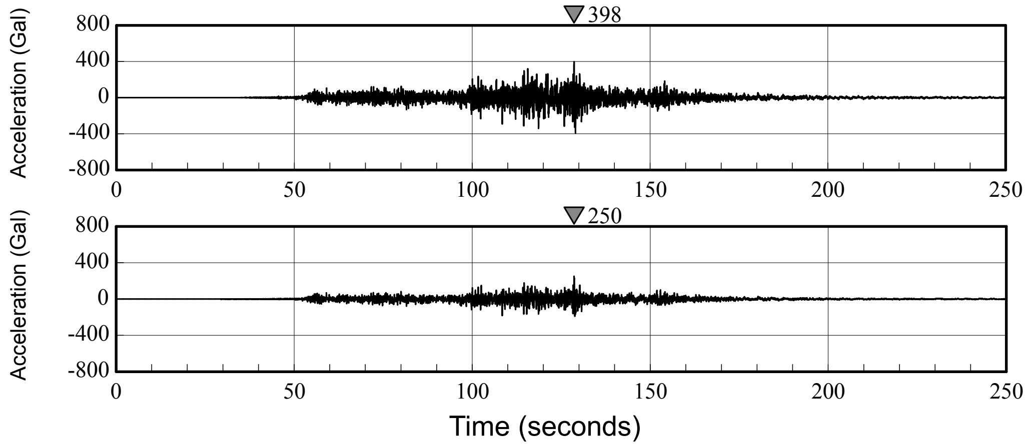


(b) EW direction (upper tier: stripped wave analysis results,
lower tier: O.P.-200.0m observation records)

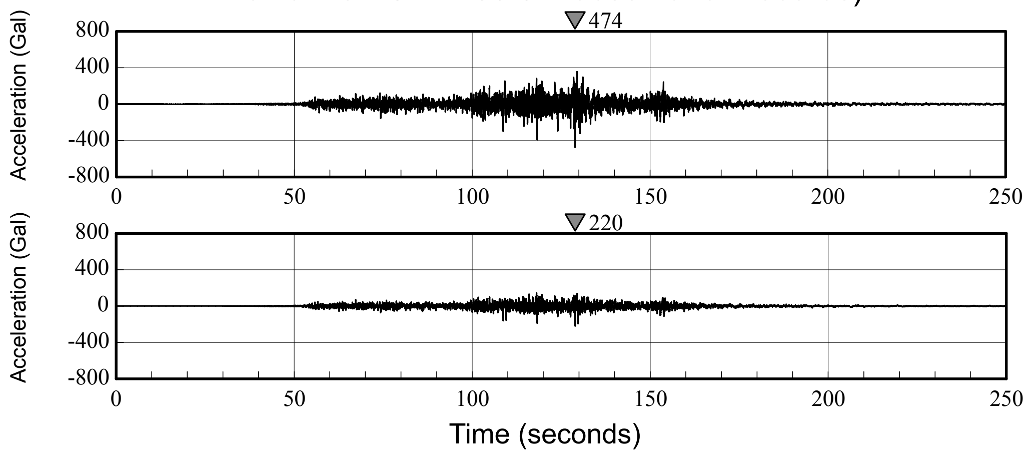


(c) Vertical direction (upper tier: stripped wave analysis results,
lower tier: O.P.-200.0m observation records)

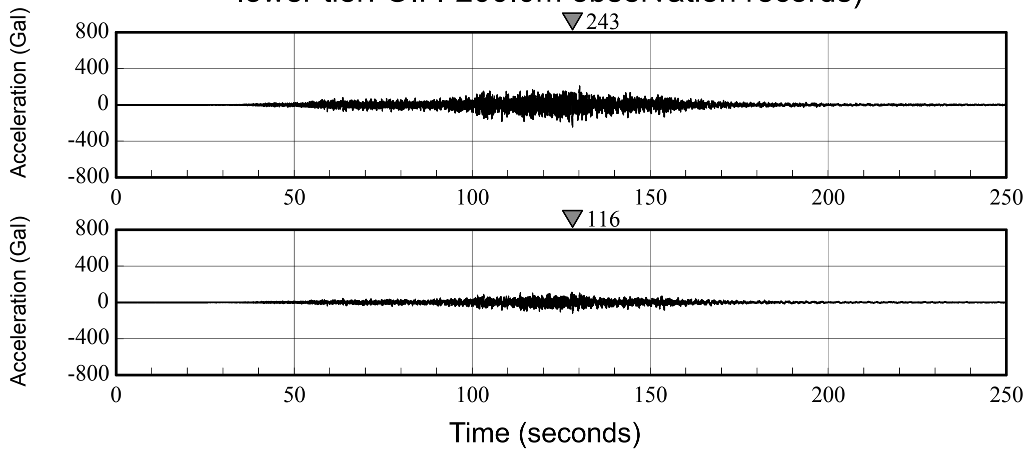
Fig. 8(1) transient wave form (free base south-side point) according to stripped wave analysis



(a) NS direction (upper tier: stripped wave analysis result,
lower tier: O.P.-200.0m observation records)



(b) EW direction (upper tier: stripped wave analysis results,
lower tier: O.P.-200.0m observation records)



(c) Vertical direction (upper tier: stripped wave analysis results,
lower tier: O.P.-200.0m observation records)

Fig. 8(2) Transient wave form (free base north-side point) according to stripped wave analysis

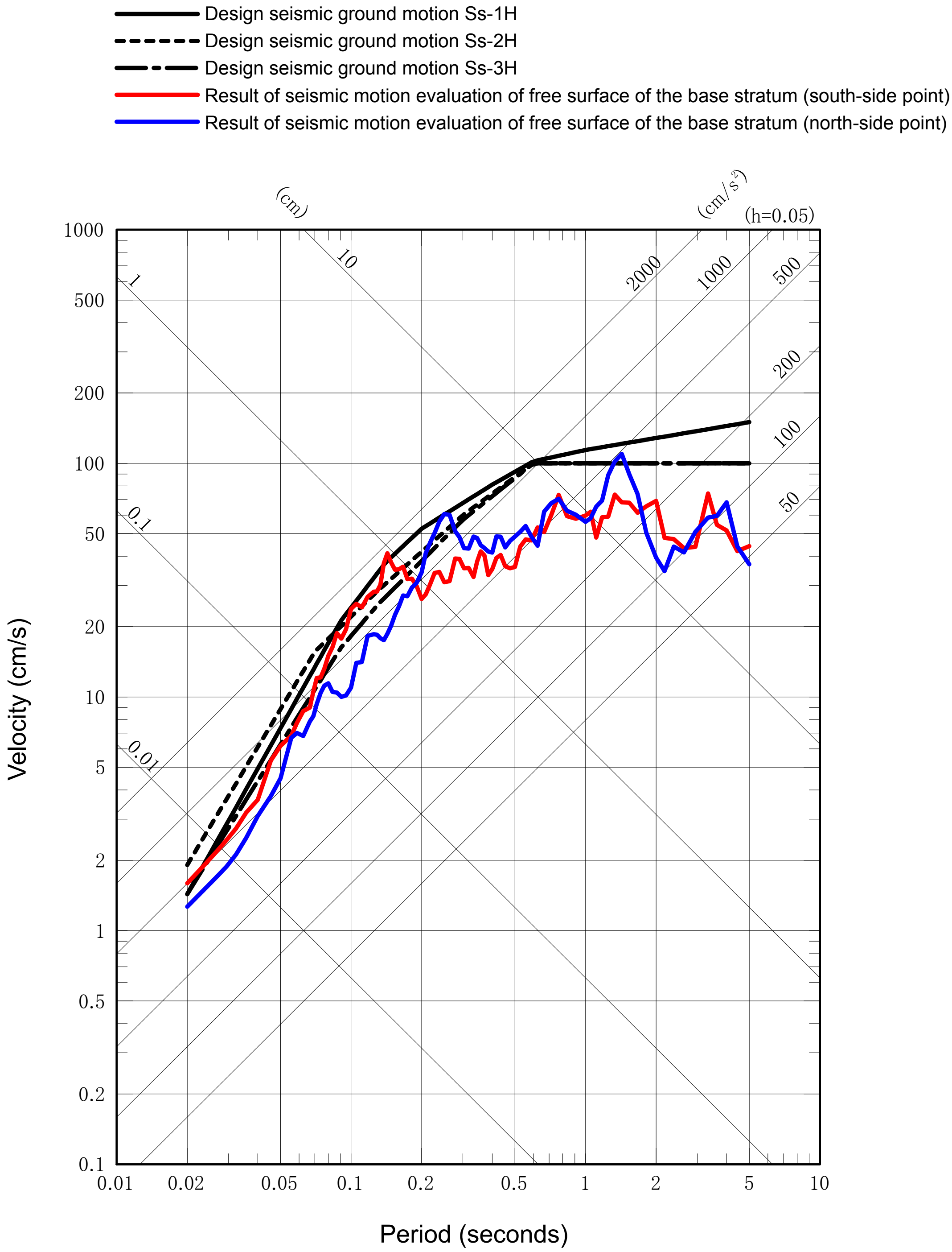


Fig. 9 - (1) Comparison of result of seismic motion evaluation of free surface of the base stratum by stripped wave analysis with design basis seismic ground motion Ss (NS direction)

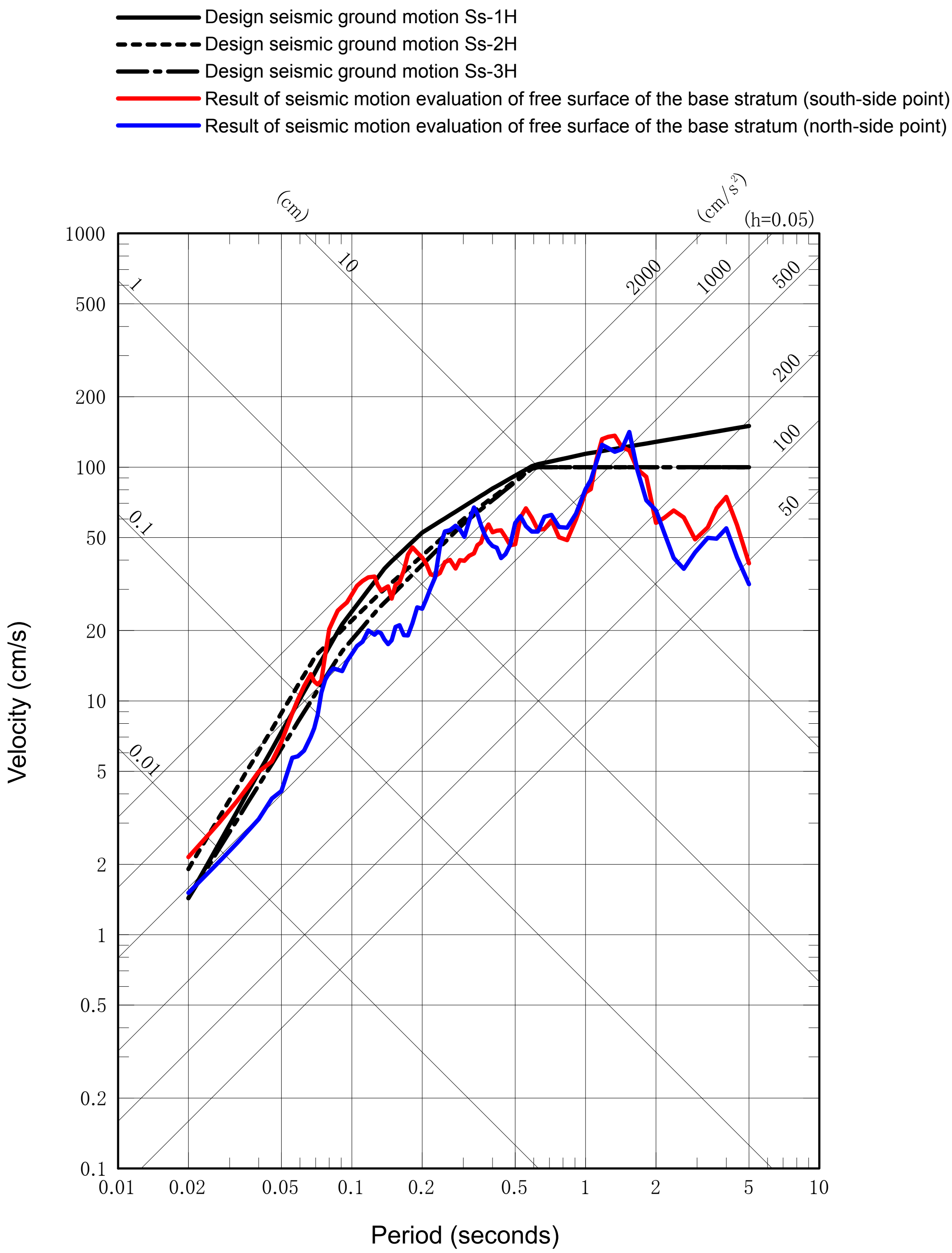


Fig. 9 - (2) Comparison of result of seismic motion evaluation of free surface of the base stratum by stripped wave analysis with design basis seismic ground motion Ss (EW direction)

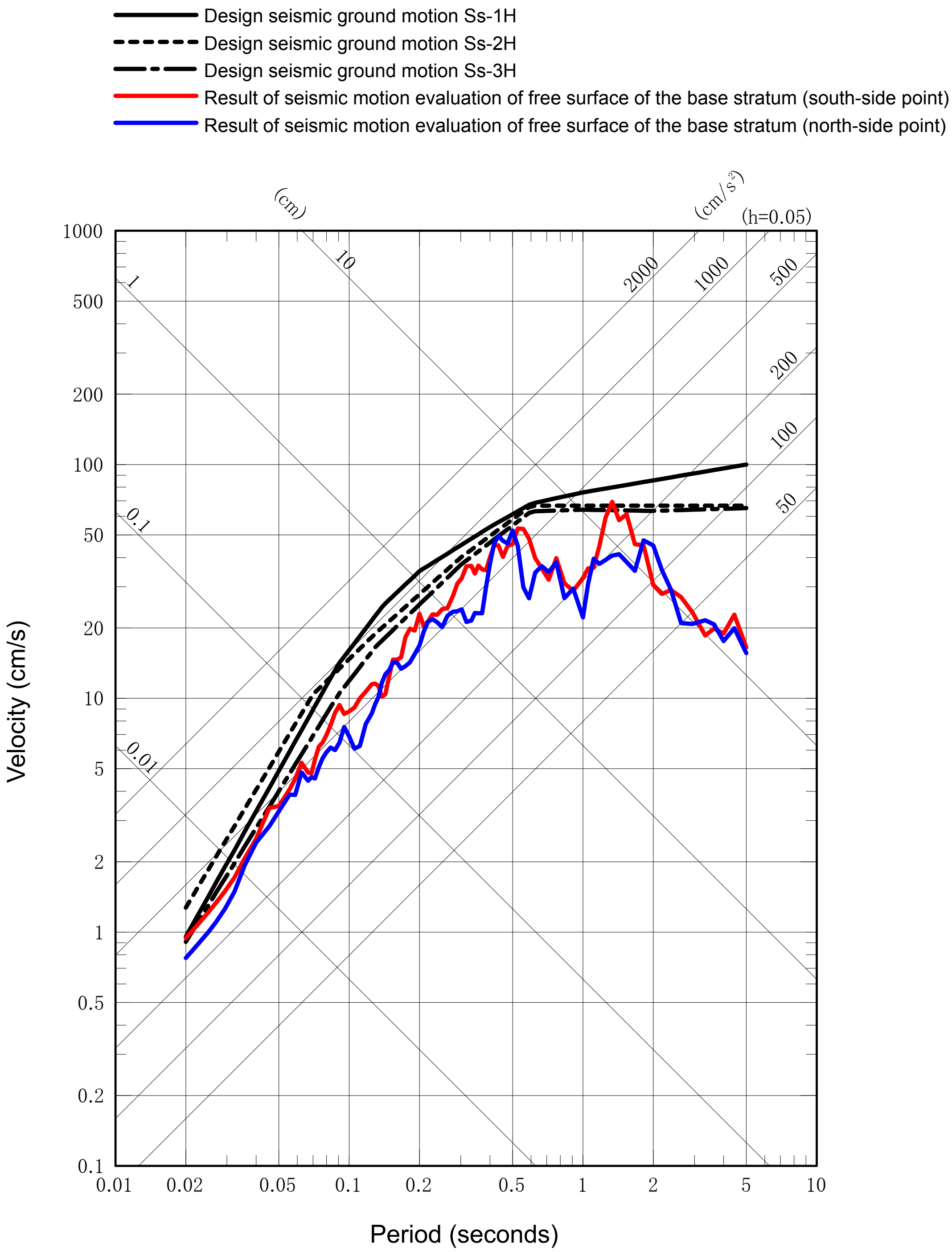


Fig. 9 - (3) Comparison of result of seismic motion evaluation of free surface of the base stratum by stripped wave analysis with design basis seismic ground motion Ss (vertical direction)

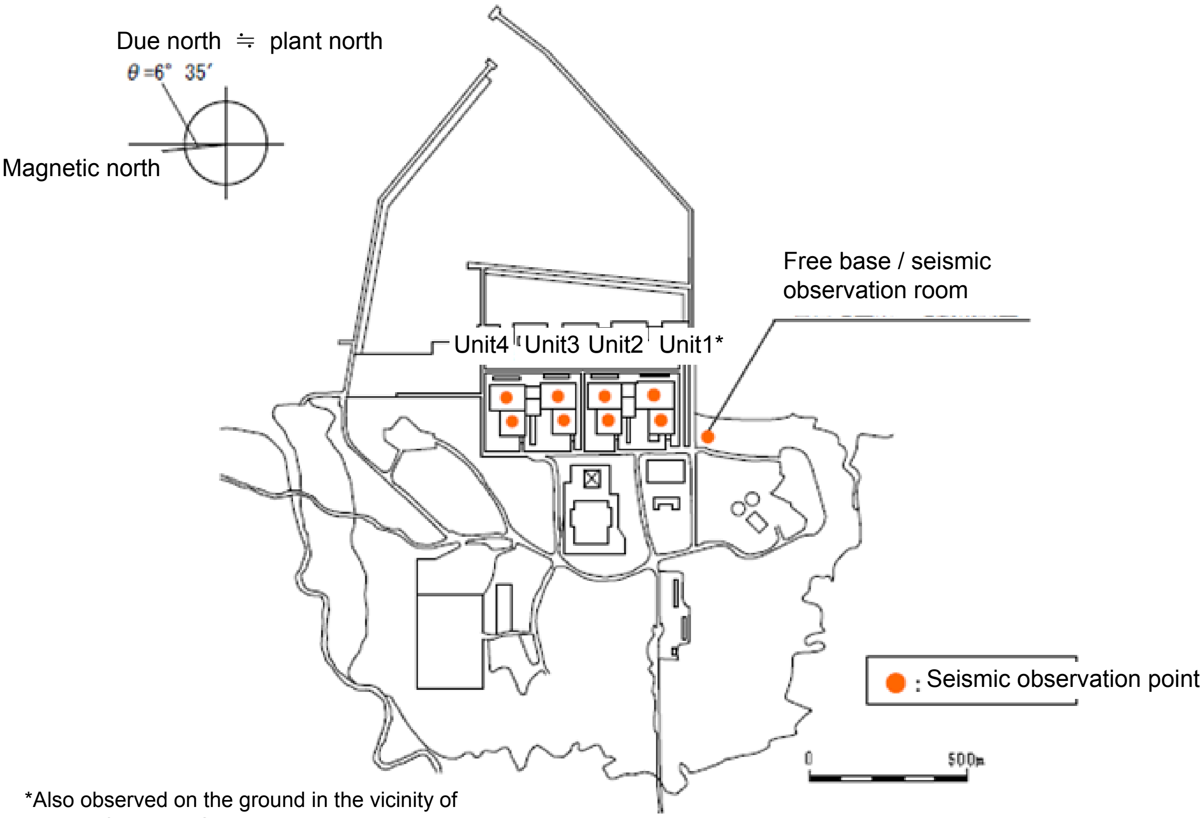
Comparison between the seismic observation records and the design seismic motion at the Fukushima Daini Nuclear Power Station

Comparison of the observation records at Fukushima Daini NPS from the Tohoku-Chihou-Taiheiyo-Oki Earthquake and the response spectrum against design basis seismic ground motion (DBSGM) Ss

Observation point (R/B base mat)	Observation records Maximum acceleration (Gal)			maximum acceleration response against DBSGM Ss (Gal)		
	NS direction	EW direction	UD direction	NS direction	EW direction	UD direction
Unit 1	254	230*	305	434	434	512
Unit 2	243	196*	232*	428	429	504
Unit 3	277*	216*	208*	428	430	504
Unit 4	210*	205*	288*	415	415	504

*Recording stopped at about 130 to 150 seconds after the start of recording

Legend: NS: North-South, EW: East-West, UD: Up-Down



*Also observed on the ground in the vicinity of building for Unit 1 Observation point

Locations of Fukushima Daini NPS seismic observation points

Figures 1-7 through 1-10 show the acceleration transient wave forms observed above the base mat of all reactor buildings at Fukushima Daini NPS Unit 1 through Unit 4 and Figures 2-7 through 2-10 show the observed spectrum with the response spectrum calculated by inputting the DBSGM SS.

Figures 2-7 through 2-10 show that a portion of the observed response spectrum exceeds the DBSGM Ss response spectrum, but for the most part they are roughly the same.

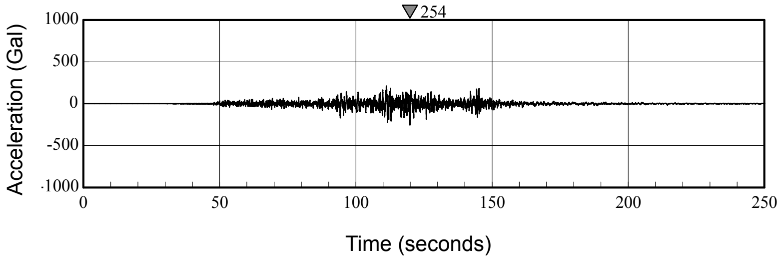


Figure 1-7 : Acceleration transient wave form (NS direction) at R/B base mat of Fukushima Daini Unit 1

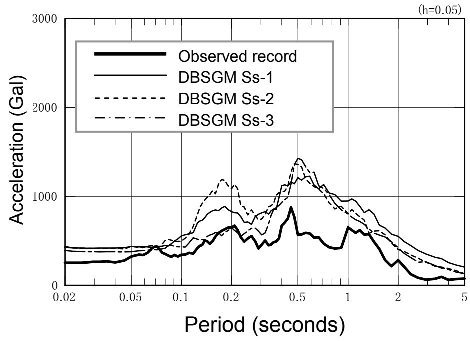


Figure 2-7 : Response spectrum (NS direction) at R/B base mat of Fukushima Daini Unit 1

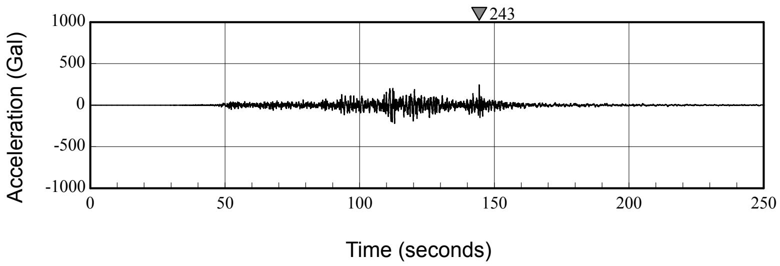


Figure 1-8 : Acceleration transient wave form (NS direction) at R/B base mat of Fukushima Daini Unit 2

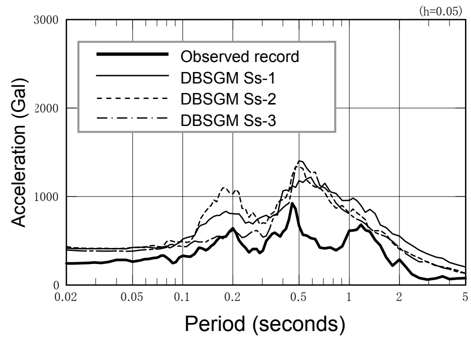


Figure 2-8 : Response spectrum (NS direction) at R/B base mat of Fukushima Daini Unit 2

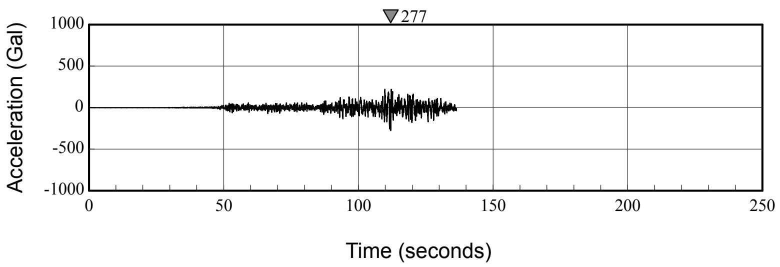


Figure 1-9 : Acceleration transient wave form (NS direction) at R/B base mat of Fukushima Daiichi Unit 3

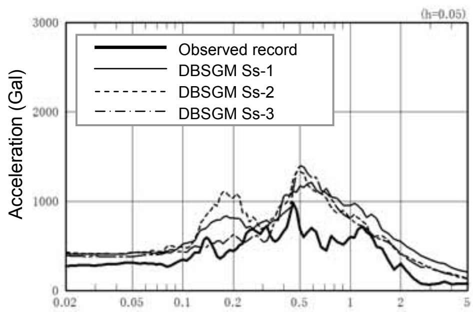


Figure 2-9 : Response spectrum (NS direction) at R/B base mat of Fukushima Daini Unit 3

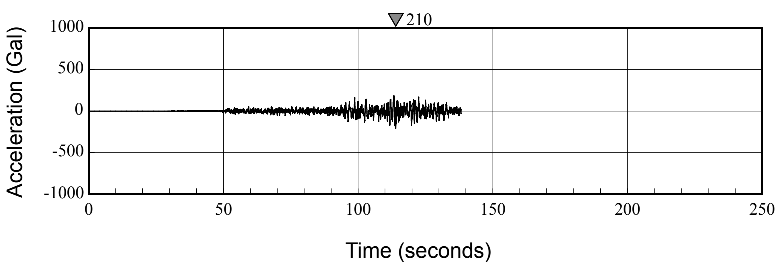


Figure 1-10 : Acceleration transient wave form (NS direction) at R/Bg base mat of Fukushima Daini Unit 4

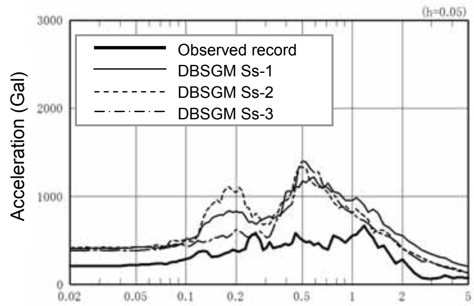


Figure 2-10 : Response spectrum (NS direction) at R/B base mat of Fukushima Daini Unit 4

* The table illustrates examples of the larger direction on the horizontal plane (Fukushima Daini: NS direction)

Stripped Wave Analysis of Seismic Observation records from Fukushima Daini Nuclear Power Station

The base model for stripped wave analysis is estimated by making use of the observation records obtained from this earthquake, the stripped wave analysis conducted using this ground model, seismic motion evaluated for the free surface of the base stratum, and then it is compared to the design basis seismic ground motion Ss.

1. Stripped wave ground model

Reverse analysis is carried out on the transfer function calculated from the records obtained from this earthquake, and the ground model is estimated for the stripped wave analysis. The transfer function evaluated using the observation records is shown in Figure 1. As it is conceivable from this data that there is no great difference between the transfer function from the NS and EW directions, investigations are carried out on the average NS and EW transfer functions for the horizontal direction.

1) Identification analysis method

- By conducting reverse analysis of the ground transfer function recorded in the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake employing theoretical ground transfer characteristics based on the one-dimensional wave motion theorem which hypothesizes vertical incidence of the S wave, optimized examination of the ground model is implemented for each of the horizontal direction and the vertical direction.
- The initial model is set taking into account the results of PS logging, and all strata are identified as the ideal S wave velocity or P wave velocity and damping ratio.
- The scope of searching for S wave velocity and P wave velocity is set at 0.8 to1.2 times the initial model. The scope for O.P.+12.2m - O.P.+8.2 is set to 0.25 to 1.2 times the initial model.
- Formula (1) frequency dependent function form is applied to the damping ratio h(f), the upper limit value of h(f) is set to 1 and lower limit value is set to 0, and the search range of h_0 and α are both set to 0-1.

$$h(f) = h_{01} \times f^{-\alpha} \quad 0 \leqq h(f) \leqq 1 \qquad \cdots (1)$$

- GA (genetic algorithm) is used for the reverse analysis, and the parameters are set to population 20, generation number 100, crossover probability 0.75, and the mutation rate is set to 1/(2 x gene length). The initial random number is changed ten times and trial calculations carried out, and after checking the convergent to the solution, the ground model adopted is the one to which the minimal error is obtained.

2) Identification results

The ground model as estimated using the free base records is shown together with the initial model and scope of search in Table 1 and Figure 2, whereas a comparison of the transfer function estimated from the ground model and the transfer function according to observation records is shown in Figure 3. When the records from the deepest location of the seismometer (O.P.-200m) is inputted into the estimated ground model, the response spectrum for near the ground surface (O.P.+10.2m) which is as shown in Figure 4, is a close match to the response spectrum calculated from the seismic observation records obtained from the said location, and therefore the estimated ground model is believed to be appropriate.

The relationship of the above with the ground model for stripped wave analysis used in the seismic safety assessment for existing nuclear reactor facilities when the "Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities" was revised before the Tohoku Earthquake is shown in Reference 1.

2. Stripped Wave Analysis

Stripped wave analysis of the records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake is conducted using the ground model, and an evaluation of the seismic motion of the free surface of the base stratum (O.P.-168m) is made. The observation records used are the records of a location at O.P.-200m near the free surface of the base stratum.

Figure 5 shows a comparison of the acceleration transient wave forms for the free surface of the base stratum calculated by the stripped wave analysis with the observation records at a location O.P.-200.0ms. Furthermore, a comparison of pseudo velocity response spectrum with the design basis seismic ground motion Ss is shown in Figure 6.

From the above, it is confirmed that the level of the seismic motion of the free surface of the base stratum is around the same level as the design basis seismic ground motion Ss.

3. Conclusion

Through investigations using the seismic observation records, the seismic motion of the Tohoku Earthquake free surface of the base stratum was evaluated and compared to the design basis seismic ground motion Ss. As the result of the examination, it is believed that the free surface of the base stratum seismic motion and the design basis seismic ground motion Ss are approximately the same level.

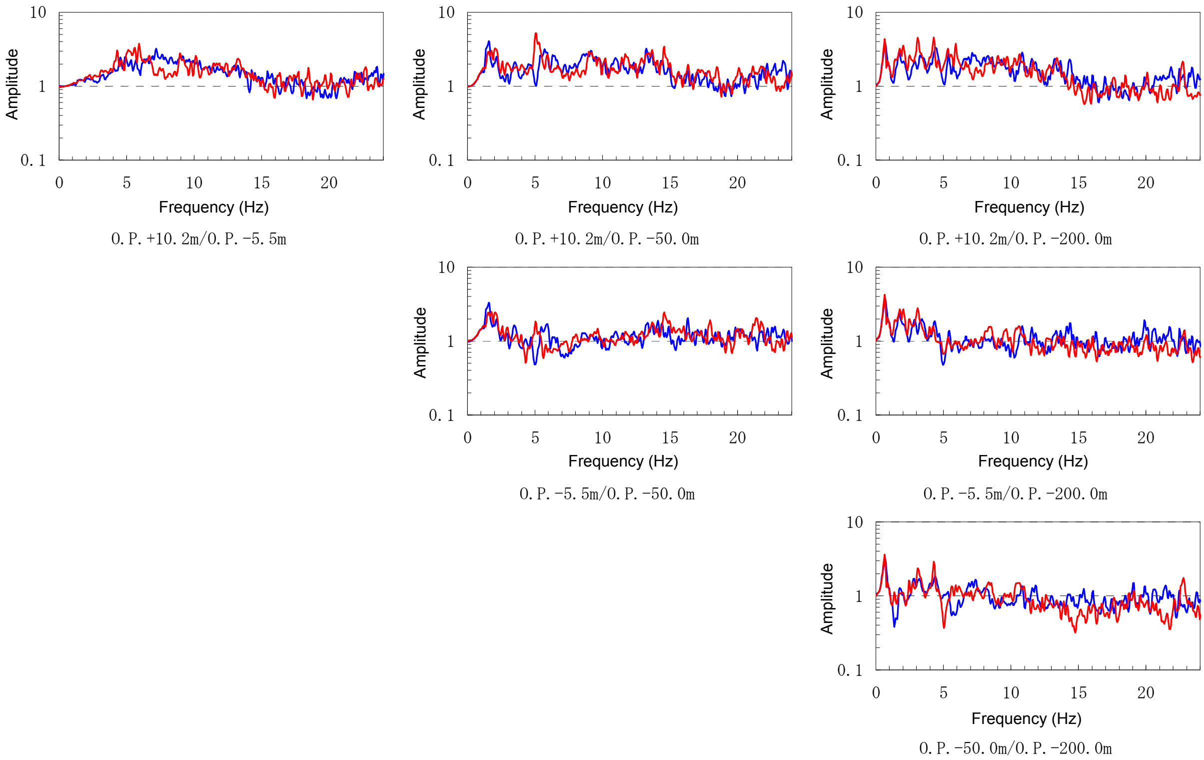


Fig. 1 comparison of NS direction (blue) / EW (red) direction transfer function (amplitude spectrum)

Table 1 - (1) Fukushima Daini, free base, ground model for horizontal direction

fixed parameters			initial model	scope of search						identification results		
O.P.	layer thickness	density	S wave velocity	S wave velocity (m/s)		damping $h(f)=h_0 \times f^{-\alpha}$				S wave velocity	damping $h(f)=h_0 \times f^{-\alpha}$	
						h_0		α				
(m)	(m)	(g/cm^3)	(m/s)	lower end	upper end	lower end	upper end	lower end	upper end	(m/s)	h_0	α
+12.2	● 2.0	1.65	350	88	420	0	1	0	1	237	0.307	0.00
+10.2	2.0	1.65										
+8.2	13.7	1.67	470	376	564	0	1	0	1	456	0.457	1.00
-5.5	● 5.3	1.67										
-10.8	28.0	1.70										
-38.8	11.2	1.73	530	424	636	0	1	0	1	514	0.063	0.72
-50.0	● 42.8	1.73										
-92.8	65.0	1.73										
-157.8	10.2	1.73	810	648	972					786		
-168.0	32.0	1.73										
-200.0	● —	1.73										

● : Seismometer

* : Fixed parameters are according to PS logging results.

Table 1 - (2) Fukushima Daini, free base, ground model for vertical direction

fixed parameters			initial model	scope of search						identification results		
O.P. (m)	layer thickness (m)	density (g/cm³)	S wave velocity (m/s)	S wave velocity (m/s) lower end	S wave velocity (m/s) upper end	damping $h(f)=h_0 \times f^{-\alpha}$ h_0 lower end	h_0 upper end	α lower end	α upper end	S wave velocity (m/s)	damping $h(f)=h_0 \times f^{-\alpha}$ h_0	α
+12.2 ●	2.0	1.65	890	223	1068	0	1	0	1	330	0.376	0.00
+10.2	2.0	1.65										
+8.2	13.7	1.67	1620	1296	1944	0	1	0	1	1655	1.000	0.98
-5.5 ●	5.3	1.67										
-10.8	28.0	1.70										
-38.8	11.2	1.73	1800	1440	2160	0	1	0	1	1833	0.261	1.00
-50.0 ●	42.8	1.73										
-92.8	65.0	1.73	1880	1504	2256					1914		
-157.8	10.2	1.73	1950	1560	2340					1985		
-168.0	32.0	1.73										
-200.0 ●	—	1.73										

● : Seismometer

* : Fixed parameters are according to PS logging results.

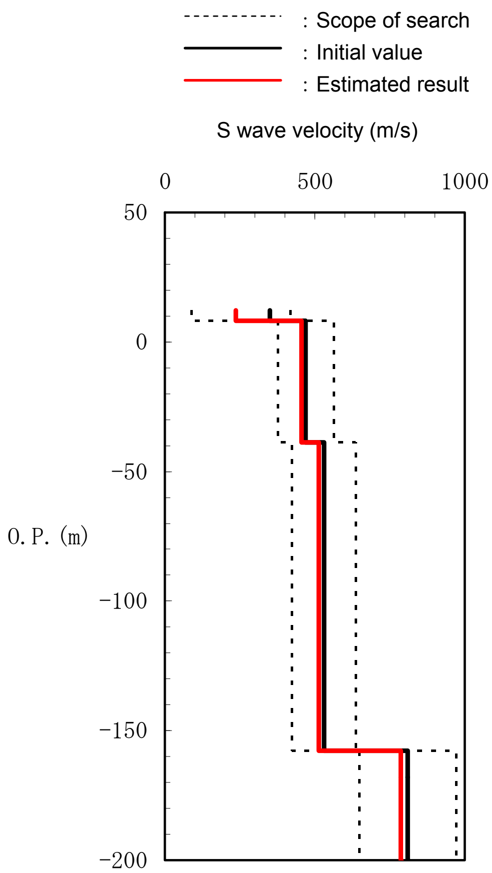


Table 2 - (1) Scope of search and estimated result
(Fukushima Daini, free base, horizontal direction)

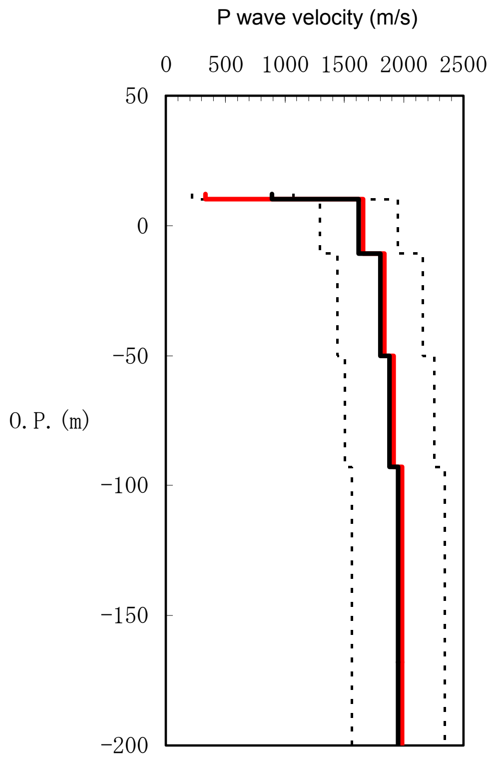
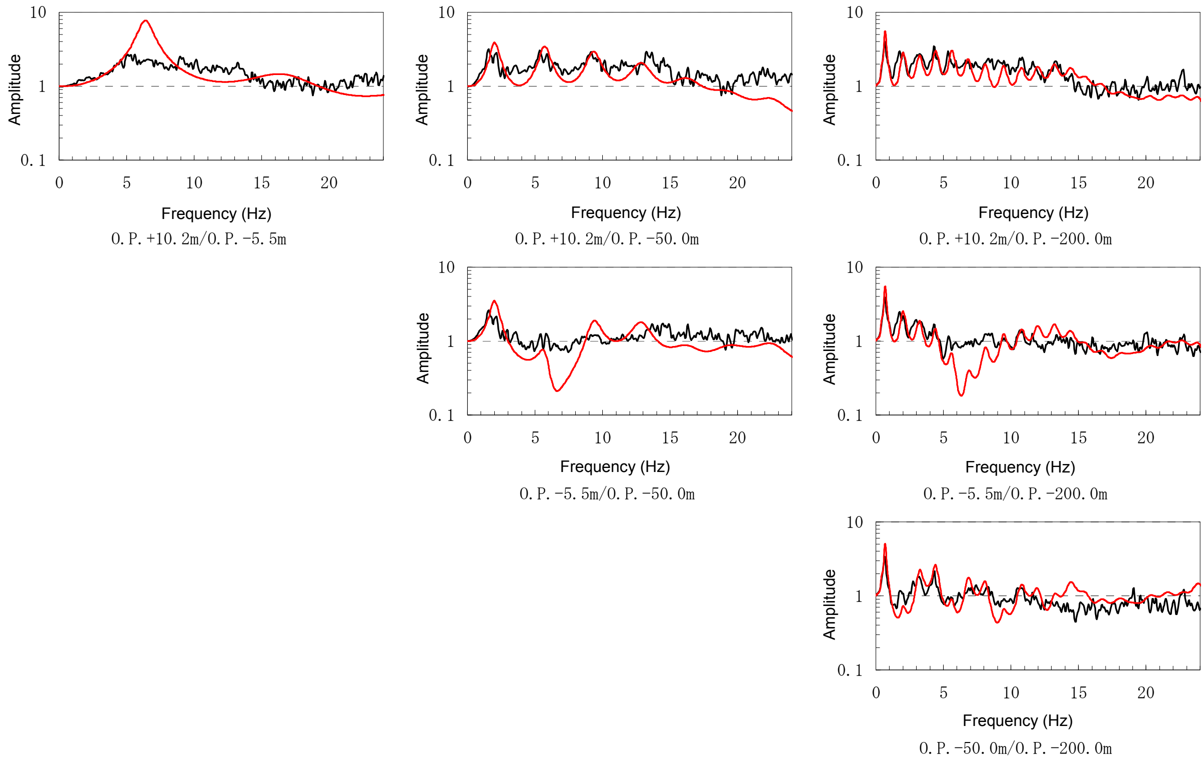
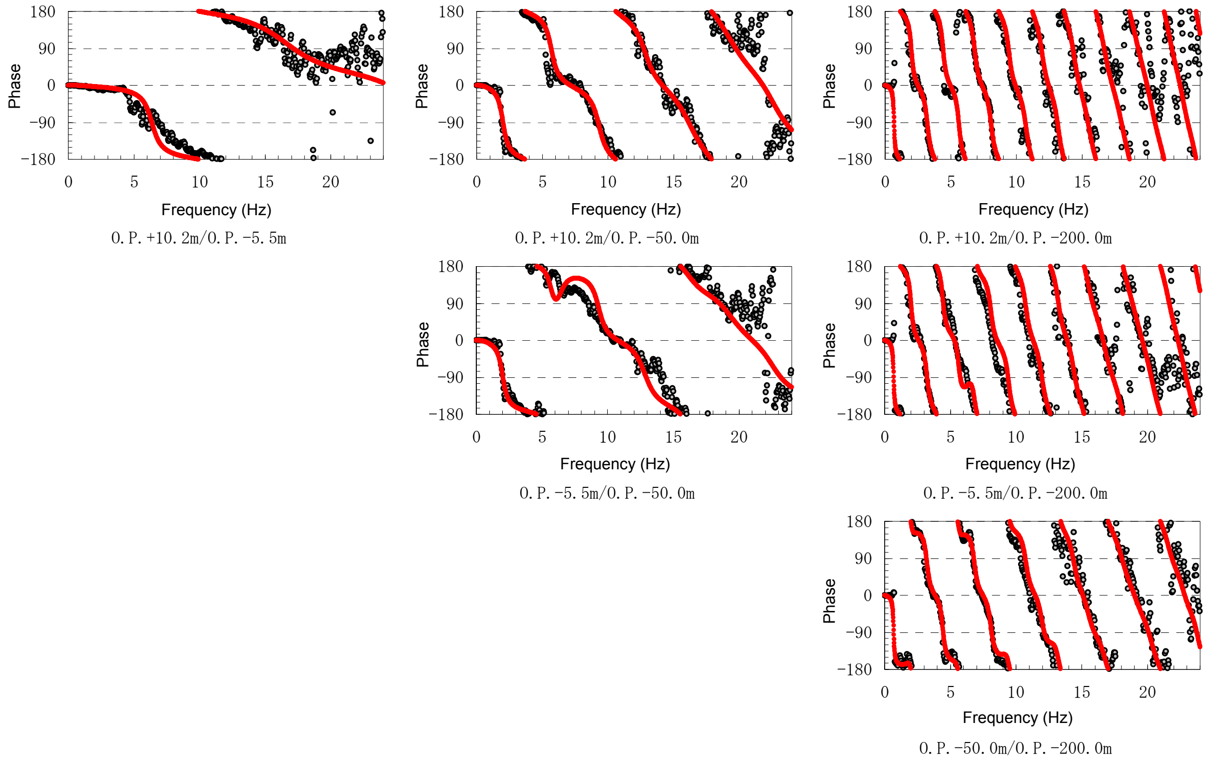


Fig. 2 - 2 Scope of search and estimated result
(Fukushima Daini, free base, vertical direction)

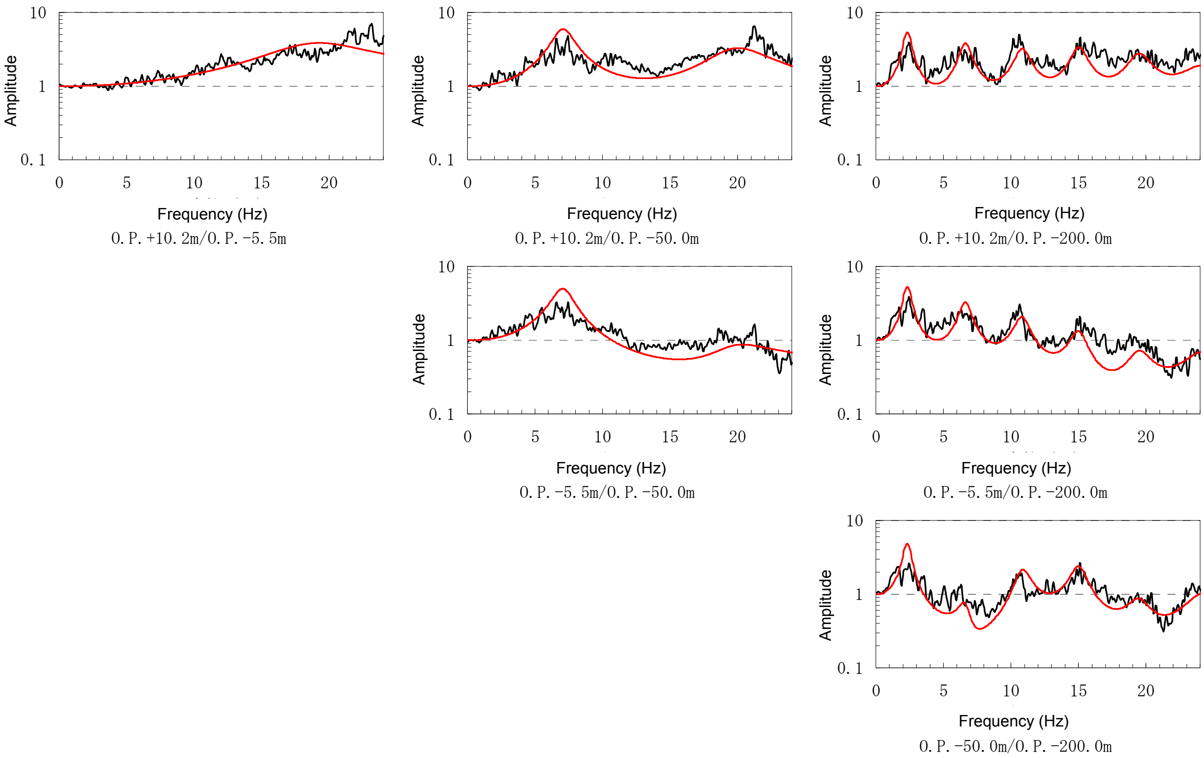


a. Amplitude spectrum

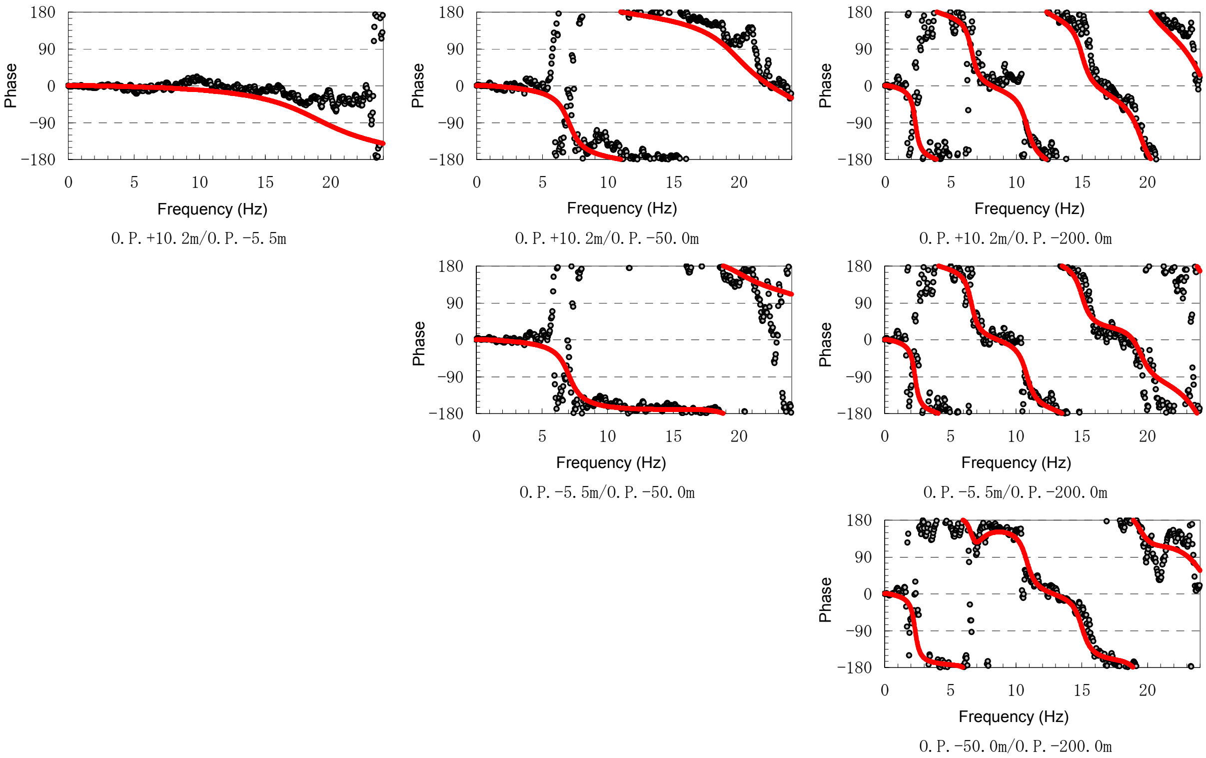


b. Phase spectrum

Fig. 3 (1) Fukushima Daini, free base, transfer function of estimated ground model for the horizontal direction and transfer function according to observation records



a. Amplitude spectrum



b. Phase spectrum

Fig. 3 - (2) Fukushima Daini, free base, transfer function of estimated ground model for vertical direction and transfer function according to observation records

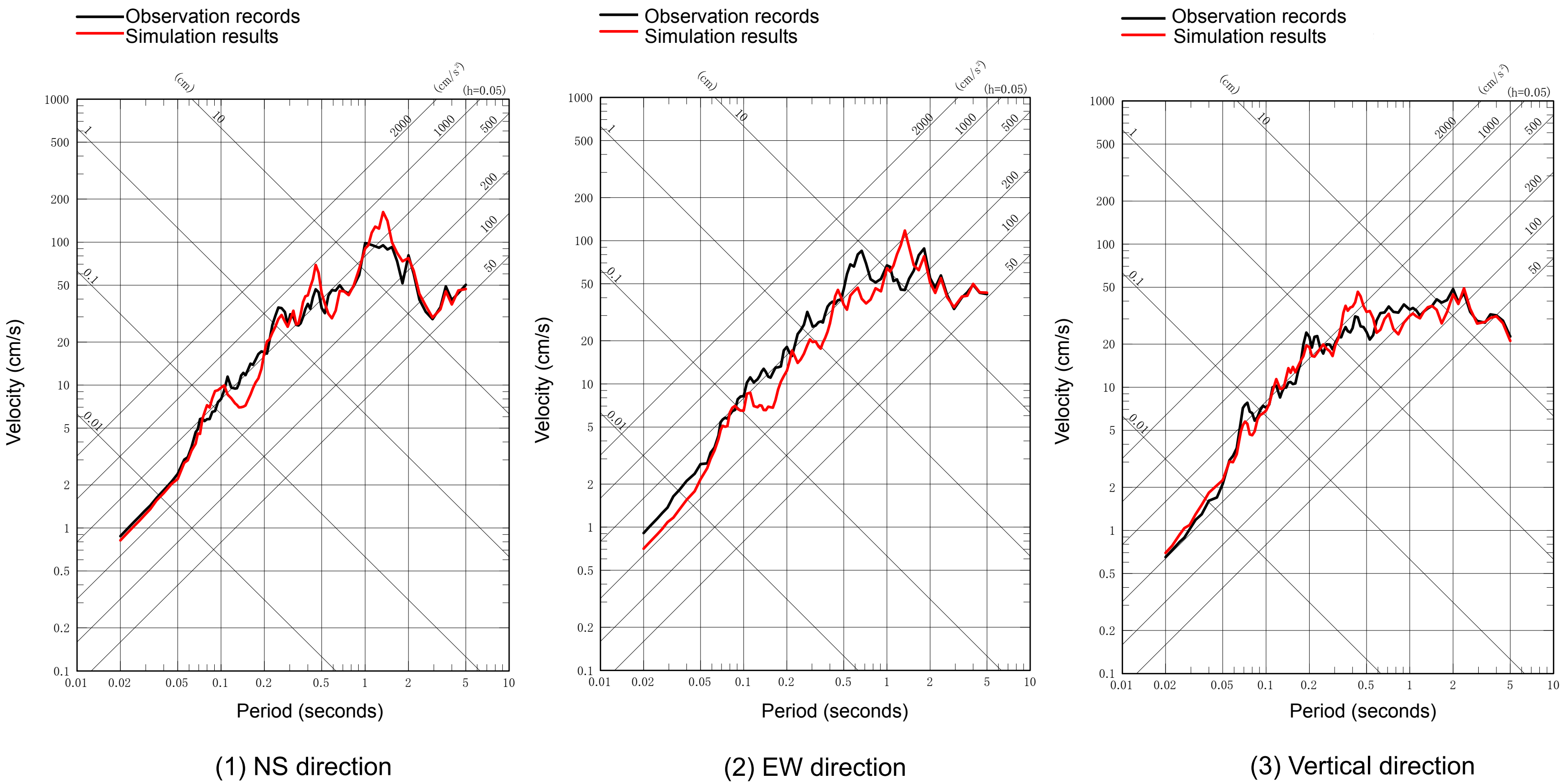
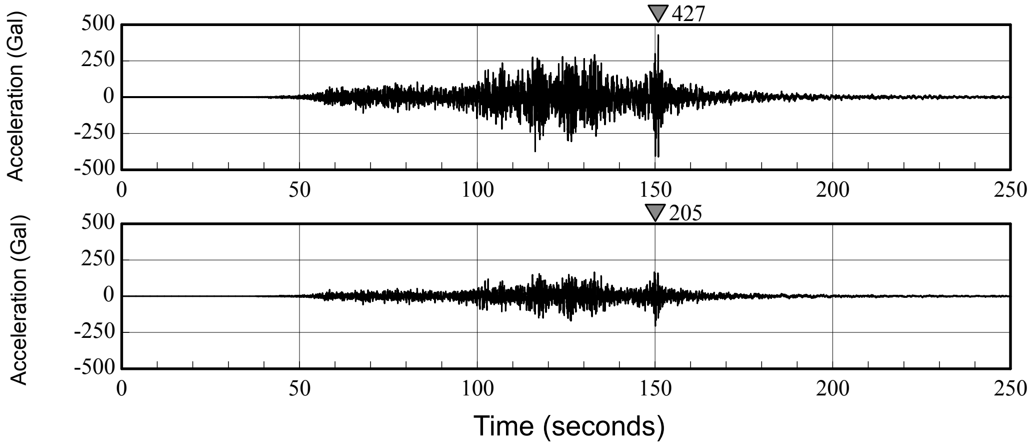
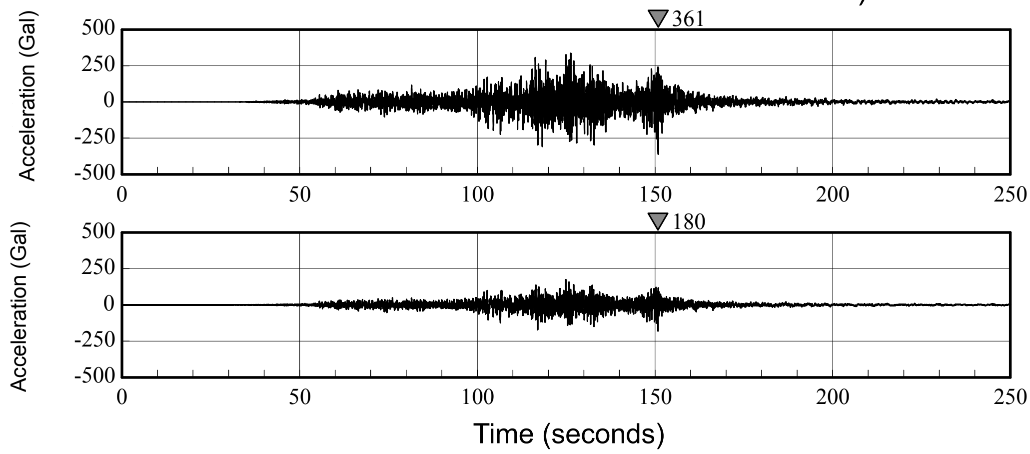


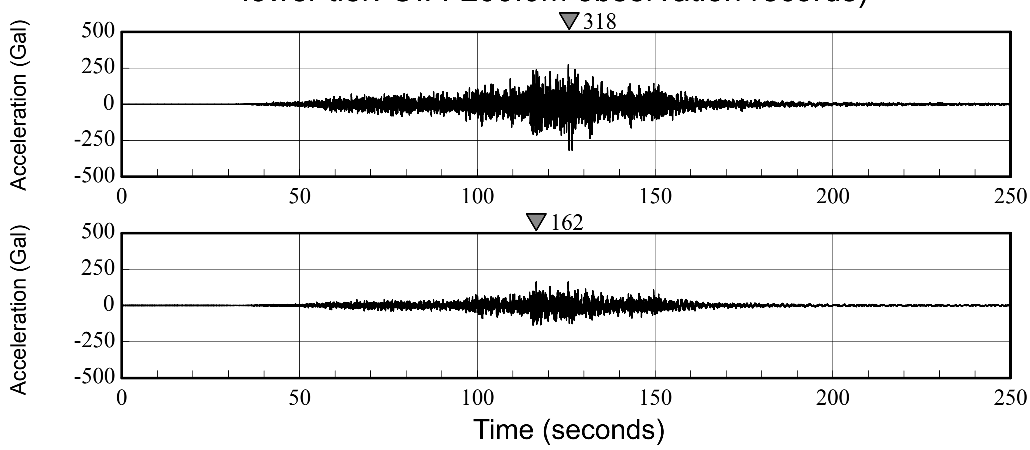
Fig. 4 ground response simulation results (Fukushima Daini, free base, O.P.-200m to O.P.-5.5m)



(a) NS direction (upper tier: stripped wave analysis result,
lower tier: O.P.-200.0m observation records)



(b) EW direction (upper tier: stripped wave analysis result,
lower tier: O.P.-200.0m observation records)



(c) Vertical direction (upper tier: stripped wave analysis result,
lower tier: O.P.-200.0m observation records)

Fig. 5 Transient wave form (free base) according to stripped wave analysis

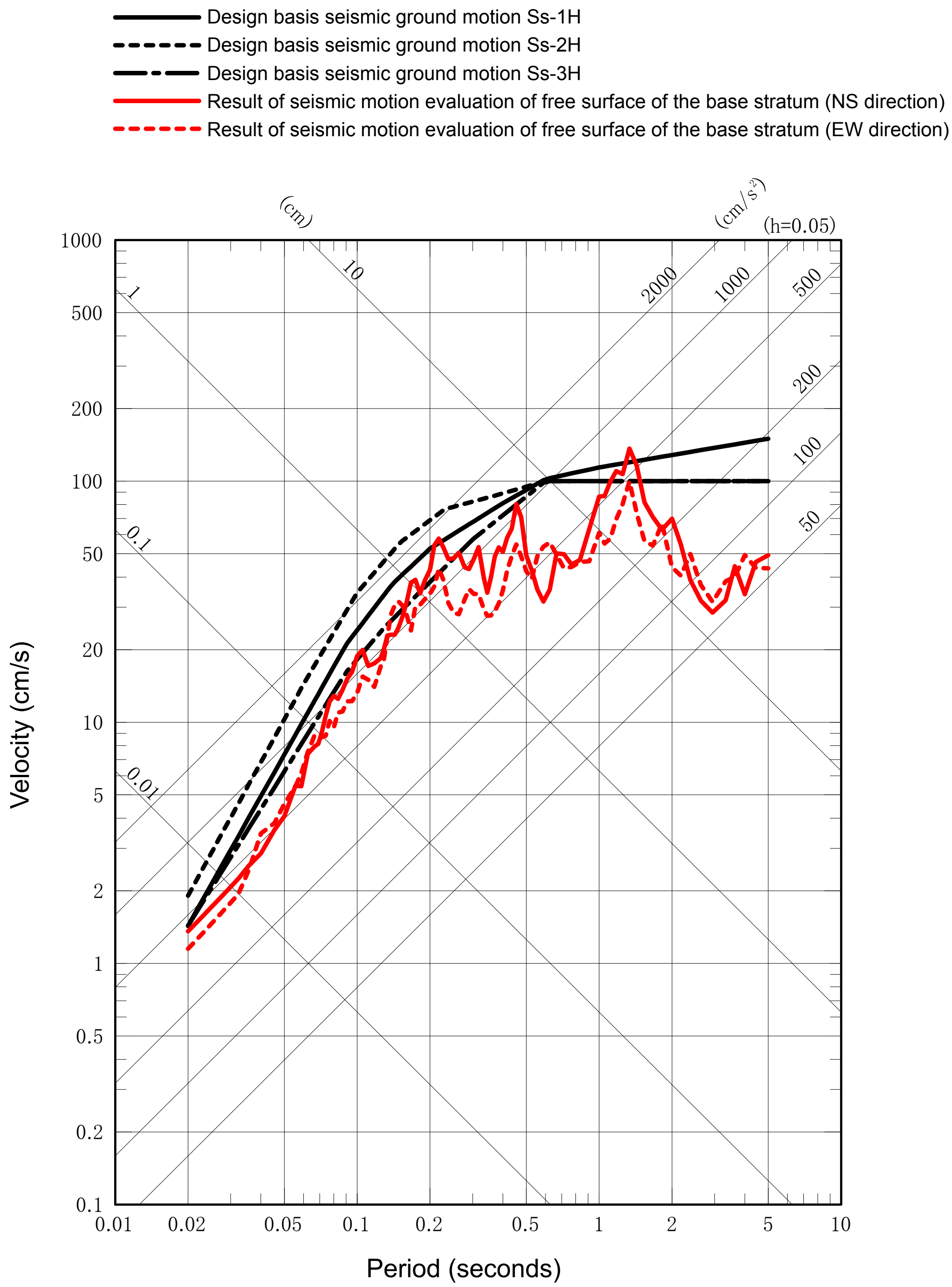


Fig. 6 - (1) Comparison of seismic ground motion evaluation of free surface of the base stratum by stripped wave analysis with design basis seismic ground motion Ss (horizontal direction)

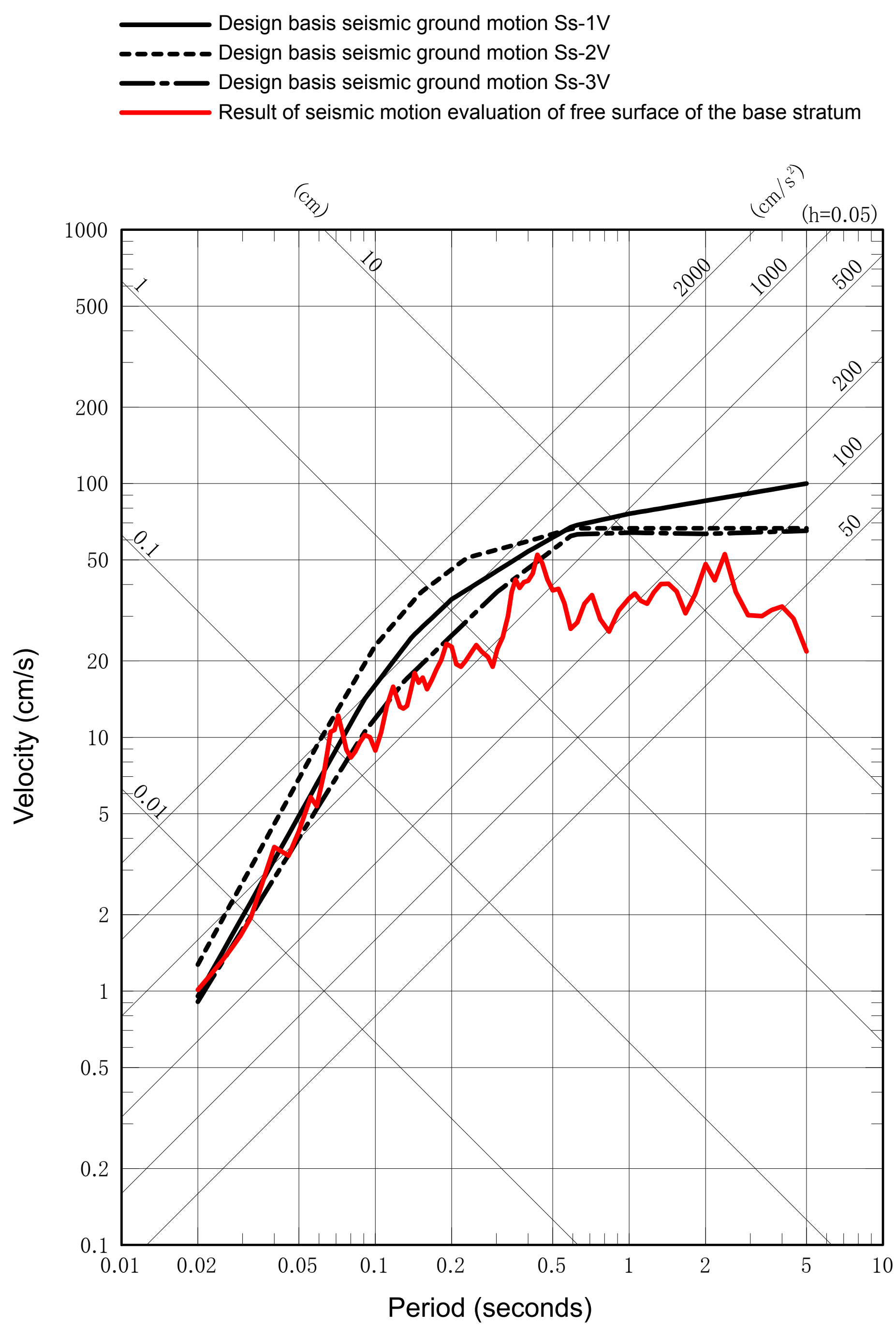


Fig. 6 - (2) Comparison of seismic ground motion evaluation of free surface of the base stratum by stripped wave analysis with design basis seismic ground motion Ss (vertical direction)

(4) Tsunami fault model of the Tohoku-Chihou-Taiheyo-Oki Earthquake
(Comparison between the calculated waveform and observed waveform of tsunami)

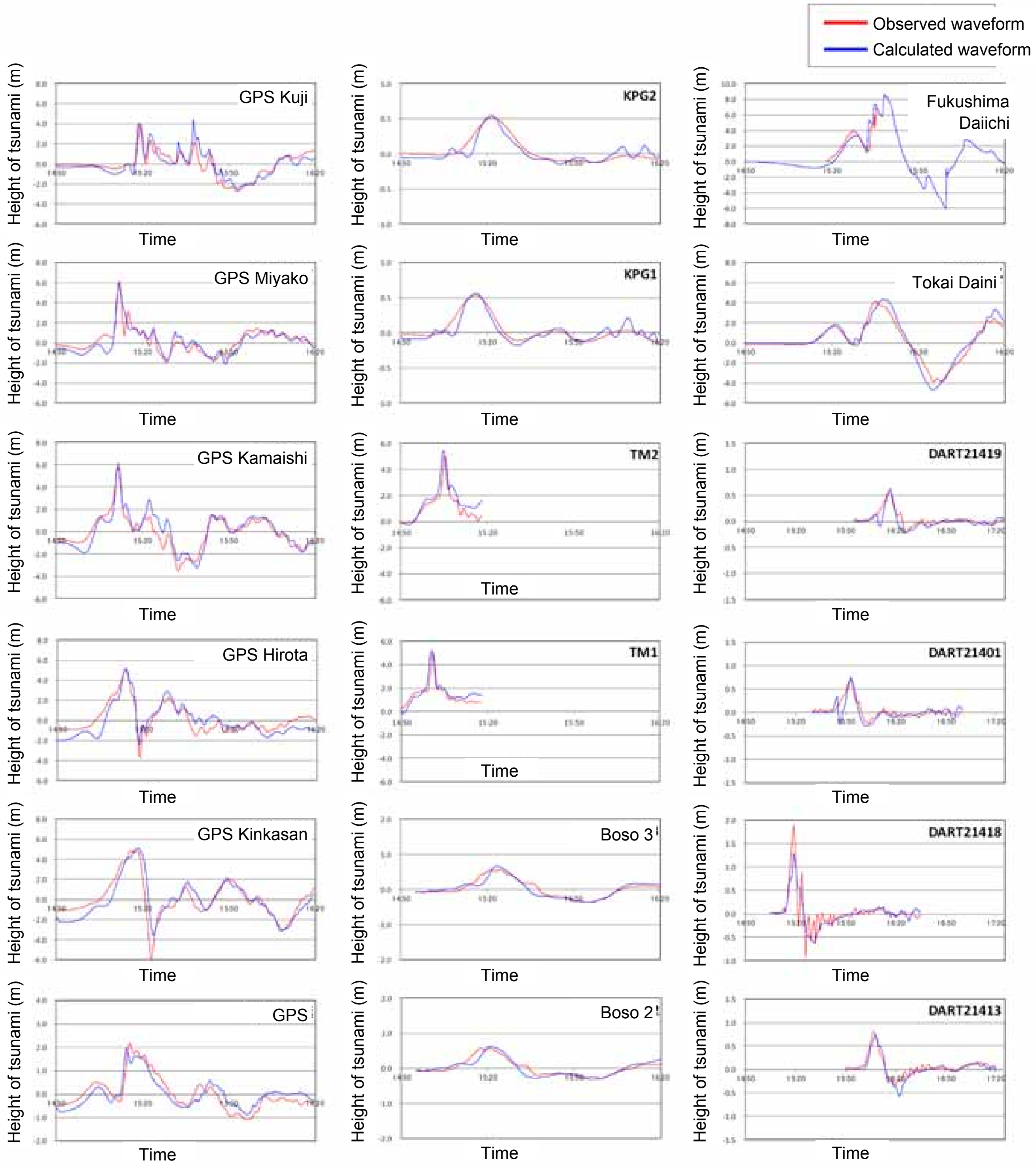
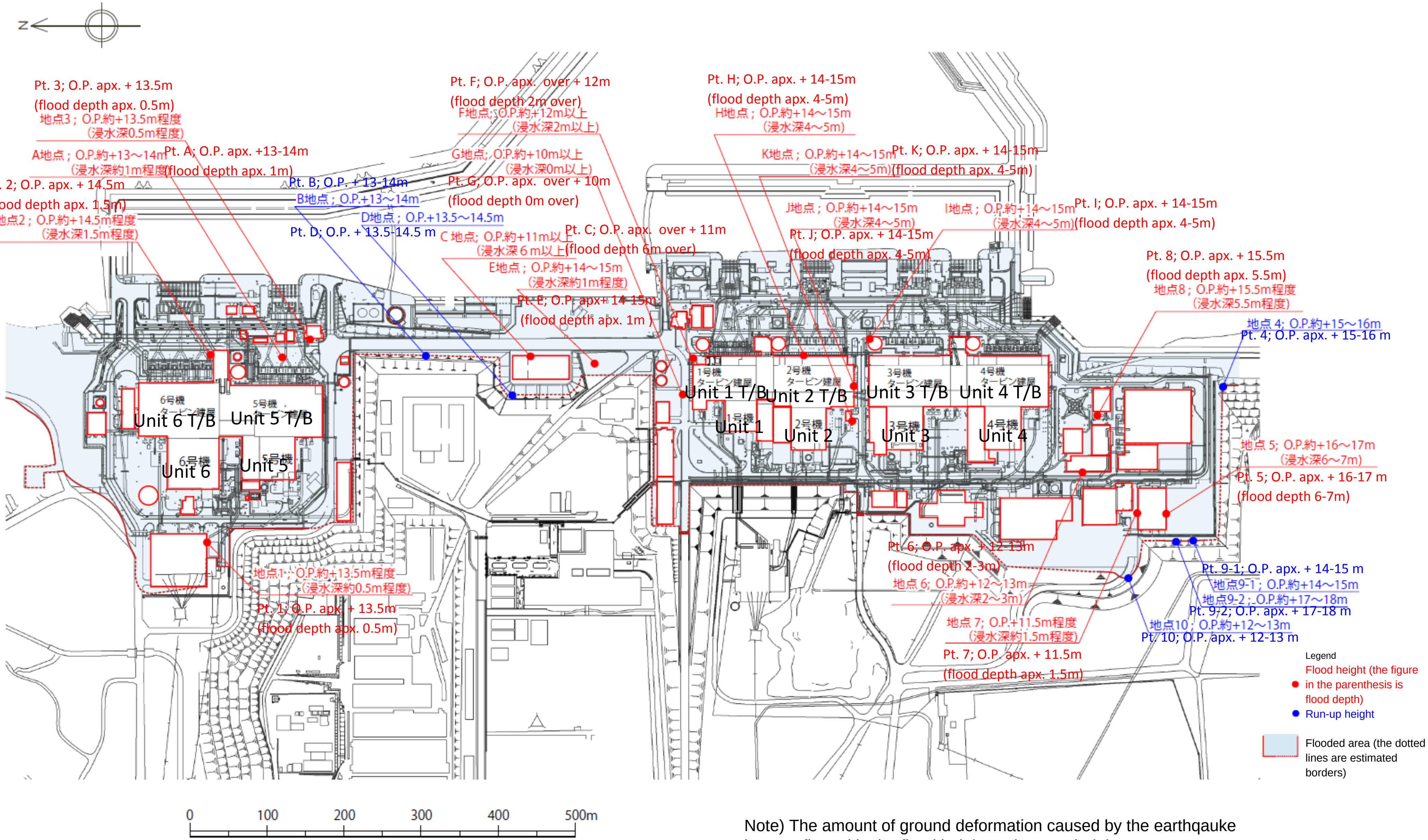


Fig. 5 Comparison between the calculated waveform and observed waveform of tsunami

Source: 12th Examination Committee on the Massive Earthquake Model of the Nankai Trough (March 1, 2012)
Reference material 1 "Tsunami fault model of the 2011 Tohoku-Chihou-Taiheyo-Oki Earthquake"

Tsunami investigation results at the Fukushima Daiichi Nuclear Power Station (Flood height, Flood depth and Flooded area)



Note) The amount of ground deformation caused by the earthqauke is not reflected in the flood height and run-up height.

Attachment 3-7

Outdoor flooding state at the Fukushima Daiichi Nuclear Power Station (March 11)

<Around the central radioactive waste treatment building at south-side of Unit 4: Ground level O.P. +10m, Heavy fuel oil tank height approximately 5.5m>

Right after flooding: 0 sec.

After 6 sec.

After 46 sec.

After 56 sec.

After 74 sec.

After 98 sec.

Note) The elapsed time is according to the built-in clock of the camera (the time of photography is not provided since there are errors of measurement).

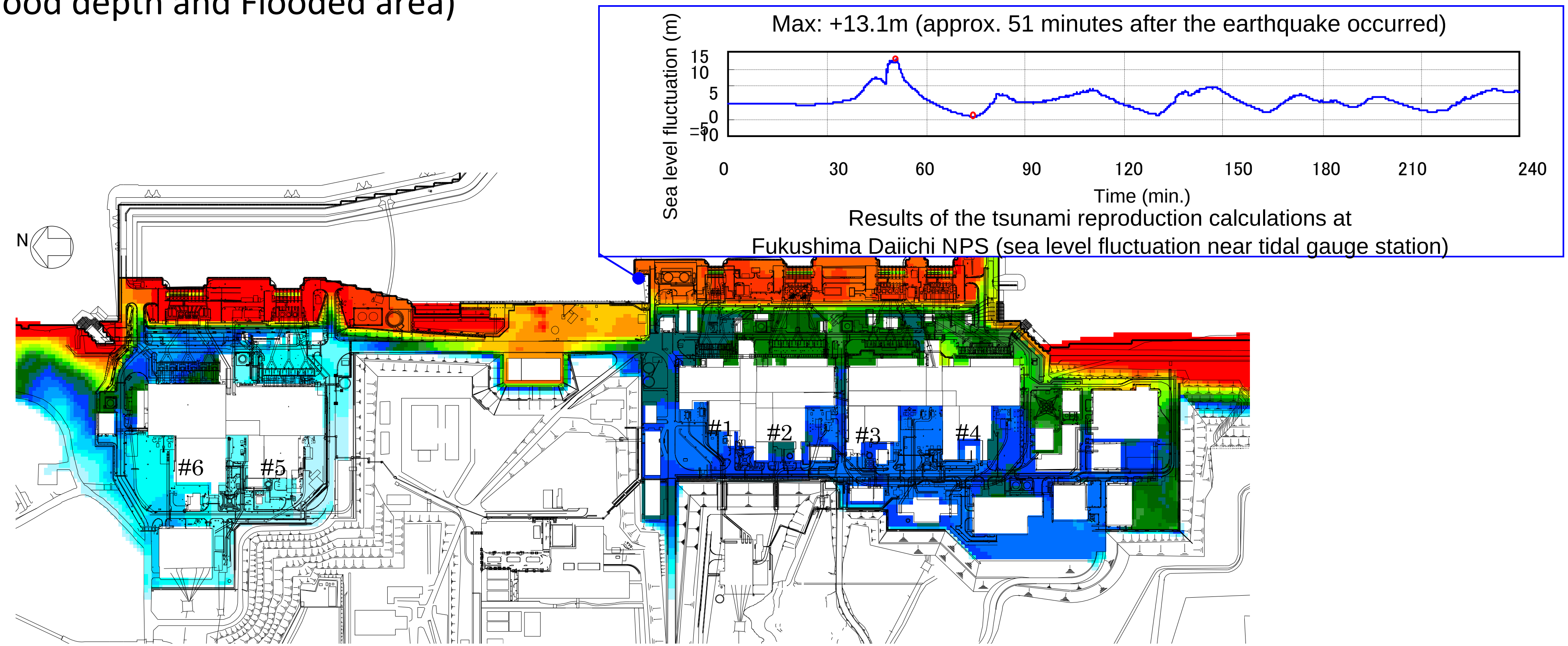
Attachment 3-8

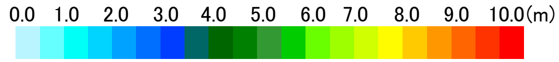
State of the tsunami that hit the Fukushima Daiichi Nuclear Power Station

<Ocean side of Fukushima Daiichi Nuclear Power Station Units 5 and 6 (east side of solid waste storage)

Attachment 3-9

Results of the tsunami reproduction calculations at the Fukushima Daiichi Nuclear Power Station
(Flood depth and Flooded area)



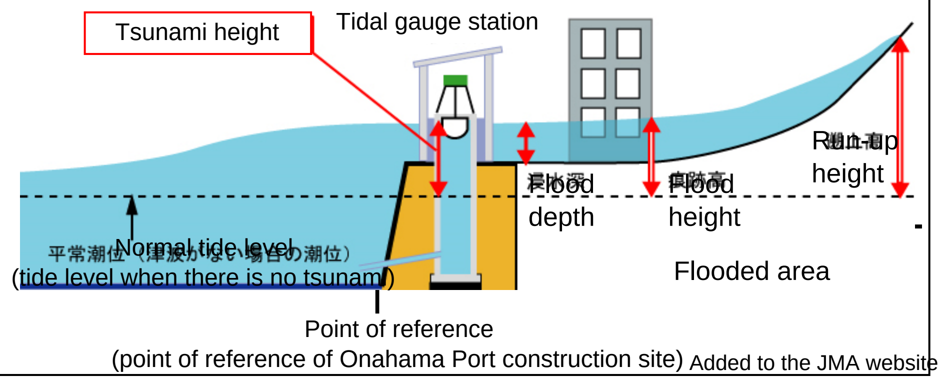


Note) Calculation results with 1.23 times the slippage of the wide reproduction model

Definitions

- -Tsunami height: Difference between the normal tidal level (tidal level when there is no tsunami) and the sea level elevated due to tsunami.
- -Flood height: Height from the point of reference to the traces of color affected areas or debris left in the building and facility (displayed in O.P.*).
- -Flood depth: Height from the ground to color affected areas or debris left in the building and facility.
- -Flooded area: Area flooded by tsunami.
- -Run-up height: Height from the point of refernce to the color affected areas or debris left on the slope or roads after the tsunami traveled inland (O.P. display*).

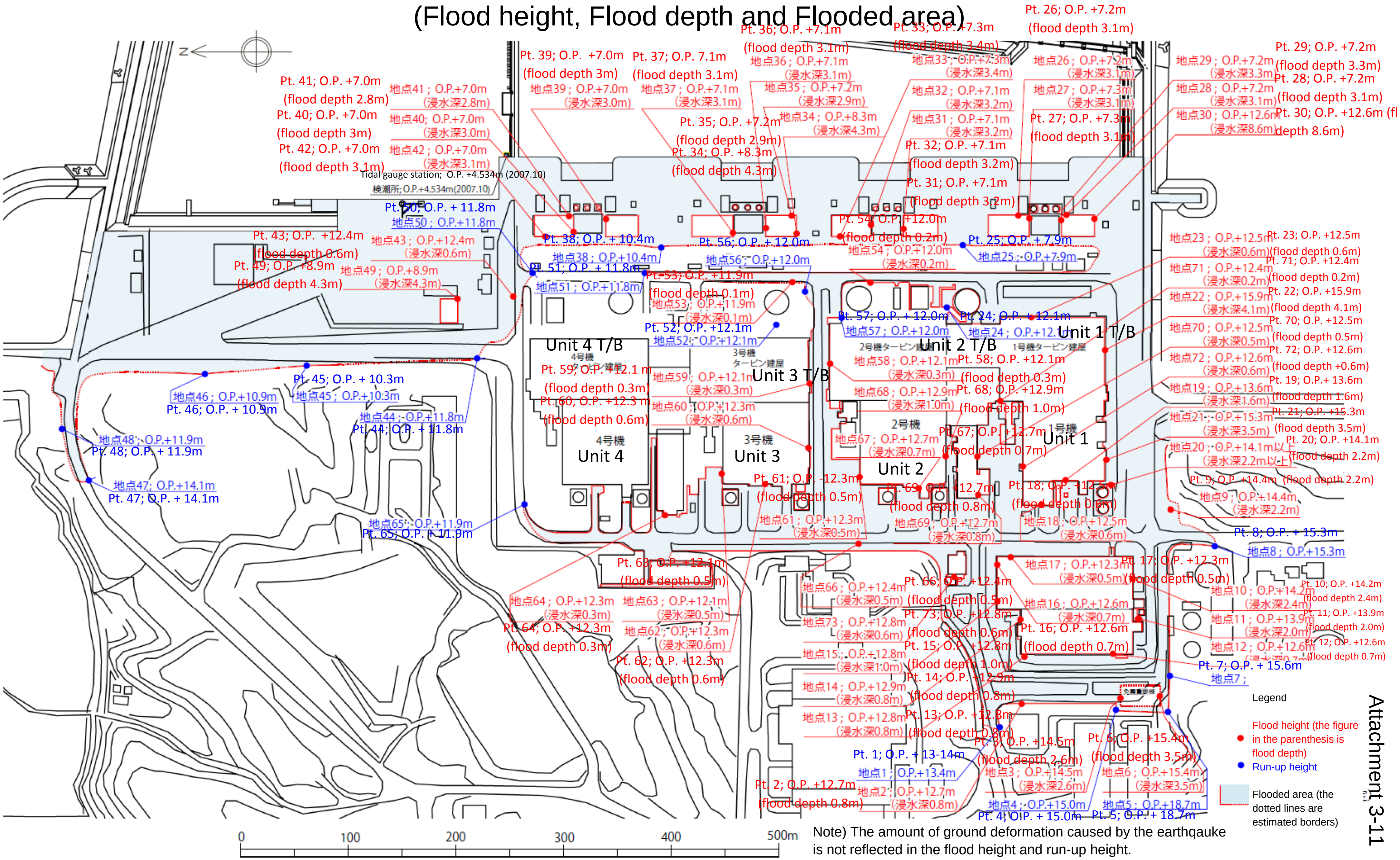
*The point of reference of the Onahama Port construction site (O.P.) is 0.727m lower than the mid-sea level of Tokyo Bay (T.P.).



Added to the JMA website

Attachment 3-10

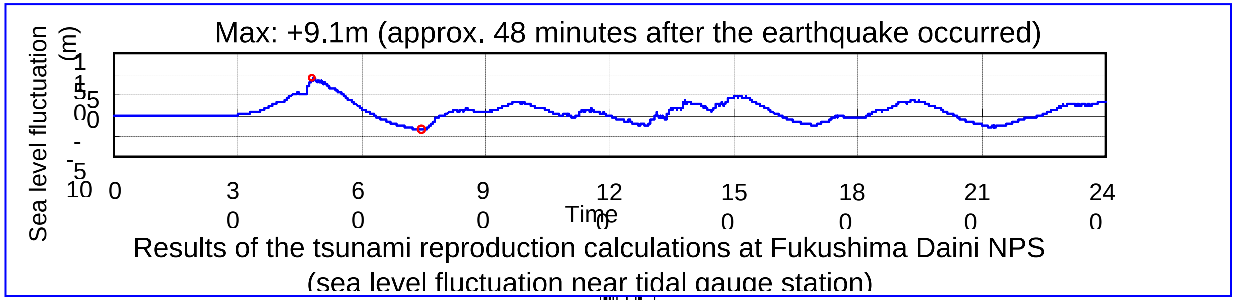
Tsunami investigation results at the Fukushima Daini Nuclear Power Station
(Flood height, Flood depth and Flooded area)

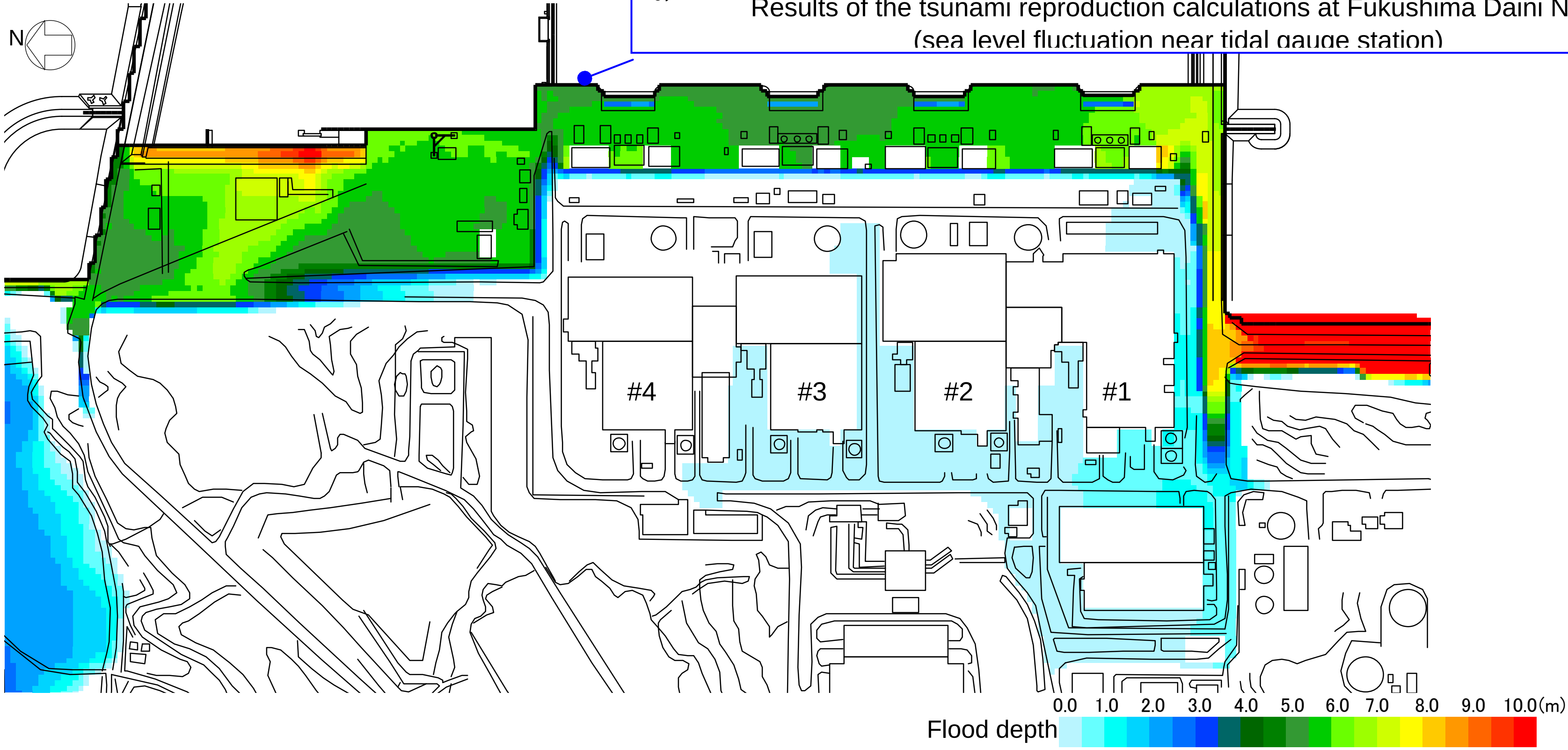


Note) The amount of ground deformation caused by the earthqauke is not reflected in the flood height and run-up height.

Attachment 3-11

Results of the tsunami reproduction calculations at the Fukushima Daini Nuclear Power Station (Flood depth and Flooded area)





Definitions

-Tsunami height: Difference between the normal tidal level (tidal level when there is no tsunami) and the sea level elevated due to tsunami.

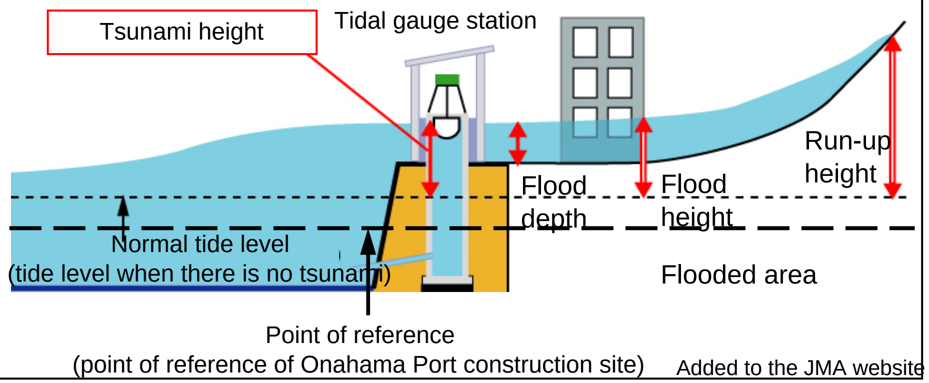
-Flood height: Height from the point of reference to the traces of darkened areas or debris left in the building and facility (displayed in O.P.*).

-Flood depth: Height from the ground to darkened areas or debris left in the building and facility.

-Flooded area: Area flooded by tsunami.

-Run-up height: Height from the point of refernce to the darkened areas or debris left on the slope or roads after the tsunami traveled inland (O.P. display*).

*The point of reference of the Onahama Port construction site (O.P.) is 0.727m lower than the mid-sea level of Tokyo Bay (T.P.).



Added to the JMA website

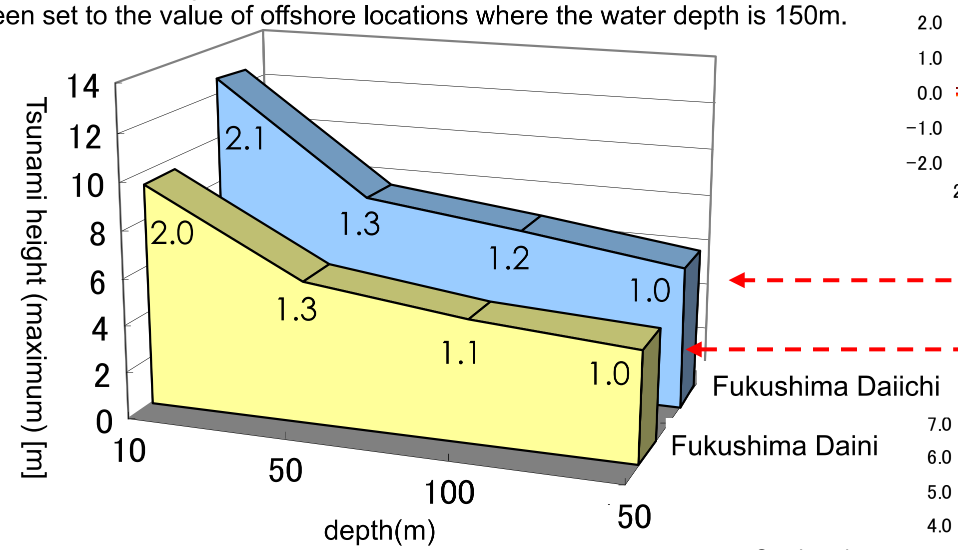
Attachment 3-12

Analysis of Disparity between Tsunami at Fukushima Daiichi and Fukushima Daini

Wave form chronology at locations of water depth of 150m off the coast of Fukushima Daiichi Nuclear Power Station

- There is no great difference of tsunami height from each of the blocks at the depth of 150m between the two power stations.
- Because the degree of overlap of the peaks of the wave forms from each block is large, the tsunami is also large.
- There is no difference of amplification factor between the two power stations at a depth of 150m or less.

The values in the graph show the amplification factor whereas the base has been set to the value of offshore locations where the water depth is 150m.

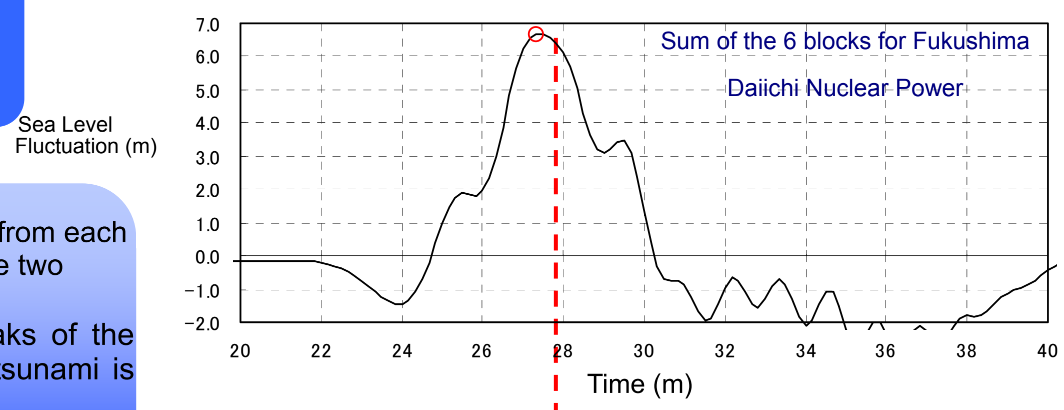


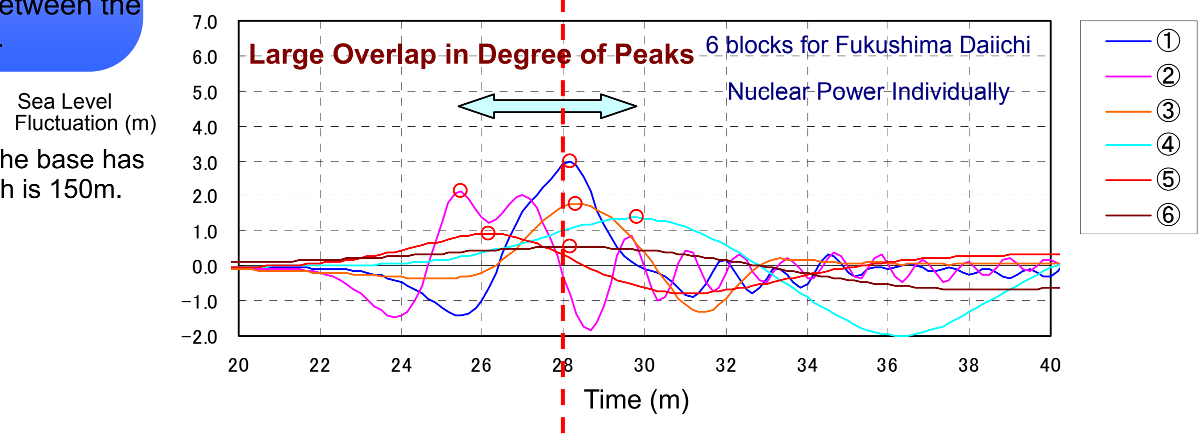
※Result of general wide-area simulation model

- There is no great difference of tsunami height from each of the blocks at the depth of 150m between the two power stations.
- Because the degree of overlap of the peaks of the wave forms from each block is small, the tsunami is also small.
- There is no difference of amplification factor between the two power stations at a depth of 150m or less.

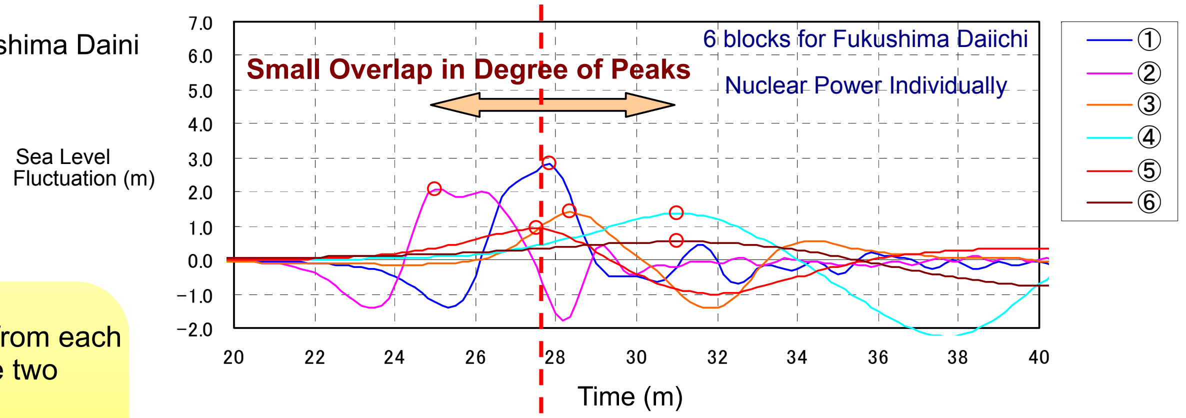
Wave form chronology at locations of water depth of 150m off the coast of Fukushima Daini Nuclear Power Station

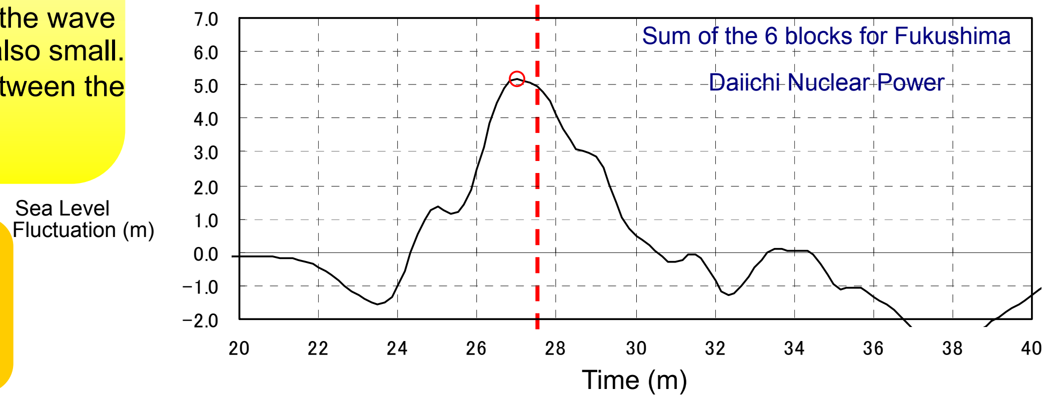
Result of extraction of the main components (blocks)





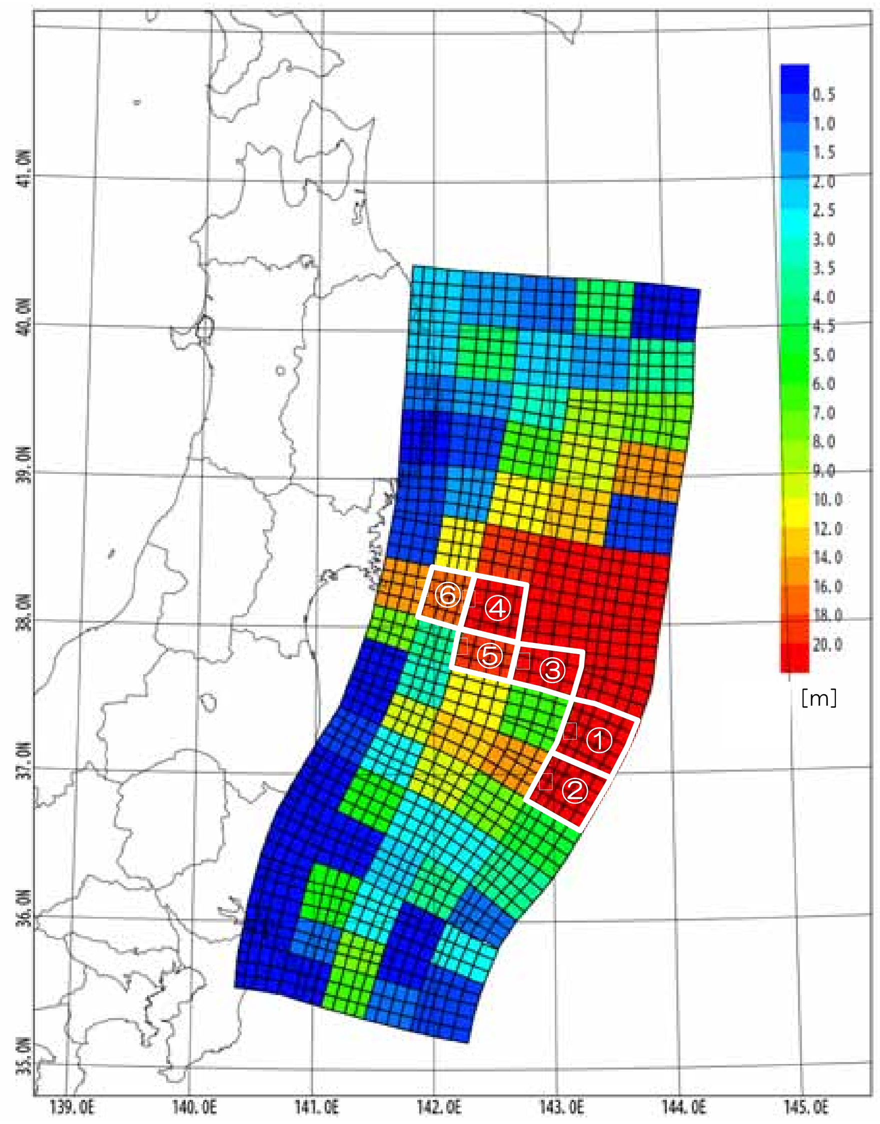
The general differences can more or less be explained by the sum of the 6 blocks.





※ Time shows the elapsed time from the earthquake

Broken down by blocks offshore from the two power stations where the tsunami height of the presumed wave source model had major impact



Analysis was carried out using the tsunami wave source model that most easily explains the flooding height, runup height, flood area, tide measurement records, and crustal changes over a wide area (from Hokkaido to Chiba Prefecture).

Summary

The main factor behind the difference of the tsunami at Fukushima Daiichi and Fukushima Daini is thought to be that the degree of overlap of the peaks of the tsunamis generated from the assumed areas, where large coseismic slips have occurred, off the coast of Miyagi Prefecture and off the coast of Fukushima Prefecture was greater at Fukushima Daiichi and lesser at Fukushima Daini.

Main developments regarding the seismic back-check

Government (Nuclear Safety Commission of Japan, Nuclear and Industrial Safety Agency, etc.)	TEPCO

<"Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities> (established in September 1978, partially revised in July 1981)> ↓
September 29, 1995 Nuclear Safety Commission of Japan
It was confirmed that nuclear power stations constructed before the establishment of the Guide met seismic safety standards according to above Guide.

2006

Government

[Establishment of the New Seismic Guidelines]
September 19, 2006 Determined by the Nuclear Safety Commission of Japan
"Regulatory Guide of Reviewing Seismic Design of Nuclear Power Reactor Facilities"

↓

[Instructions for seismic back-checks]
September 20, 2006 Instructed by the Nuclear and Industrial Safety Agency
"Implementing Seismic safety assessments of existing nuclear power reactor facilities following the revision of the Regulatory Guide of Reviewing Seismic Design of Nuclear Power Reactor Facilities"

TEPCO

[Submission of the seismic back-check plan]
October 18, 2006
Submission of the implementation plan for the seismic safety assessment

	Geological survey	Seismic safety assessment
1F	March 2007	June 2009
2F	March 2007	March 2009

July 16, 2007 Niigata-Chuetsu-Oki Earthquake

2007

Government

[Addition of assessment items]
July 20, 2007 Instructed by the Minister of Economy, Trade and Industry
"Measures based on the 2007 Niigata-Chuetsu-Oki Earthquake"

[Addition of assessment items]
December 27, 2007 Nuclear and Industrial Safety Agency
"Report to the Nuclear Safety Commission of Japan on examinations based on the impact of the Niigata-Chuetsu-Oki Earthquake on TEPCO's Kashiwazaki-Kariwa Nuclear Power Station, and notification to nuclear operators of matters that need to be reflected in seismic back-checks (Interim Summary)"

TEPCO

[Submission of the revised seismic back-check plan]
August 20, 2007
Submission of the reviewed implementation plan for the seismic safety assessment

	Geological survey (Interim Report)	Seismic safety assessment
1F	March 2008	June 2009
2F	March 2008	March 2009

2008

Government

[Addition of assessment items]
September 4, 2008 Nuclear and Industrial Safety Agency
"Matters that Need to be Reflected in Evaluations of Seismic Safety of Nuclear Power Stations based on the Niigata-Chuestu-Oki Earthquake"

TEPCO

[Submission of the Interim Report (1F5, 2F4)]
March 31, 2008
Submission of the seismic safety assessment (Interim Report), etc. of representative plants

[Postponement of the seismic back-check plan]
December 8, 2008
Postponement of the seismic safety assessment (implementation date undetermined), implementation of the same assessment as the representative plants (Interim Summary) according to the following schedule

	Interim Summary timing
1F (Units 1-4 and 6)	Scheduled for June 2009
2F (Units 1-3)	Scheduled for March 2009

2009

TEPCO

[Submission of the Interim Report (2F1-3)]
April 3, 2009
Submission of the seismic safety assessment (revised Interim Report), etc. of Fukushima Daini Nuclear Power Station

[Submission of the Interim Report (1F1-4, 1F6)]
June 19, 2009
Submission of the seismic safety assessment results (revised Interim Report), etc. of Fukushima Daiichi Nuclear Power Station

Government

[Assessment of the validity of the Interim Report]
Nuclear and Industrial Safety Agency
July 15, 2009 **Review completed**
July 21, 2009 **Seismic safety assessment judged as valid and disclosed as such**

↓

[Assessment of the validity of the Interim Report]
Nuclear Safety Commission of Japan
November 19, 2009 **Seismic safety assessment judged as valid and disclosed as such**

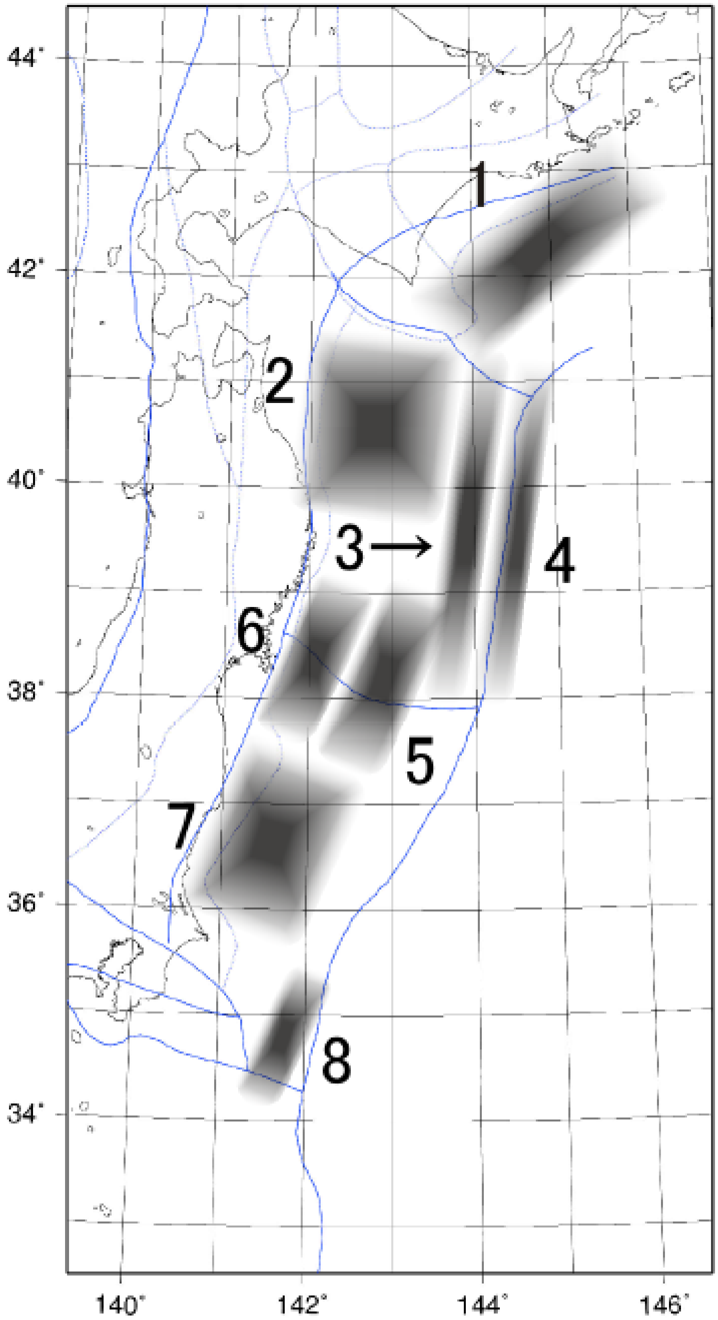
Principle Chronology of Tsunami Safety Assessment

	Principle Chronology	TEPCO's Response
Fukushima Daiichi Nuclear Power Station, 1966 to 1972, Establishment Application and Permit based on the Chilean earthquake, -- Water level: O.P. +3.122m		
February 2002	Japan Society of Civil Engineers (JSCE) publishes “Tsunami Assessment Methodology for Nuclear Power Plants in Japan” (hereafter referred to as “Tsunami Assessment Methodology”)	Safety evaluation carried out based on “Tsunami Assessment Methodology” Required measures such as raising the electric pump, preparations for operating procedures, building water tightness implemented Fukushima Daiichi : Water level : O.P.+5.4m~5.7m
July 2002	The central government's Headquarters for Earthquake Research Promotion (hereinafter referred to as “HERP”) publicly announces long-term evaluation (hereinafter referred to as “Opinion of the HERP”) → JSCE begins consideration of adopting the probabilistic analysis method slated for consideration in 2003. (There is no historical record of tsunami originating from the Japan Trench region off the coast of Fukushima Prefecture. Thus, no wave source model.)	
2003～2005	JSCE considers the probabilistic analysis method	In addition to scrutinizing JSCE's examination, TEPCO also examines the probabilistic analysis method
July2006	JSCE compiles a report on examination results of probabilistic analysis method between 2003 and 2005 ※Thereafter, JSCE continues examination of the probabilistic analysis method.	Using the 2003 to 2005 in-development probabilistic analysis method examination result, trial analysis is conducted and TEPCO announces its report to the 14th International Conference on Nuclear Engineering (ICONE 14).
September 2006	Revision of Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (clarification of language used regarding tsunami safety as the tsunami is a secondary effect of an earthquake) Directive on anti-seismic back-checks	Start of anti-seismic back-checks
July 2007	Niigata-Chuetsu-Oki Earthquake →Response to Niigata-Chuetsu-Oki Earthquake	
March 2008		Submit Interim Report on anti-seismic back-checks (planned evaluation of final report on tsunami)

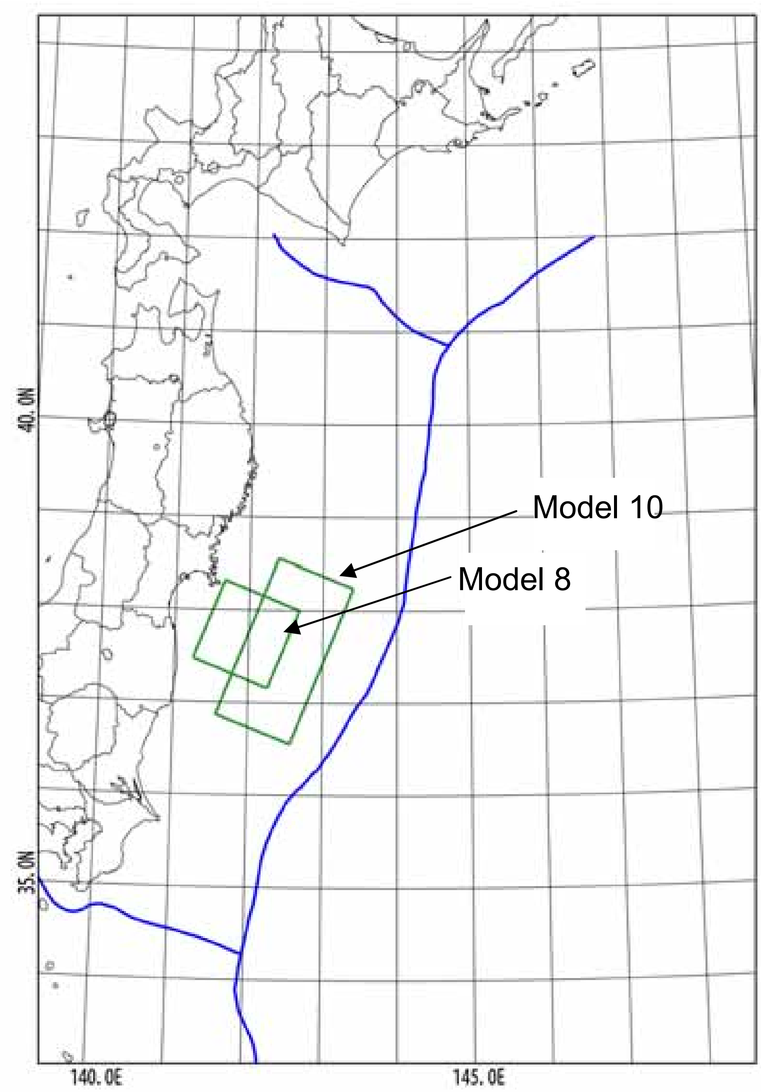
April～ October 2008 December 2008	Receive Jogan Tsunami research paper in progress from Dr. Satake	Implement trial calculation on "Opinion of the HERP" <u>Coordination begins toward revising Tsunami Assessment Methodology and deliberation on wave source model</u> Implement trial calculations on Jogan Tsunami
February 2009		Under discussion Safety evaluation is carried out based on "Tsunami Assessment Methodology" taking into account the latest submarine topography and tidal level observation data in preparation for submitting the final anti-seismic back-check report, and the necessary measures are implemented. Fukushima Daiichi : Water level : O.P.+5.4~6.1m
April 2009 June 2009 July 2009 August~ September 2009 December2009 March 2010	Dr. Satake of AIST※1 publishes paper on the Jogan Tsunami (conclusion is that further investigation needed in order to establish the wave source model) Joint working group points out Jogan Tsunami in regard to TEPCO's anti-seismic back-check interim report NISA※2 : evaluation of anti-seismic back-check interim report ("appropriate response to result of Jogan Tsunami research and study") TEPCO explains about Jogan Tsunami to NISA※2	<u>Deliberations on the Opinion of the HERP and Jogan Tsunami requested to JSCE</u> Tsunami deposit surveys (start) Tsunami deposit surveys (finish)
January 2011 March 2011	Give explanation to NISA※2	Report on result of tsunami deposit surveys (※) submitted to Japan Geoscience Union Meeting ※Tsunami deposits from the Jogan tsunami not found in southern area of Fukushima Prefecture

※1: National Institute of Advanced Industrial Science and Technology, ※2: Nuclear and Industrial Safety Agency

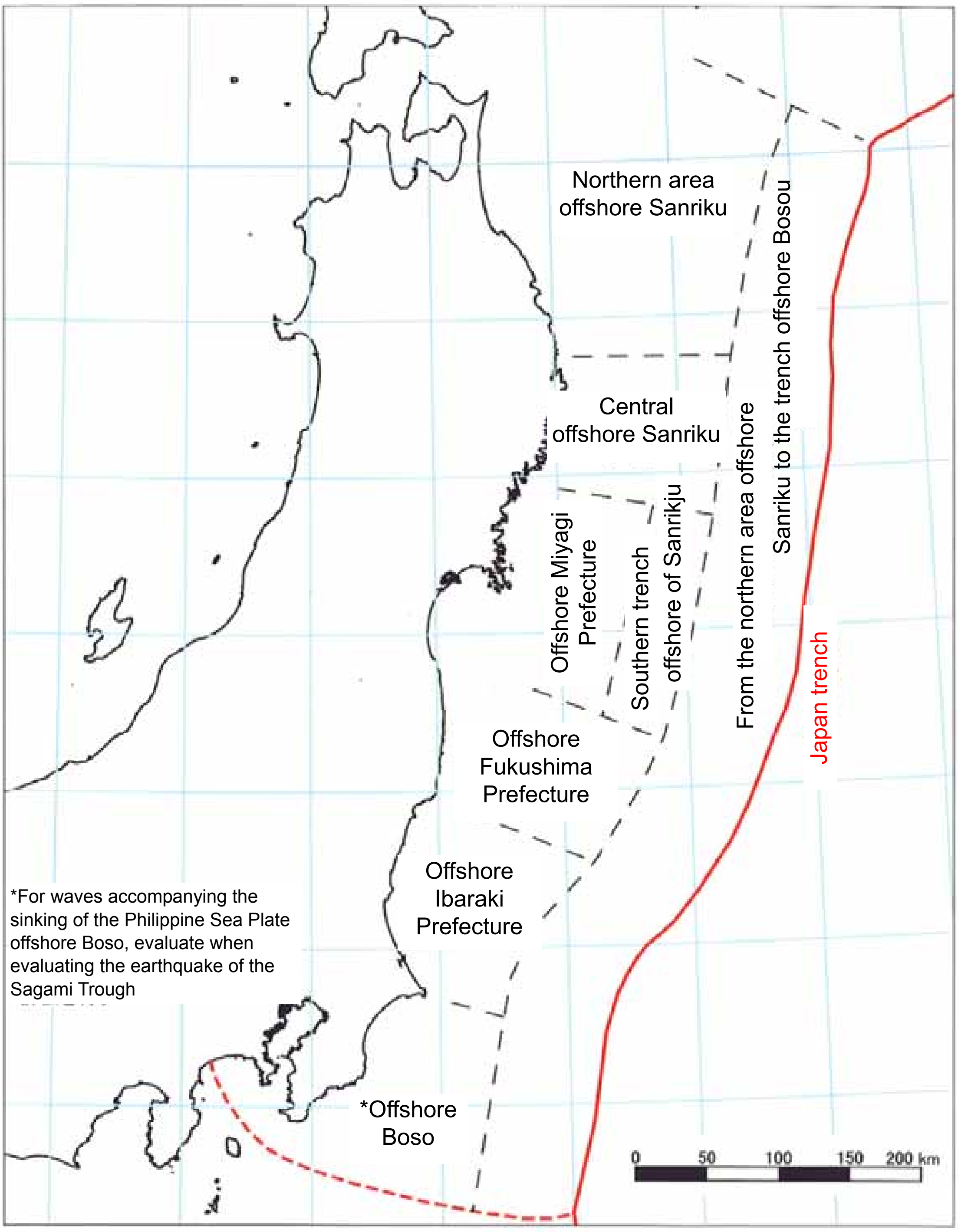
Wave source and wave source area proposed by various research organizations, etc.



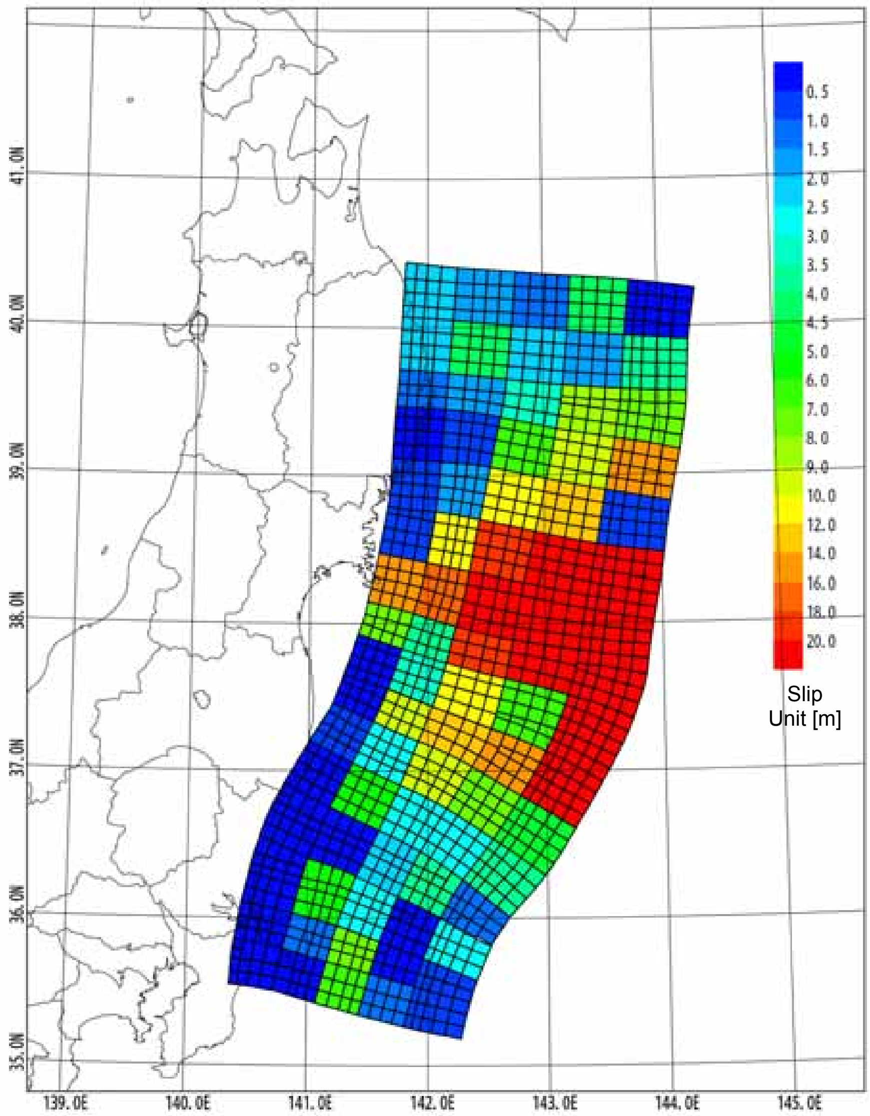
Wave source proposed by the Japan Society of Civil Engineers (JSCE) (2002)



Wave source of the Jogan tsunami (Satake et al., Created based on 2008)

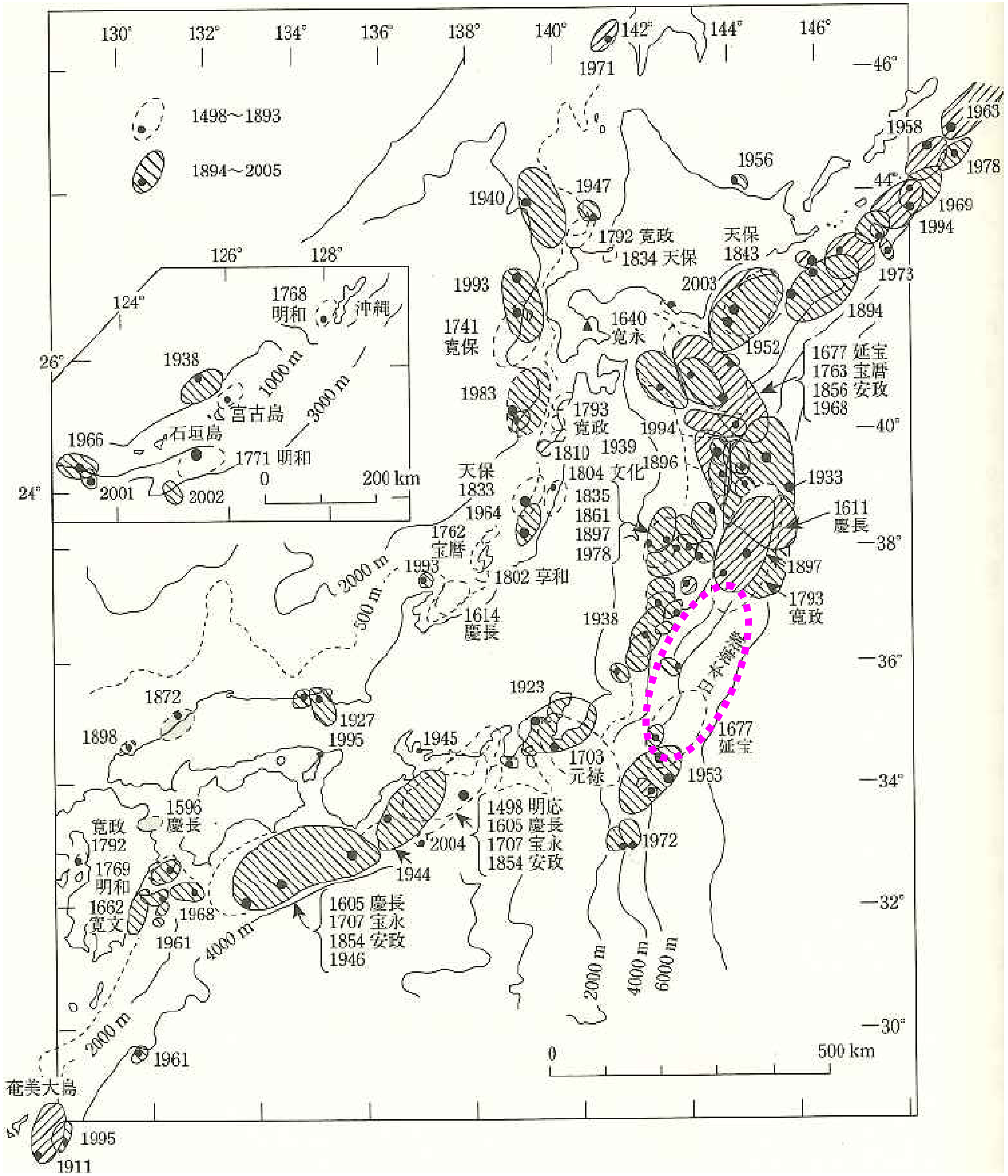


Evaluation area from the northern area offshore Sanriku to offshore Boso
(Headquarters for Earthquake Research Promotion (HERP) website,
Earthquake Investigation Committee July 31, 2002)



Wave source estimated by the inversion analysis (TEPCO 2011)

Major Tsunami in the Vicinity of the Tohoku Region in the Past



869 Jogan Tsunami		(approx. M8.4)
1611 Keichou Sanriku Tsunami		Mw8.6
1677 Empo Bousou Tsunami		Mw8.2
1896 Meiji Sanriku Tsunami		Mw8.3
1933 Showa Sanriku Tsunami		Mw7.9

Mw (moment magnitude) in the Japan Society of Civil Engineers fault model (2002) explaining height of sediment traces of past tsunami

Distribution of hypothesized Japan Sea tsunami wave source area

Design of Fukushima Daiichi Nuclear Power Station Building Complex Site Ground Level

1. Summary of Investigation Results

The largest tsunami of the past was taken into consideration as the ground level design condition for the Fukushima Daiichi Nuclear Power Station (NPS) building complex site in the first place, and due consideration was given to the avoiding of a tsunami reaching the major building site. Below is a comparison of the ground level of other power stations located on the Pacific coast that were ravaged by a tsunami similar to TEPCO's Fukushima Daiichi NPS but managed to safely achieve cold shutdown. Judging from these results, there are no facts that the level at which the buildings at Fukushima Daiichi NPS are built is low.

2. Height of the Tsunami and Design Ground Level

In embarking on a comparative examination, data regarding the design height of the tsunami of other power companies is taken from the Japanese central government's report submitted to the ministerial summit IAEA meeting of June 2011.

(1) Fukushima Daiichi NPS (O.P. refers to Onahama Port construction site point of reference)

- ground level of major buildings: O.P.+10.0m
- Tsunami Assessment Methodology: O.P.+6.1m
- Application for establishing permit: O.P.+3.122m

(2) Japan Atomic Power Company Tokai Daiini NPS (H.P. refers to Hitachi Port construction site point of reference)

- ground level of major buildings: H.P.+8.9m
- Tsunami Assessment Methodology: H.P.+5.8m
- Application for establishing permit: not listed

(3) Tohoku Electric Power Co., Inc. Onagawa NPS (O.P. refers to Onagawa NPS Port construction site point of reference)

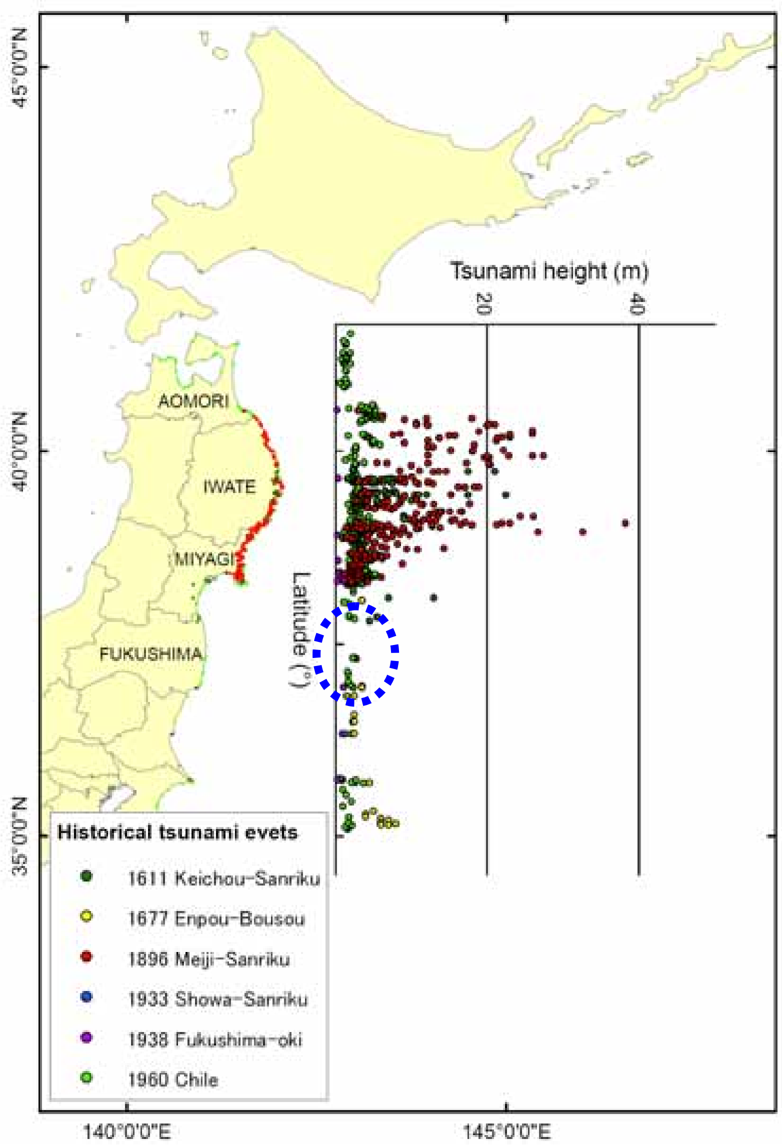
- ground level of major buildings: O.P.+14.8m
- Tsunami Assessment Methodology: O.P.+13.6m
- Application for establishing permit: O.P.+9.1m

3. Result of Comparison of Design Tolerance

Tolerance derived from the data in the preceding paragraph is as follows:

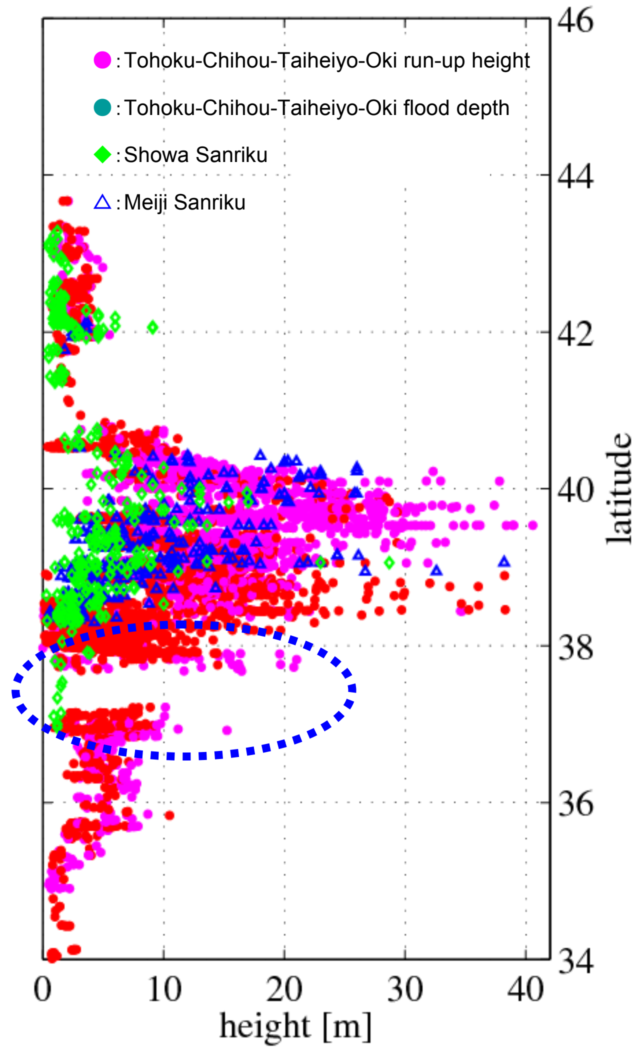
Name of power station	Major site ground level (m) [A]	Height of the tsunami (m)		(A-B)/A	(A-C)/A
		Establishing permit [B]	Japan Society of Civil Engineers [C]		
Fukushima Daiichi NPS	+10.0	+3.122	+6.1	68%	39%
Tokai Daini NPS	+8.9	not listed	+5.8	—	34%
Onagawa NPS	+14.8	+9.1 (Unit 2) +approx. 3 (Unit 1)	+13.6	38% 80%	8%

Traces of Tsunami Sediment Left Behind by Tsunami that have Ravaged the Tohoku Region in the Past



Distribution of traces of the main tsunami sediment height records since the Edo Era

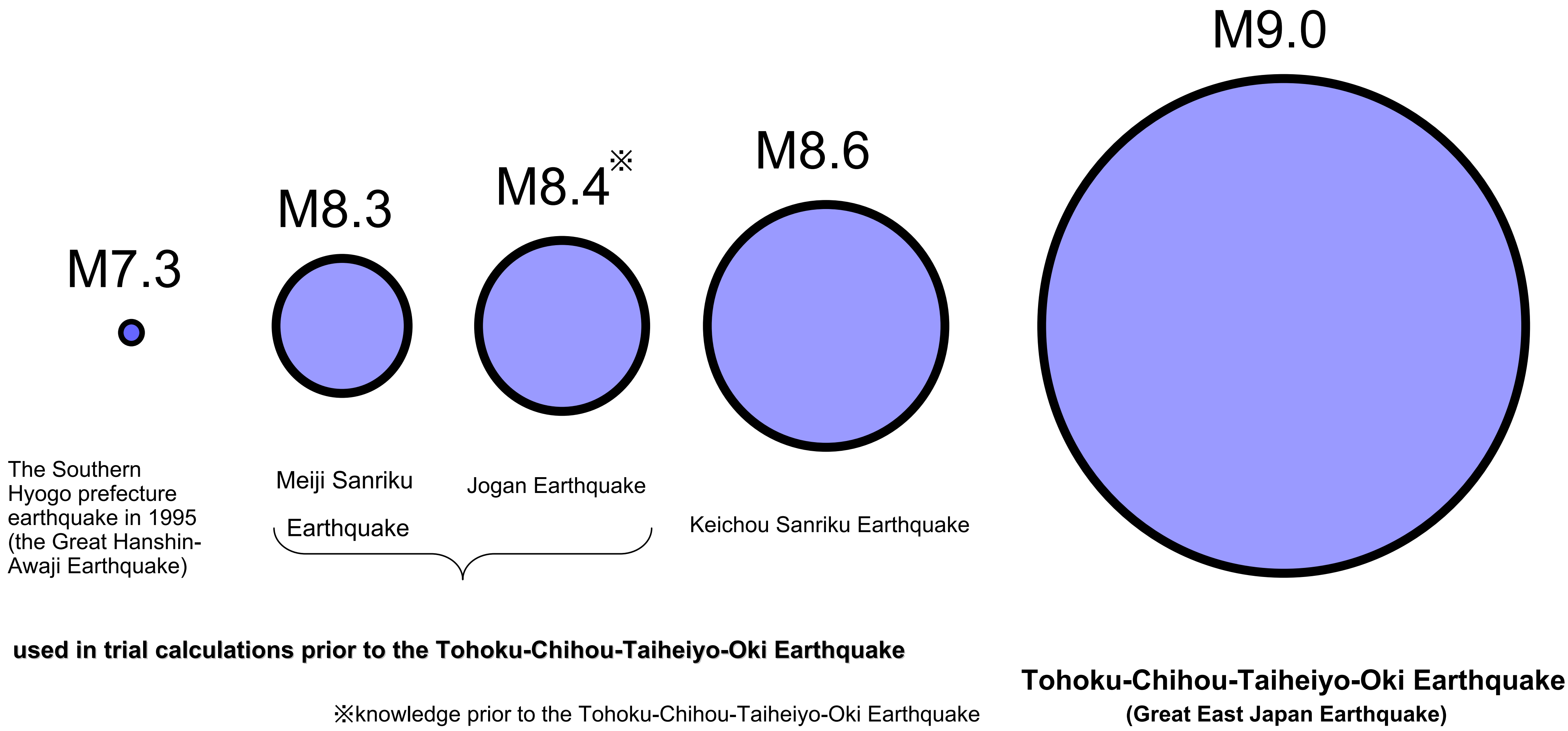
Comparison of Tohoku-Chihou-Taiheiyo-Oki Tsunami with Meiji Sanriku Tsunami and Showa Sanriku Tsunami



Distribution of traces of tsunami sediment along the Tohoku coast

Attachment 3-19

Strength of an Earthquake's Energy in Terms of Magnitude

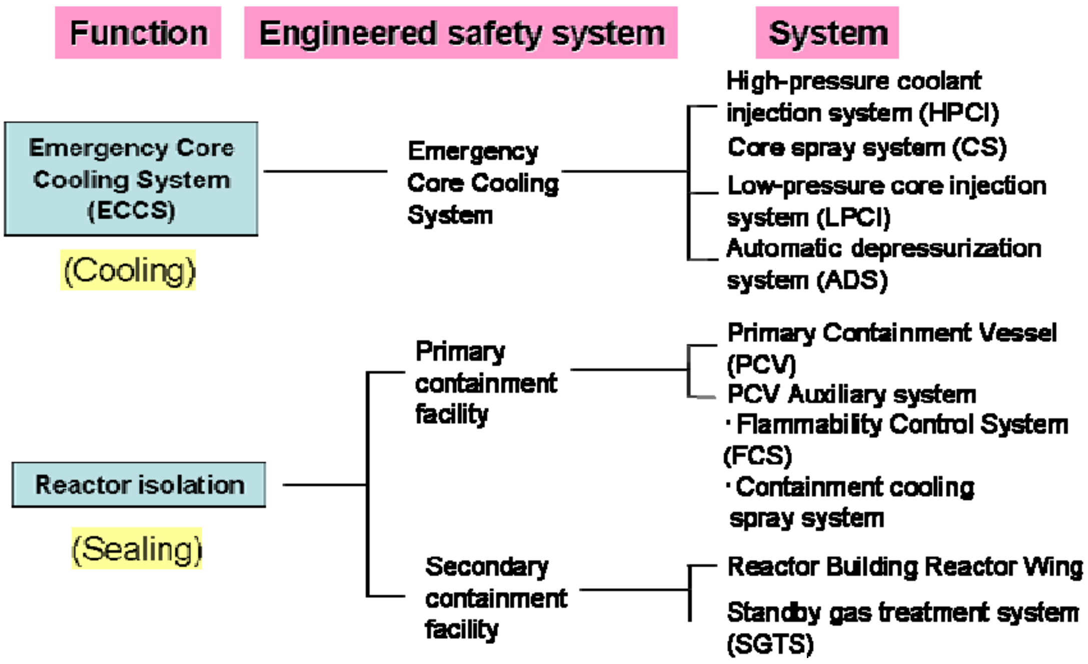


Attachment 3-20

Redundancy, Diversity, and Autonomy of Engineered Safety Systems at Nuclear Power Stations

The Regulatory Guide for Reviewing Safety Design of Light Water Nuclear Power Reactor Facilities requires that systems that have particularly important safety functions must be redundant, diverse, and independent in consideration of the configuration of the system, principles of operation, and the characteristics of the safety functions to perform. Systems important for safety, such as the emergency core cooling system (ECCS), Reactor protection systems, and electrical systems, etc., need to be designed so that the system does not lose safety function even in the event that a single piece of equipment fails.

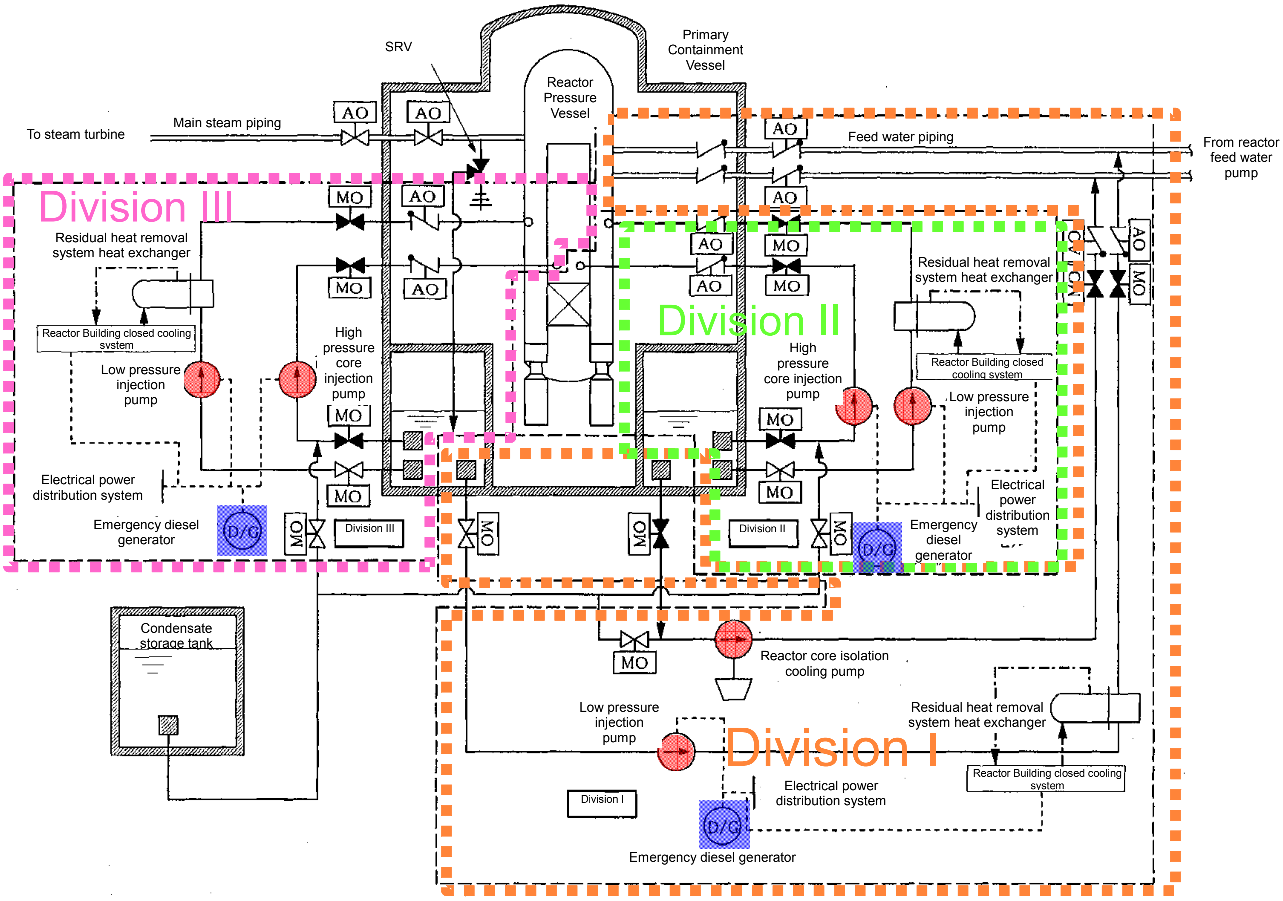
Engineered safety system configuration (BWR-4 example)



Redundancy, diversity, and independence

(1) “Redundancy” refers to having two or more systems or pieces of equipment that have the same attributes and the same function.

(Ex. Emergency core cooling system (ECCS) pump (in the case of an ABWR)



(2) “Diversity” refers to having two or more systems or pieces of equipment that have the same function but different attributes.

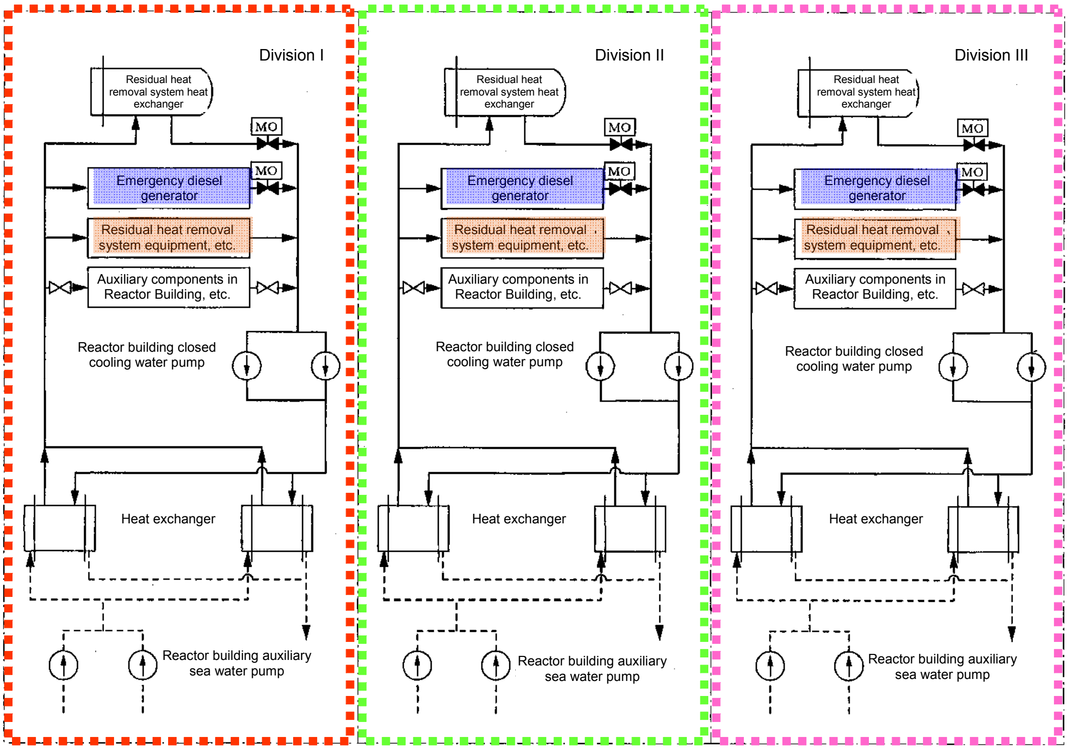
(Ex. Reactor shutdown function

- Control rods: control rods are inserted into the core
- Standby Liquid Control (SLC): If the control rods cannot be inserted, boric acid is inserted into the reactor to shut it down.

(3) “Independence” refers to two or more systems or pieces of equipment that shall not lose function simultaneously due to common or dependent factors amidst environmental conditions or operational states that they are designed for.

(Ex. 1: Auxiliary unit cooling water system (sectored design)

- Provides cooling water to the emergency core cooling system (ECCS) pump and emergency equipment such as diesel generators.
- An auxiliary unit cooling water system is installed for each division (even if the auxiliary unit cooling water system in one division becomes inoperable, multiple divisions will not become inoperable at the same time)



(Ex. 2: Emergency core cooling system (ECCS) pump location (inside the reactor building) (physical separation)

- Each ECCS pump is located in a different room.
- This prevents other pumps from being affected if an abnormality occurs in one pump room (flooding due to a pipe rupture, etc.)

Status of installation of facilities with "Cooling down" and "Confining inside" functions in each unit

	Objective	Facility Name	Fukushima Daiichi Unit 1	Fukushima Daiichi Units 2 to 5	Fukushima Daiichi Unit 6	Fukushima Daini Units 1 to 4
"Cooling down"	Normal coolant injection	Feed water and condensate systems (FDW)	Yes	Yes	Yes	Yes
"Cooling down"	High pressure water injection	Reactor core isolation cooling system (RCIC) Isolation condenser system (IC) High-pressure coolant injection / core spray (HPCI/HPCS) Control rod drive hydraulic pressure system (CRD)	— Yes Yes Yes	Yes — Yes Yes	Yes — Yes Yes	Yes — Yes Yes
"Cooling down"	Pressure reduction	Safety relief valve (SRV,ADS)	Yes	Yes	Yes	Yes
"Cooling down"	Low pressure water injection	Core spray system (CS/LPCS) Residual heat removal system (LPCI)	Yes —	Yes Yes	Yes Yes	Yes Yes
"Cooling down"	Alternate water injection (AM)*	Make-up water condensate system (MUWC) Fire protection system (FP)	Yes Yes	Yes Yes	Yes Yes	Yes Yes
"Cooling down"	Final heat removal	Shutdown cooling system (SHC) Residual heat removal system (RHR-SHC)	Yes —	— Yes	— Yes	— Yes
"Confining inside"	PCV cooling	Containment cooling spray system (CCS) Residual heat removal system (RHR)	Yes —	— Yes	— Yes	— Yes
"Confining inside"	PCV venting (AM)*	PCV hardened vent piping, rupture disk	Yes	Yes	Yes	Yes

*Prepared as part of accident management measures from 1994 to 2002.

Details of Fukushima Daiichi Unit 1 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power – Off-site power [D/G (A)] C-BUS	Facility requiring AC power – Off-site power [D/G (B)] D-BUS	Facility requiring AC power – Off-site power A-BUS	Facility requiring AC power – Off-site power B-BUS	Facility requiring AC power – Off-site power S-BUS	Remarks (C,D-BUS can receive power from D/G)
Shutting down	Scram	Control rod drive hydraulic pressure systems	HCU	97 units	○						Automatic scram upon station black out
Shutting down	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B				
Cooling down	High pressure water injection	Isolation condenser system	IC	2 system	A-train / B-train						Operates on DC power
Cooling down	High pressure water injection	High-pressure coolant injection system	HPCI	1 system	○						Operates on DC power
Cooling down	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	4	○						Operates on DC power
Cooling down	Low pressure water injection	Core spray system	CS	2 system		Subsytem A	Subsytem B				
Cooling down	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B				
Cooling down	Alternate water injection (AM)	Fire protection system (motor-operated pump)	FP	1						Pump	
Cooling down	Alternate water injection (AM)	Fire protection system (diesel-operated pump)	FP	1	○						Operates on DC power
Cooling down	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 3				Pump A,B	Pump C		
Cooling down	Normal coolant injection	Feed water and condensate system	FDW	Condensate system 3				Pump A	Pump B,C		
Cooling down	Normal coolant injection	Control rod drive system	CRD	1 system		Pump A	Pump B				
Cooling down	Final heat removal	Shutdown cooling system	SHC	2 system		Subsytem A	Subsytem B				
Confining inside	PCV cooling	Containment cooling spray system	CCS	2 system		Subsytem A	Subsytem B				
Confining inside	PCV vent (AM)	S/C vent valve	–				PCV vent valve [MO valve]				Operates on D-BUS AC power, AC120V vital AC power and pressurized air (S/C vent valve [AO valve])
Confining inside	PCV vent (AM)	D/W vent valve	–				PCV vent valve [MO valve]				Operates on D-BUS AC power, AC120V vital AC power and pressurized air (D/W vent valve [AO valve])

Details of Fukushima Daiichi Unit 2 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power					Remarks (C,D,E-BUS can receive power from D/G)
						Off-site power					
						[D/G (A)]	[D/G (B)]				
						C-BUS	E→D-BUS	A-BUS	B-BUS	S-BUS	
Shutting down	Scram	Control rod drive hydraulic pressure systems	HCU	137 units	○						Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B				
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○						Operates on DC power
		High-pressure coolant injection system	HPCI	1 system	○						Operates on DC power
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	8	○ ○ ○						Operates on DC power
	Low pressure water injection	Core spray system	CS	2 system		Subsytem A	Subsytem B				
		Residual heat removal system	RHR-LPCI	2 system		Subsystem A	Subsystem B				
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B				
		Fire protection system (motor-operated pump)	FP	1						Pump	
		Fire protection system (diesel-operated pump)	FP	1	○						Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2				Pump A	Pump B		
				Condensate system High pressure 3				Pump A,C	Pump B		
				Condensate system Low pressure 3				Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B				
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		Subsystem A	Subsystem B				
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		Subsystem A	Subsystem B				
	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (S/C vent valve [AO valve])
		D/W vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (D/W vent valve [AO valve])

Details of Fukushima Daiichi Unit 3 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power Off-site power [D/G (A)] C-BUS	[D/G (B)] D-BUS	A-BUS	B-BUS	S-BUS	Remarks (C,D-BUS can receive power from D/G)
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	137 units	○						Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B				
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○						Operates on DC power
		High-pressure coolant injection system	HPCI	1 system	○						Operates on DC power
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	8	○ ○ ○						Operates on DC power
	Low pressure water injection	Core spray system	CS	2 system		Subsytem A	Subsytem B				
		Residual heat removal system	RHR-LPCI	2 system		Subsystem A	Subsystem B				
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B				
		Fire protection system (motor-operated)	FP	1						Pump	
		Fire protection system (diesel-operated)		1	○						Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2				Pump A	Pump B		
				Condensate system High pressure 3				Pump A,C	Pump B		
				Condensate system Low pressure 3				Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B				
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		Subsystem A	Subsystem B				
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		Subsystem A	Subsystem B				
	PCV vent (AM)	S/C vent valve		–		PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (S/C vent valve [AO valve])
		D/W vent valve		–		PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (D/W vent valve [AO valve])

Attachment 4-2 (4/9)

Attachment 4-2 (5/9)

Details of Fukushima Daiichi Unit 4 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power					Remarks (C,D,E-BUS can receive power from D/G)
						Off-site power					
						[D/G (A)]	[D/G (B)]				
						C-BUS	E→D-BUS	A-BUS	B-BUS	S-BUS	
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	137 units	○						Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B				
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○						Operates on DC power
		High-pressure coolant injection system	HPCI	1 system	○						Operates on DC power
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	11	○ ○ ○						Operates on DC power
	Low pressure water injection	Core spray system	CS	2 system		Subsytem A	Subsytem B				
		Residual heat removal system	RHR-LPCI	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B				
		Fire protection system (motor-operated pump)	FP	1						Pump	
		Fire protection system (diesel-operated pump)		1	○						Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2				Pump A	Pump B		
				Condensate system High pressure 3				Pump A,C	Pump B		
				Condensate system Low pressure 3				Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B				
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (S/C vent valve
		D/W vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (D/W vent valve

Details of Fukushima Daiichi Unit 5 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power					Remarks (C,D-BUS can receive power from D/G)
						Off-site power					
						[D/G (A)]	[D/G (B)]				
						C-BUS	D-BUS	A-BUS	B-BUS	S-BUS	
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	137 units	○						Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B				
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○						Operates on DC power
		High-pressure coolant injection system	HPCI	1 system	○						Operates on DC power
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	11	○ ○ ○						Operates on DC power
	Low pressure water injection	Core spray system	CS	2 system		Subsytem A	Subsytem B				
		Residual heat removal system	RHR-LPCI	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B				
		Fire protection system (motor-operated pump)	FP	1						Pump	
		Fire protection system (diesel-operated pump)	FP	1	○						Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2				Pump A	Pump B		
				Condensate system High pressure 3				Pump A,C	Pump B		
				Condensate system Low pressure 3				Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B				
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		A-train (Pump A,C)	B-train (Pump B,D)				
	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (S/C vent valve
		D/W vent valve	–			PCV vent valve [MO valve]	PCV vent valve [MO valve]				Operates on C or D-BUS power, DC power and pressurized air (D/W vent valve

Attachment 4-2 (6/9)

Details of Fukushima Daiichi Unit 6 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power						Remarks (C,D,H-BUS can receive power from D/G)
						Off-site power						
						[D/G (A)]	[D/G (B)]	[D/G (H)]				
						C-BUS	D-BUS	H-BUS	A-BUS	B-BUS	S-BUS	
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	185 units	○							Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B					
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○							Operates on DC power
		High pressure core spray system	HPCS	1 system				○				
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	18	○ ○ ○							Operates on DC power
	Low pressure water injection	Low pressure core spray system	LPCS	1 system		○						
		Residual heat removal system	RHR-LPCI	3 system		Subsystem A	Subsystem B,C					
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B					
		Fire protection system (motor-operated pump)	FP	1							Pump	
		Fire protection system (diesel-operated pump)	FP	1	○							Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2					Pump A	Pump B		
				Condensate system High pressure 3					Pump A	Pump B,C		
				Condensate system Low pressure 3					Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B					
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		Subsytem A	Subsytem B					
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		Subsytem A	Subsytem B					
	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]						Operates on C, D, vital power and pressurized air (S/C vent valve [AO valve])
		D/W vent valve	–			PCV vent valve [MO valve]						Operates on C, vital power and pressurized air (D/W vent valve [AO valve])

Details of Fukushima Daini Unit 1/3/4 facilities (facilities used for "shutting down", "cooling down", "confining inside")

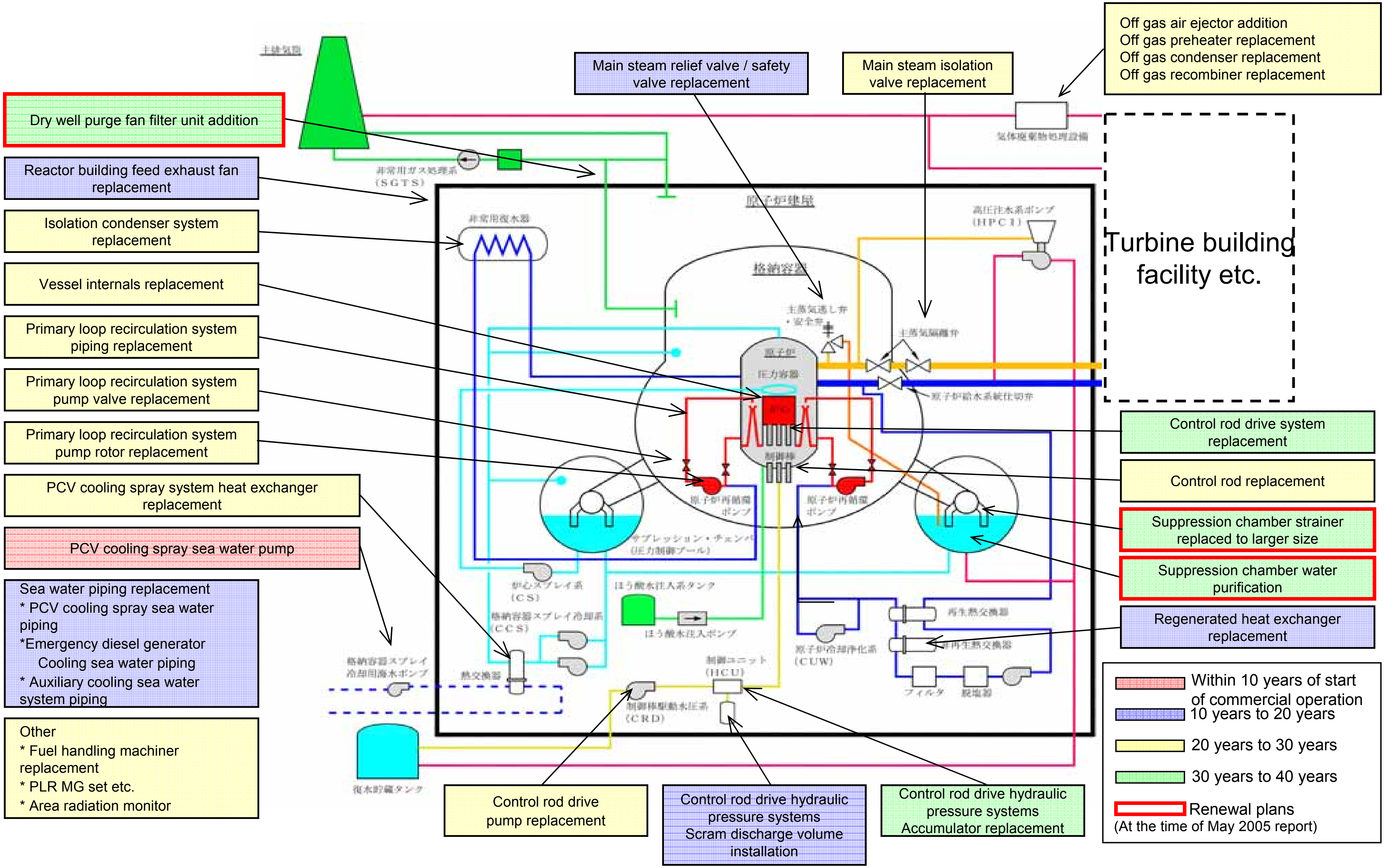
Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power / Off-site power [D/G (A)] C-BUS	[D/G (B)] D-BUS	[D/G (H)] H-BUS	A-BUS	B-BUS	S-BUS	Remarks (C,D,H-BUS can receive power from D/G)
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	185 units	○							Automatic scram upon station black out
	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B					
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○							Operates on DC power
		High pressure core spray system	HPCS	1 system				○				
	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	18	○							Operates on DC power
	Low pressure water injection	Low pressure core spray system	LPCS	1 system		○						
		Residual heat removal system	RHR-LPCI	3 system		Subsystem A	Subsystem B,C					
	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A,C	Pump B					
		Fire protection system (motor-operated pump)	FP	1							Pump	
		Fire protection system (diesel-operated pump)		1	○							Operates on DC power
	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2					Pump A	Pump B		
				Condensate system High pressure 3					Pump A	Pump B,C		
				Condensate system Low pressure 3					Pump A	Pump B,C		
		Control rod drive system	CRD	1 system		Pump A	Pump B					
	Final heat removal	Residual heat removal system	RHR-SHC	2 system		Subsytem A	Subsytem B					
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		Subsytem A	Subsytem B					
	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]						Operates on C, vital power and pressurized air (S/C vent valve [AO valve])
		D/W vent valve	–			PCV vent valve [MO valve]						Operates on C, vital power and pressurized air (D/W vent valve [AO valve])

Details of Fukushima Daini Unit 2 facilities (facilities used for "shutting down", "cooling down", "confining inside")

Objective		Facility name		No. of systems (amount)	Facility not requiring AC power	Facility requiring AC power						Remarks (C,D,H-BUS can receive power from D/G)
						Off-site power						
						[D/G (A)] C-BUS	[D/G (B)] D-BUS	[D/G (H)] H-BUS	A-BUS	B-BUS	S-BUS	
Shutting down	Scram	Control rod drive hydraulic pressure	HCU	185 units	○							Automatic scram upon station black out
Shutting down	Subcriticality	Standby liquid control system	SLC	2 system		Subsytem A	Subsytem B					
Cooling down	High pressure water injection	Reactor core isolation cooling system	RCIC	1 system	○							Operates on DC power
Cooling down	High pressure water injection	High pressure core spray system	HPCS	1 system				○				
Cooling down	Pressure reduction	Safety relief valve (ADS function / relief valve function / safety valve function)	SRV	18	○ ○ ○							Operates on DC power
Cooling down	Low pressure water injection	Low pressure core spray system	LPCS	1 system		○						
Cooling down	Low pressure water injection	Residual heat removal system	RHR-LPCI	3 system		Subsystem A	Subsystem B,C					
Cooling down	Alternate water injection (AM)	Make-up water condensate system	MUWC	1 system		Pump A	Pump B					
Cooling down	Alternate water injection (AM)	Fire protection system (motor-operated pump)	FP	1							Pump	
Cooling down	Alternate water injection (AM)	Fire protection system (diesel-operated pump)	FP	1	○							Operates on DC power
Cooling down	Normal coolant injection	Feed water and condensate system	FDW	Feed water system 2					Pump A	Pump B		
Cooling down	Normal coolant injection	Feed water and condensate system	FDW	Condensate system High pressure 3					Pump A	Pump B,C		
Cooling down	Normal coolant injection	Feed water and condensate system	FDW	Condensate system Low pressure 3					Pump A	Pump B,C		
Cooling down	Normal coolant injection	Control rod drive system	CRD	1 system		Pump A	Pump B					
Cooling down	Final heat removal	Residual heat removal system	RHR-SHC	2 system		Subsytem A	Subsytem B					
Confining inside	PCV cooling	Residual heat removal system	RHR	2 system		Subsytem A	Subsytem B					
Confining inside	PCV vent (AM)	S/C vent valve	–			PCV vent valve [MO valve]						Operates on C, vital power and pressurized air (S/C vent valve [AO valve])
Confining inside	PCV vent (AM)	D/W vent valve	–			PCV vent valve [MO valve]						Operates on C, vital power and pressurized air (D/W vent valve [AO valve])

Continuous Risk Reduction (Continuous Improvements)
- Examples of facility modification -

Performance of replacement/repair of facility/equipment at Fukushima Daiichi Unit 1 (R/B facility)



Attachment 4-3

Flooding Study Group and Response Status

January to July 2006: Discussion at the Flooding Study Group

NISA and the Japan Nuclear Energy Safety Organization (JNES) established the Flooding Study Group. The Federation of Electric Power Companies (FEPC) and operators of electric utilities participated as observers. This study group studied issues such as the design vulnerabilities of US nuclear power plants to internal flooding and studies on seawater pump flooding at Indian nuclear power plants due to the Sumatra tsunami. The achievements of this study group were published as “Flooding Study Task” in the FY2007 JNES Annual Report.

October 2006: Request from NISA

Based on the review done by the study group, NISA requested as follows during a meeting about a plan for seismic back checks: “The JSCE methodology, which is conservative, is acceptable for tsunami assessment (safety is ensured by it). However, if there is a tsunami that exceeds the JSCE assessment, emergency seawater pumps at lower elevations would lose capability and lead to core damage. Therefore, we want plants with low margin for entry of tsunamis (high waves and receding waves) to consider specific countermeasures and take action (*Flooding of buildings was not mentioned).” FEPC verbally received this request from NISA and was asked to communicate this to the upper management of each operator.

Status of TEPCO efforts at that time

TEPCO shared information about NISA’s request as far as the CNO. At Fukushima Daiichi NPS, the maximum tsunami height from the JSCE assessment was 5.7m (finally 6.1m), and the emergency seawater pump installation height was 4m. Therefore, actions were already taken to increase the elevation of the motors, thus safety had been ensured. In terms of maintaining functionality of emergency seawater pumps, TEPCO had verified performance of bearings as a forward action as part of making emergency seawater pump motors water tight. However, considering NISA’s requests, further voluntary actions were pursued such as investigating the applicability of water-tightness on actual equipment for emergency seawater pump motors. In addition, even if the emergency seawater pumps were to be flooded by a tsunami and lose function, Fukushima Daiichi NPS had an air-cooled EDG. Therefore, it was understood that, as long as a tsunami does not reach the building ground level, it would not result in SBO.

April 2007: Report to NISA

FEPC reported the following as study results for NISA's request of October 2006.

- Assessment results using the JSCE methodology will be reported for seismic back checks.
- Investigate further improvement of plant safety against tsunamis (making motors watertight).

There were no new additional instructions from NISA.

In the Flooding Study Group at that time, they selected several nuclear plants across Japan and hypothetically assumed flooding of the building site for consideration.

Consideration status at Flooding Study Group

- ○ It hypothesized that flooding would be up to ground level +1m and would continue indefinitely.
- ○ Results showed that when the building site is flooded, water flows into the openings on the buildings and power facilities, etc. are submerged and lose function.
- ○ However, this result is not a finding that was realized based on NISA's comments. It was understood that, assuming that there is water ingress into areas that have not been designed for exposure to water, it would inevitably lead to loss of function. This study did not take into account the realistic possibility or probability of such tsunamis, but was a mere exercise to confirm the impact. The results of this study group have been compiled in "External Flooding Study Group Study Results (August 2, 2006)."

Results of Flooding Study Group and presumed tsunami height

- ○ With respect to the assessment of tsunami height, NISA's go-ahead was obtained on using the JSCE methodology and reflecting that in the seismic back checks, determining the conservativeness of such methodology.

Accordingly, TEPCO conducted conservative assessments based on the JSCE methodology and understood that the power station's safety was ensured at that time. In addition, responding to an emerging need for a new wave source model due to the HERP opinion and Jogan Tsunami paper, parallel actions were being pursued for considerations to make emergency seawater pump motors watertight and for requesting JSCE to review their assessment methodology.

○ Meanwhile, it is understood that there was a request from NISA to further improve safety because, when looking at nuclear power plants across Japan, there are plants that have a smaller apparent margin against assessed tsunami heights for their emergency seawater pumps. Therefore, the intention of the NISA request was not for countermeasures that would have prevented the tsunami impacts suffered at this time such as flooding prevention of buildings.

End

Restricted
No copying

August 2, 2006

External Flooding Study Group Study Results (1/2)

1. Introduction

It is understood that safety of nuclear power plants against tsunamis is sufficiently ensured because, in terms of tsunami assessment and design of nuclear power plants, not only past maximum tsunami, but also a larger tsunami, the possibility of the occurrence of which cannot be rejected, is postulated in accordance with the Tsunami Assessment Methodology for Nuclear Power Plants in Japan (2002 Japan Society of Civil Engineers). At this time, a purely hypothetical study of the plants bearing capacity to unexpected tsunamis was conducted based on tsunami water levels that far exceed these postulations.

2. Selection of representative plants

Representative nuclear power plants located along the coast of different ocean regions were selected for the study.

Representative plants: Tomari Units 1 & 2, Onagawa Unit 2, Fukushima Daiichi Unit 5, Hamaoka Unit 4, Ohi Units 3 & 4

3. Conditions of the study

Though very conservative, the above indicated representative plants were studied in the range of ground level +1m. As an example, a simplified drawing of the ground level at Fukushima and Tomari are shown in Fig. 1 and 2. Note that flooding assessment into buildings requires that tsunami continuation time be accounted for, but this was not taken into account for this study because it is a simplified assessment (hypothesized that continuation time: ∞).

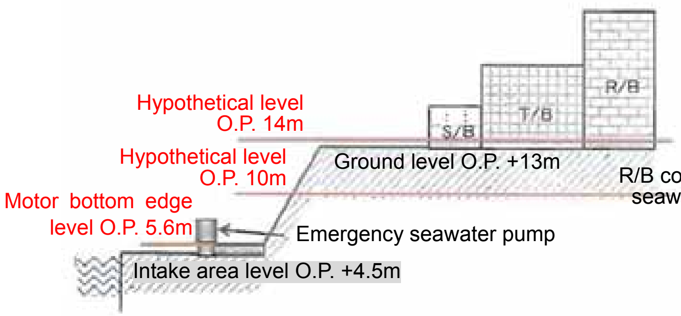


Fig. 1 Ground level overview (Fukushima Daiichi Unit 5)

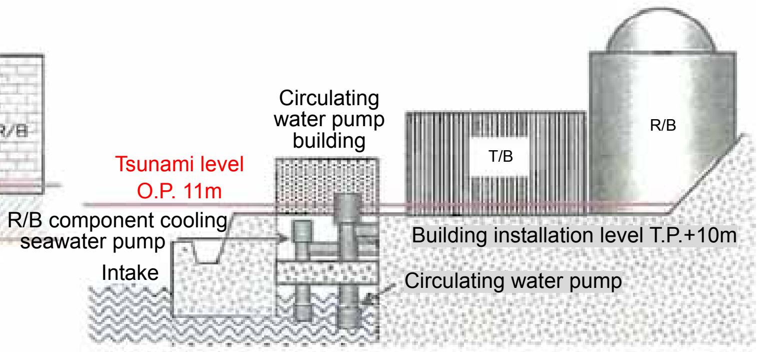


Fig. 2 Ground level overview (Tomari Unit 1, 2)

4. Results of the study

4.1 Overview of study on flooding impact on outdoor facilities (Fukushima Daiichi, Tomari)

Table 1 indicates the possibility of flooding of major facilities due to the hypothesized tsunami water level. When assuming it is ground level +1m, results showed that the possibility of flooding cannot be rejected for all plants (Fig. 3, 4 indicate openings that are particularly vulnerable to tsunamis). For Fukushima Daiichi Unit 5 and Tomari Unit 1, 2, field investigations were conducted to verify the validity of the above study results.

Table 1 Possibility of flooding of major facilities or impact on equipment due to beyond-design tsunamis

Plant	Hypothetical tsunami level	Emergency seawater pump	Circulating water pump building (R/B component cooling seawater pump)	R/B	T/B	S/B
Fukushima Daiichi Unit 5	O.P. 10m	×		○	○	○
	O.P. 14m	×		×	×	×
Tomari Unit 1, 2	T.P. 11m		×	×	×	

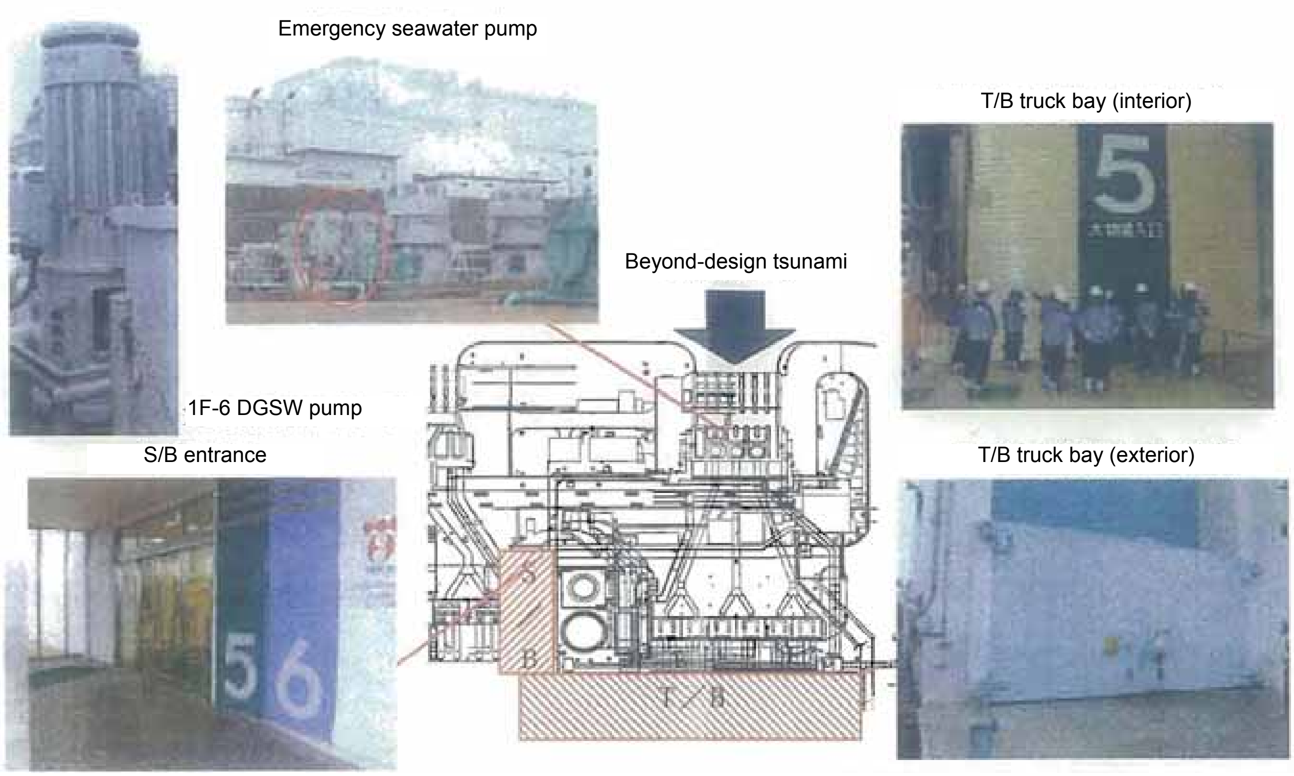


Fig. 3 Outdoor facilities that may be flooded due to beyond-design tsunamis (Fukushima Daiichi Unit 5)

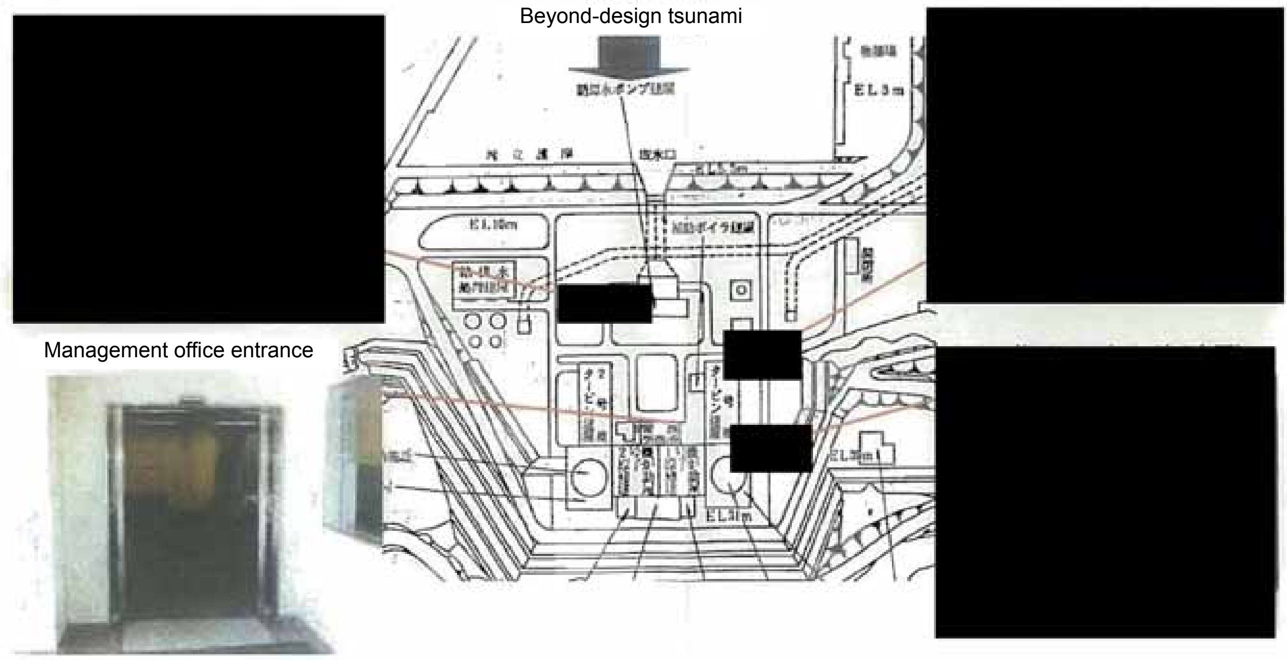


Fig. 4 Outdoor facilities (Tomari Unit 1) that may be flooded due to beyond-design tsunamis

August 2, 2006

External Flooding Study Group Study Results (2/2)

4.2 Impact on equipment due to flooding of buildings

The impact on equipment inside of buildings when buildings are flooded through openings as shown in Fig. 3 and 4 was studied.

①1F-5 (Fukushima Daiichi Unit 5)

[Tsunami water level O.P. 10m] Since it is understood that there is no flooding into the building, there is no impact on equipment inside the building.

[Tsunami water level O.P. 14m] When it is postulated that water flows into the T/B truck bay or S/B entrance, it is verified that all T/B areas will be flooded and there is possible loss of function of power supply facilities (Fig. 5).

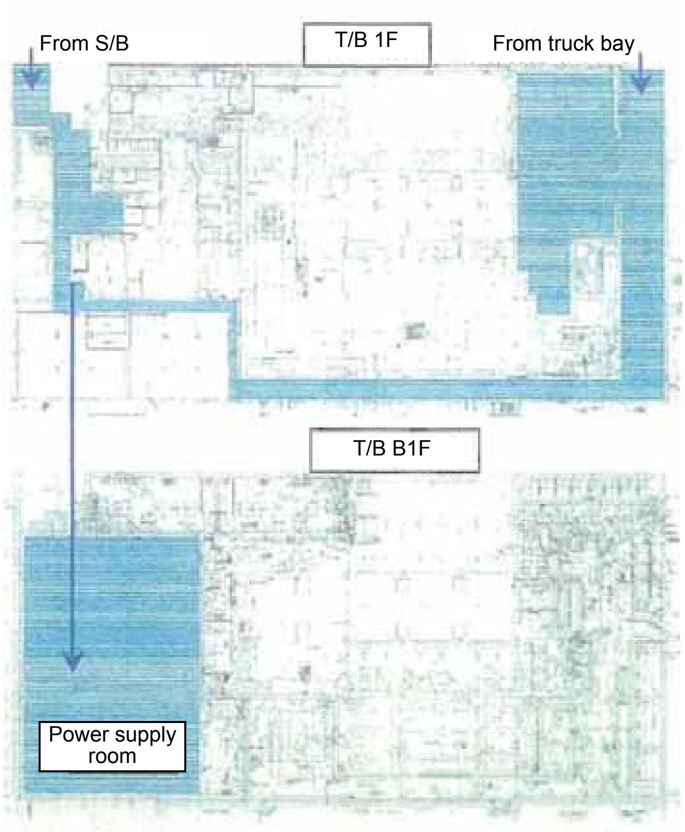


Fig. 5 Tsunami water ingress pathway (1F-5)

②Tomari Unit 1, 2

Of the flooding pathways, the flooding range for the pathways from the reactor auxiliary building to the reactor building via the opened management office entrance and protective doors opened during outage was studied. Results identified that flooded areas included the controlled areas of the reactor auxiliary building and reactor building at or below EL11m.

4.3 Results of study on plant impact

The results of studies described in 4.1 and 4.2 are described in Table 2 for representative plants.

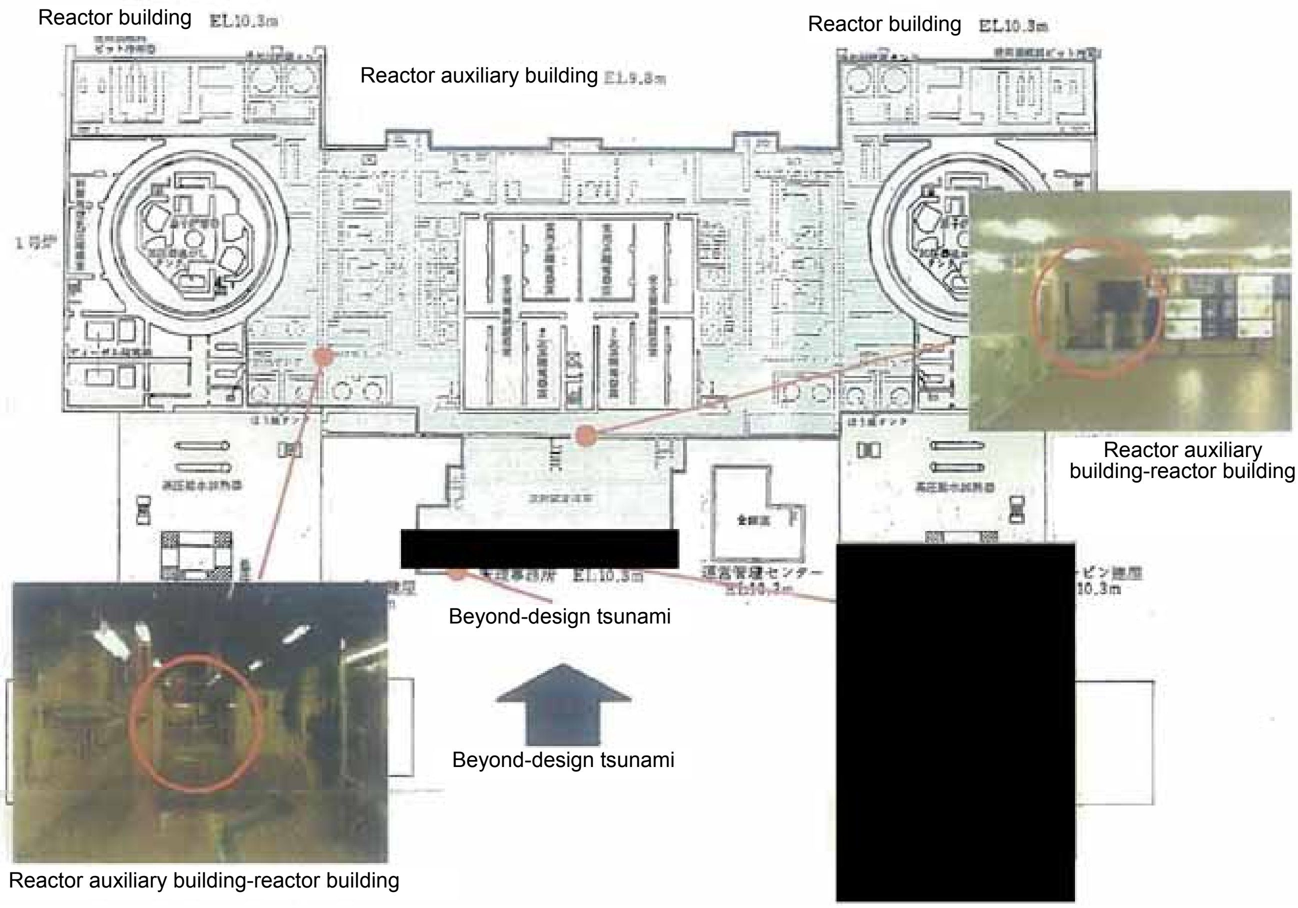


Fig. 6 Tsunami water ingress pathway (Tomari Unit 1, 2)

Table 2 Impact of beyond-design tsunamis on outdoor facilities (ground level +1m)

Plant	Hypothetical tsunami level	Major facilities impacted by tsunami	Ground level (installation level)	Major facilities losing function	Comments
Tomari Unit 1, 2	T.P. +11m	R/B component cooling seawater pump, power facilities*	T.P. +10,	ECCS, DG	JSCE assessment: T.P. +8.3m License assessment: T.P. +4.1m
Onagawa Unit 2	O.P. +15.8m	Emergency seawater pump, power facilities*	O.P. +14.8m	ECCS, DG, RCIC*	JSCE assessment: O.P. +13.6m License assessment: O.P. +9.1m
Fukushima Daiichi Unit 5	O.P. +10m	DGSW pump	O.P. +5.6m	ECCS, DG	JSCE assessment: O.P. +5.6m License assessment: O.P. +3.122m
		RHRS pump	O.P. +6.16m		
	O.P. +14m	DGSW pump RHRS pump Power facilities*	O.P. +13m	ECCS, DG, RCIC*	
Hamaoka Unit 4	T.P. +7m	D/G fuel transfer pump, reactor equipment cooling seawater pump, power facilities*	T.P. +6m	ECCS, DG, RCIC*	JSCE assessment: T.P. +6.8m License assessment: T.P. +6.0m Front sand dune height: T.P. +10-15m
Ohi Unit 3, 4	T.P. +10.7m	R/B component cooling seawater pump	T.P. +9.7m	ECCS, DG	JSCE assessment: T.P. +1.86m License assessment: No tsunami level indicated. However, since site elevation is T.P. +9.3m, there is no tsunami impact.

*When tsunami duration is not considered (infinite duration).

Examples of How the Lessons Learned from the Niigata-Chuetsu-Oki Earthquake are being applied to the Fukushima Daiichi and Fukushima Daini Nuclear Power Stations

Efforts to improve the seismic resistance of the Fukushima Daiichi and Fukushima Daini Nuclear Power Stations have been underway since 2006. These continuing efforts address many issues related to earthquakes, such as the lessons learned from the on-site transformer fire, and the response to such fire, that occurred in the wake of the Niigata-Chuetsu-Oki Earthquake of July 2007.

Based on the evaluation of equipment and structural damage caused by the earthquake at the Kashiwazaki-Kariwa Nuclear Power Station, those issues that should be addressed first in order to improve the seismic resistance of the Fukushima Daiichi and Fukushima Daini Nuclear Power Station facilities have been examined and countermeasures are being voluntarily implemented. Actual examples of these countermeasures are as follows.

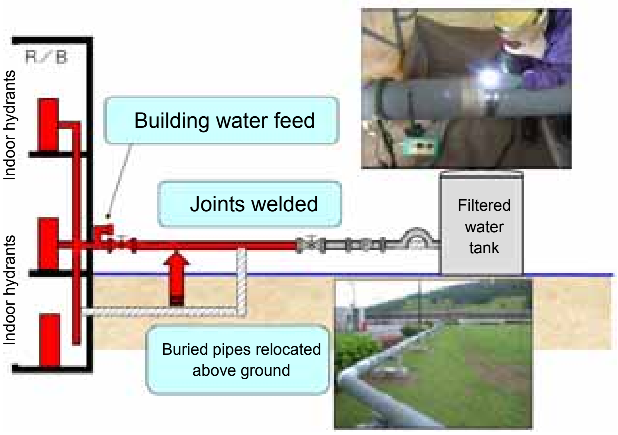
1. Improving the reliability of firefighting facilities

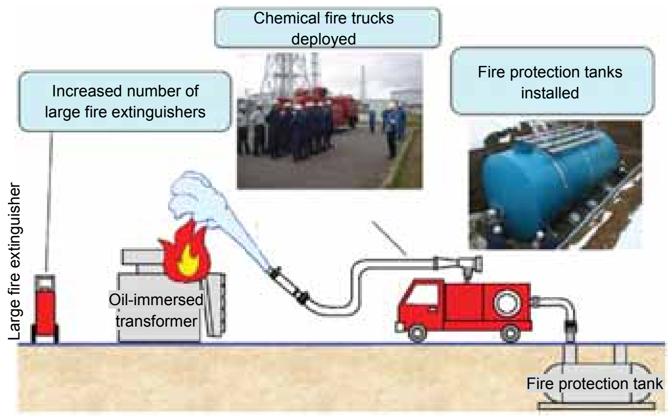
- The Niigata-Chuetsu-Oki Earthquake caused firefighting system pipes buried outside underground to rupture thereby inhibiting initial firefighting activities.

→ Firefighting facilities have been diversified, made redundant, and made seismic-resistant

○ Firefighting system pipes buried outside underground have been relocated above ground, building water feed inlets have been installed, and joints have been welded.

○ Chemical fire engines have been deployed on-site, fire protection tanks have been erected, and the number of large fire extinguishers has been increased.



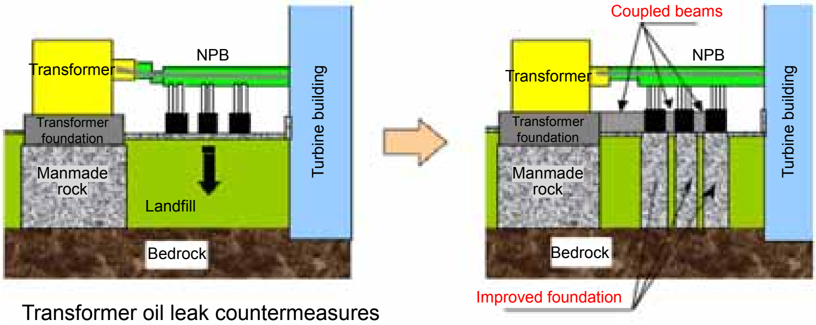


2. Reinforcing the foundation around transformers

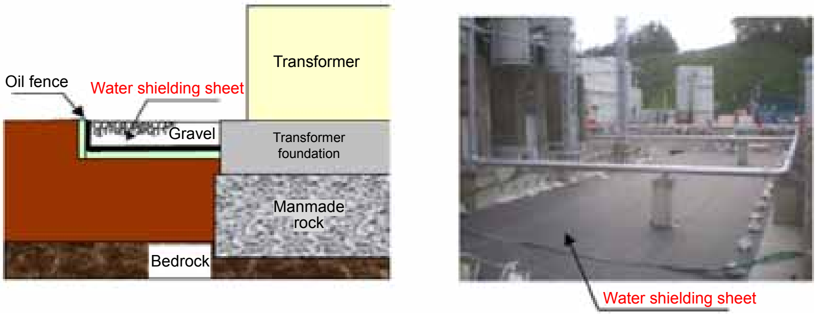
- The Niigata-Chuetsu-Oki Earthquake caused the foundation around transformers and surrounding equipment to subside. The difference between the foundation structures of each piece of equipment caused uneven subsidence.
- In conjunction with this subsidence the secondary bushing terminal of the transformer came in contact with the non-segregated phase bus (NPB) duct. This caused an arc discharge that ignited insulation oil leaking from the transformer thereby resulting in a fire.
- Furthermore, insulation oil leak into the ground because the transformer oil fence was damaged by the earthquake.

→ As a countermeasure for uneven subsidence the ground beneath the NPB foundation was improved and the foundation was unified with that of the transformer. A rubber insulation sheet was also installed within the duct as a measure to enhance NPB duct insulation. And, an incombustible water shielding sheet (polychlorinated vinyl sheet) that conforms to displacement has been attached to the inside of the oil fence in order to prevent insulation oil from leaking into the soil in the event that the oil fence is damaged.

Transformer foundation subsidence countermeasures



Transformer oil leak countermeasures
Water shielding sheet attached



3. New installation of seismic isolated building

- The Niigata-Chuetsu-Oki Earthquake hindered first response, such as emergency notification, by preventing entry into the Emergency Response Center (ERC) due to damaged doors.

→ Equipment function necessary for first response has been secured even in the event of a magnitude 7 earthquake.

○ Adopting a seismic isolated structure reduces earthquake vibration

○ Power supply has been enhanced by installing an emergency generator

○ The center has been equipped with important equipment, such as communications equipment and computers


Outer view of seismic isolated building

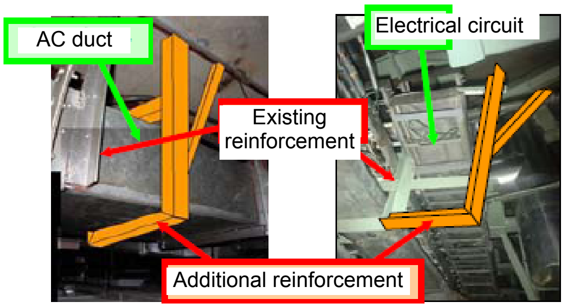

Emergency Response Center

4. Reinforcing emergency air conditioning facility and electrical circuits

In order to improve seismic-resistance emergency, air conditioning facility and electrical circuits (cable trays, wire conduits) have been reinforced.

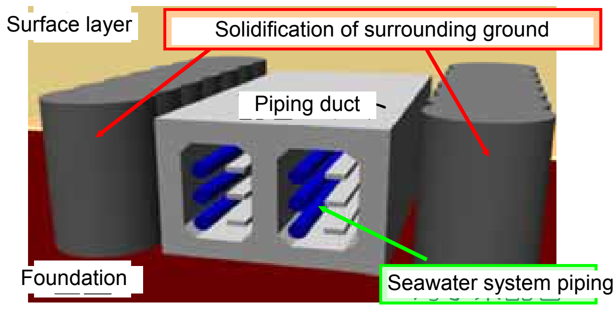
○ Additional reinforcement of emergency air conditioning facility

○ Additional reinforcement of electrical circuits



5. Reinforcement of emergency seawater system piping ducts

The earth surrounding piping ducts has been solidified in an effort to improve seismic-resistance.



6. Other countermeasures

Anchoring machinery

New reinforcements installed

Preventing drums from falling

Drums secured with belts

Installing handrails

Installation of a handrail at the control panels in the Main Control Room

Background on Accident Management Development

[Policy Statement concerning Accident Management (AM)]

May 1992 The Nuclear Safety Commission (NSC) strongly recommended that operators develop AM measures. The NSC decided that reports from administrative agencies on actual policies and measures are to be given to the NSC as necessary.

(Basic approach to AM development (NSC Decision documents and others)
- Safety of reactor facilities in Japan is ensured by current safety regulations by implementing strict safety measures based on the defense-in-depth concept.
- As a result, the possibility of severe accidents is sufficiently low to the extent that such accidents would not be deemed as realistic from an engineering viewpoint, and thus, the risk of reactor facilities is considered to be sufficiently low.
- Implementation of accident management should be recommended or expected as long as implementation is possible without drastic modification of equipment of reactor facilities and it reduces risk effectively.)

July 1992 The Ministry of International Trade and Industry (MITI), currently METI, strongly requested that operators develop AM measures, and decided that it would request the operators reports in which AM details, etc. were compiled and evaluate such for adequacy.

[Confirming the Adequacy of Accident Management (AM) Plans]

March 1994 TEPCO reported to the Ministry of International Trade and Industry (MITI), currently METI, on the deliberation results of AM developments for each TEPCO nuclear power station unit.

(The following were picked up as the functions that should be examined in order to further improve safety:
- Alternative cooling water injection measures (configuration that allows cooling water injection using the make-up water condensate system (MUWC) and fire pumps
- Means of removing heat from the PCV (PCV hardened vents)
- Power supply means (power source cross-ties with neighboring plants))

October 1994 The Ministry of International Trade and Industry (MITI), currently METI, determined that the details above reported on by the operator were adequate and so reported to the NSC. The Ministry also urged the operator to develop AM measures within the following six years and required the operator to give appropriate notification in regard to those developments even if they did not require government approvals and licenses.

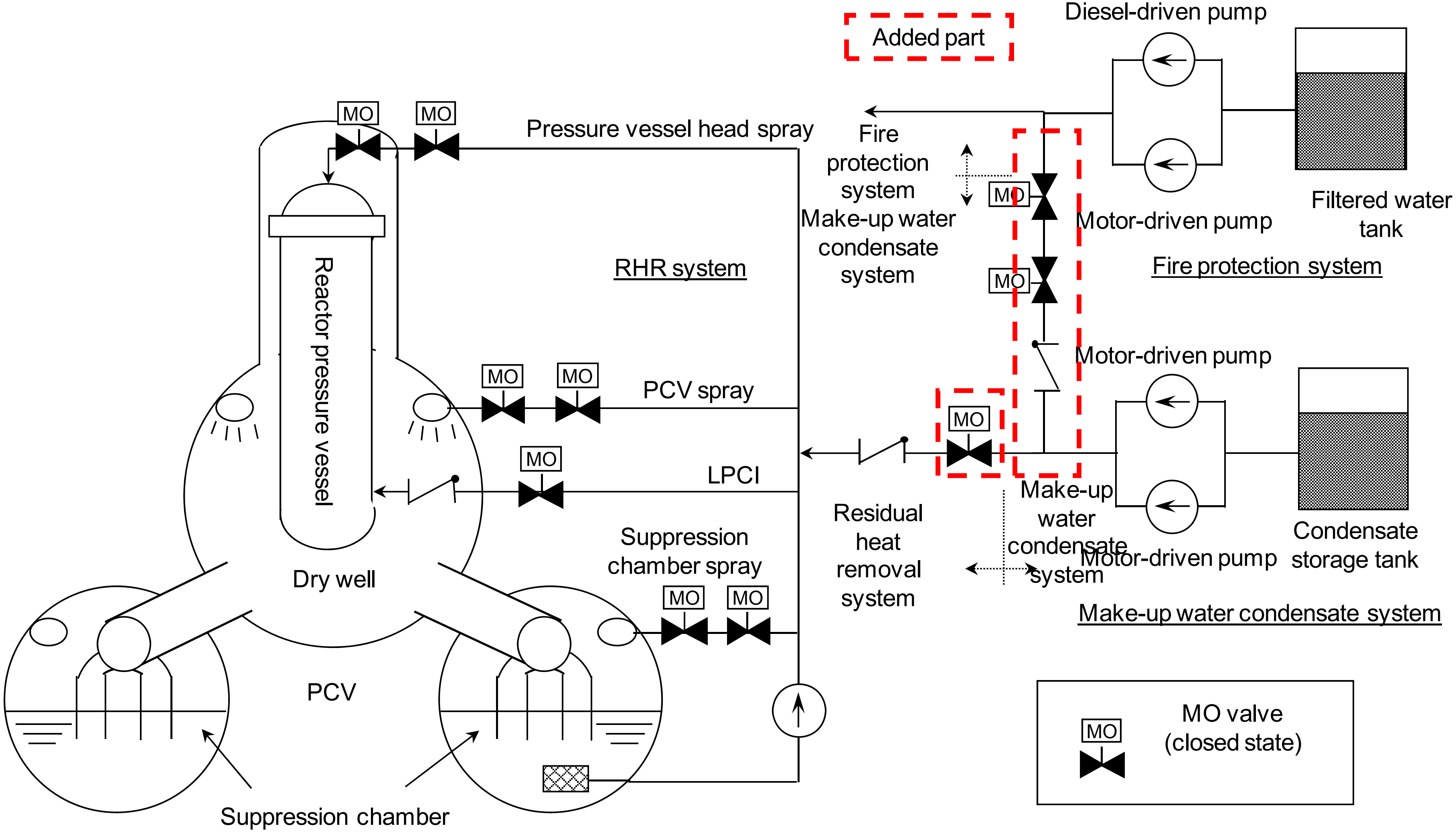
December 1995 The NSC determined that the report from the Ministry of International Trade and Industry (MITI), currently METI, (i.e., the report that suggests that the AM plans by the operator were adequate) to be adequate.

[Report on the Results of Accident Management Development]

Thereafter, operators (including TEPCO) developed AM measures, such as renovating their facilities, and reported on the status of developments and submitted an efficacy evaluation to the Nuclear and Industrial Safety Agency (NISA) (in May 2002). NISA deemed the operator reports to be adequate and so reported to the NSC.

Prepared AM details
- Reinforcing "cooling down" function -

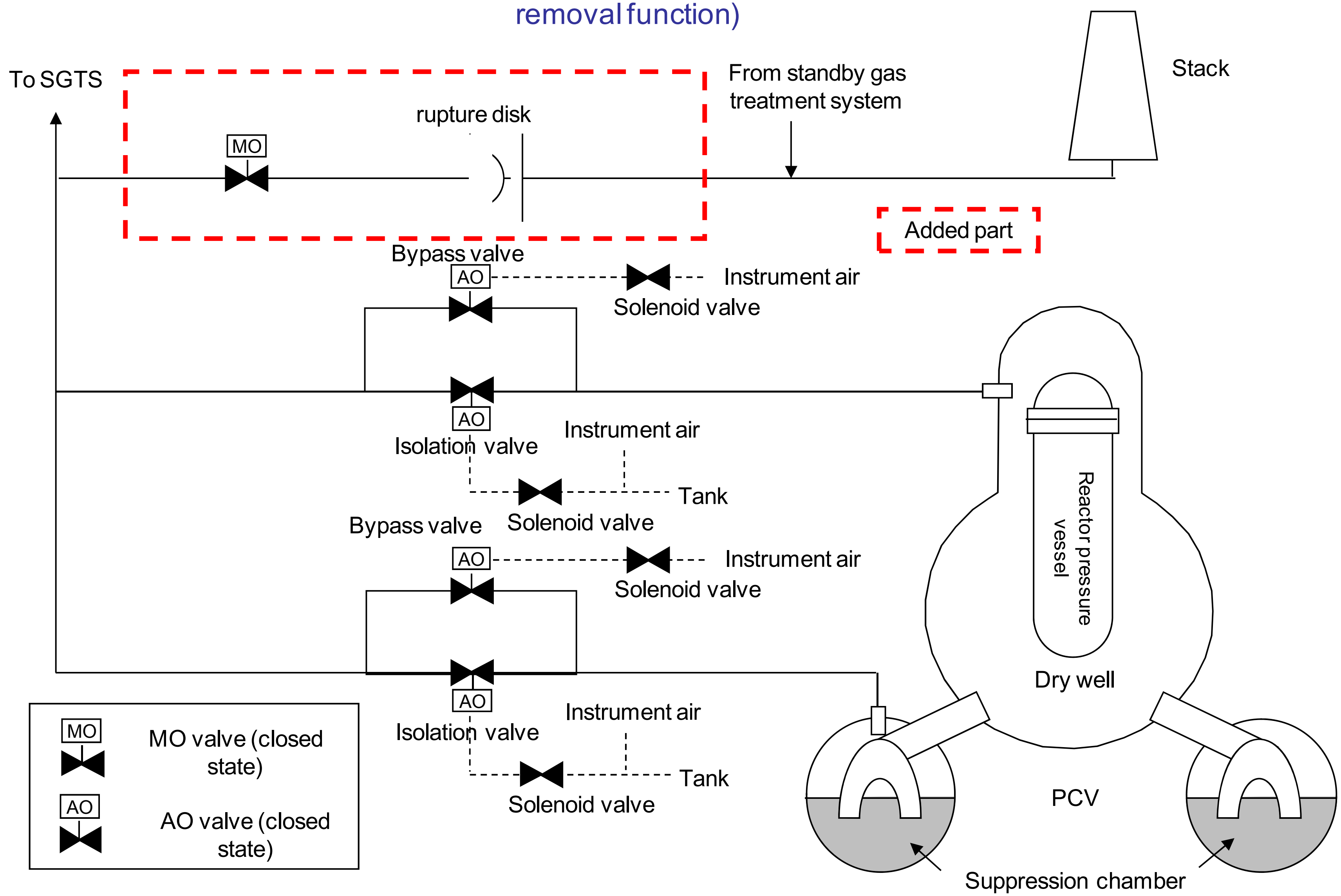
Implemented line modification to enable reactor cooling water injection from make-up water condensate system (MUWC) and fire protection system (FP) in the event of all emergency core cooling system (ECCS) failure



Attachment 4-7 (1/3)

- Reinforcing "confining inside" function -

Reinforced PCV venting (PCV hardened vent) in the event that all RHR systems fail (Loss of PCV heat removal function)



Attachment 4-7 (2/3)

- Reinforcing power supply function -

Secure power supply from neighboring units in the event that all EDG fail

When AC power cannot be supplied do to loss of power accident

--> Core damage due to station black out

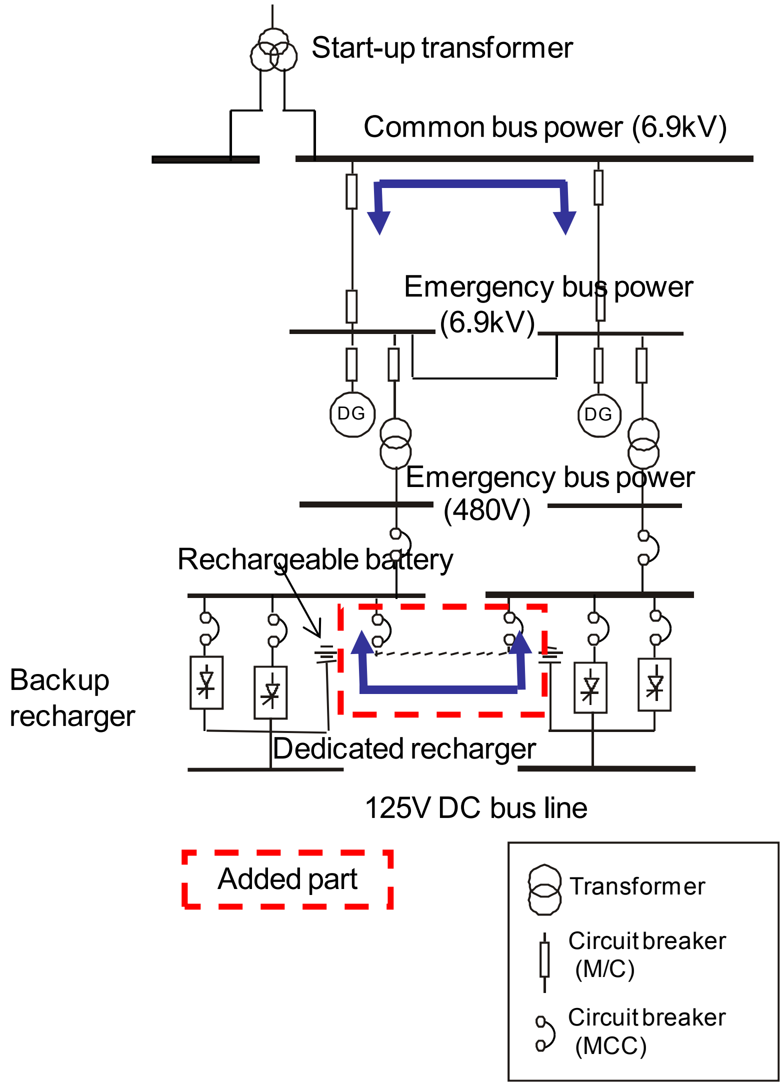
AM measure preparations

(1) Interconnecting power

Interconnecting high pressure / low pressure AC power

(2) Restoration of EDG

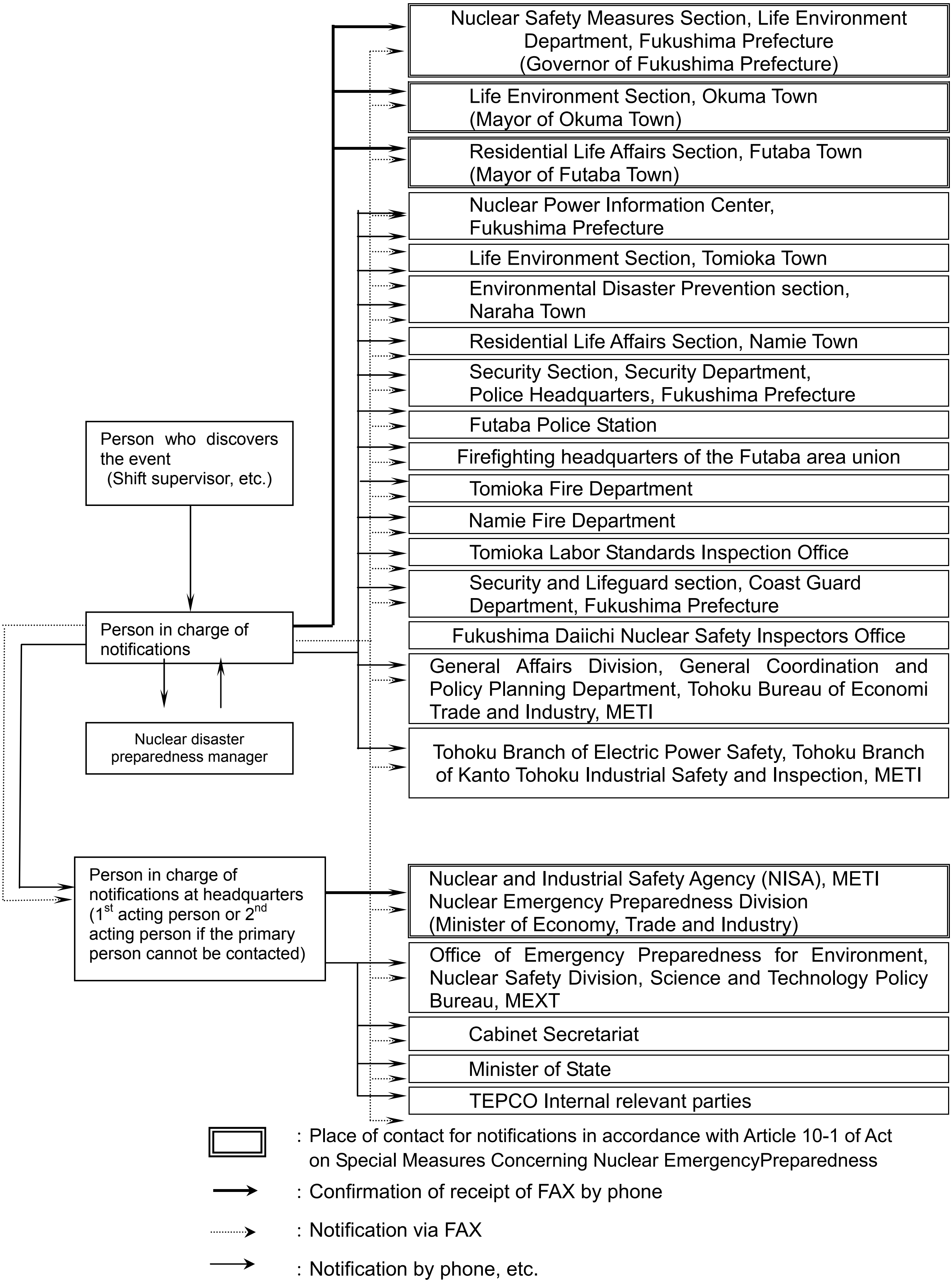
Restore the EDG using extra time



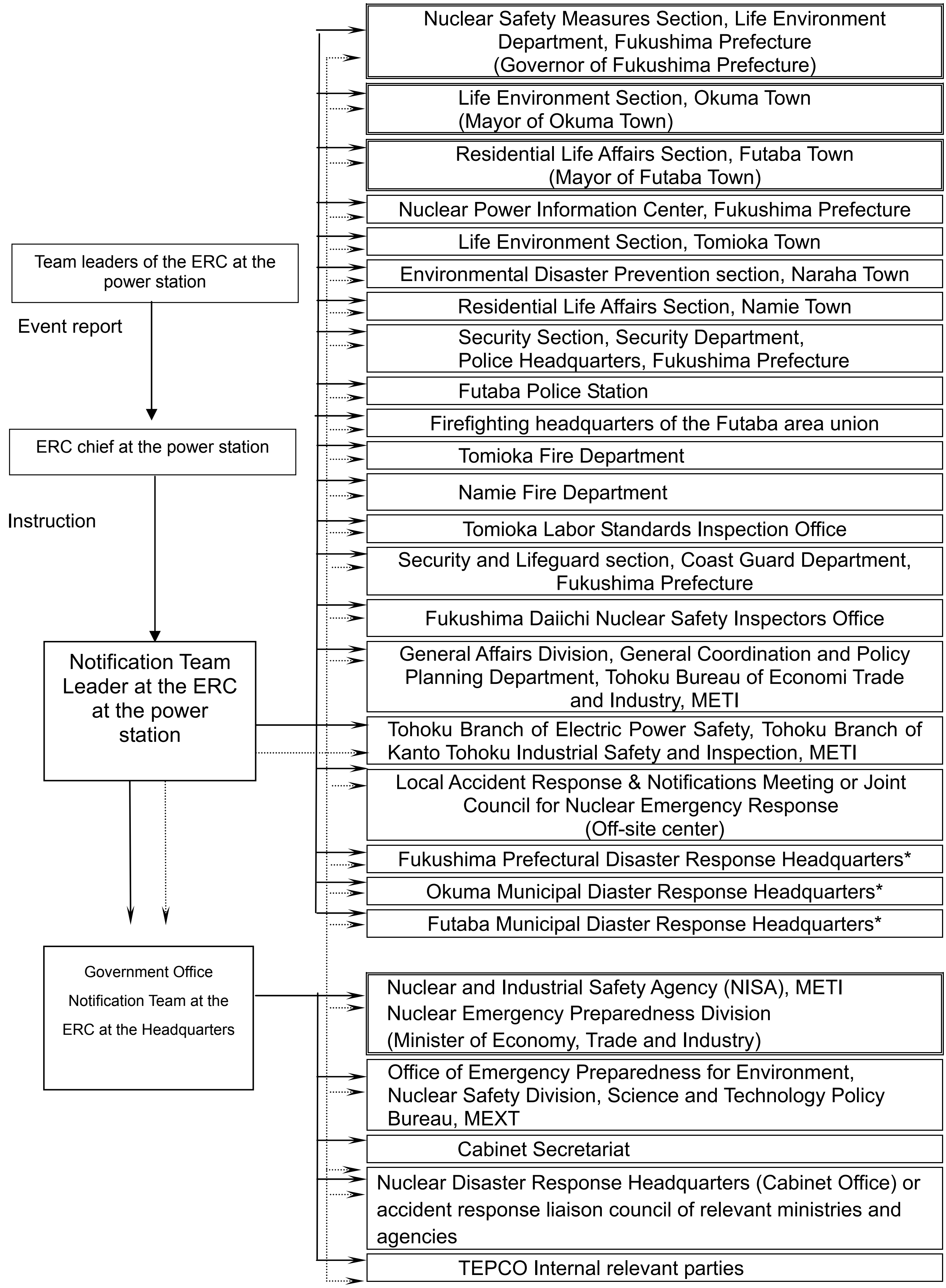
Attachment 4-7 (3/3)

Where to make notifications in accordance with Article 10 of Act on Special Measures Concerning Nuclear Emergency Preparedness

(Fukushima Daiichi Nuclear Power Station)



Where to notify after making notifications in accordance with Article 10 of Act on Special Measures Concerning Nuclear Emergency Preparedness
(Fukushima Daiichi Nuclear Power Station)



▭ : Place of contact for notifications of the summary of immediate actions taken in accordance with Article 25-2 of Act on Special Measures Concerning Nuclear Emergency Preparedness

⇢ : Notification via FAX

→ : Notification by phone, etc.

※ : Only for cases when an emergency disaster countermeasures headquarters has been established.

Organization structure and duties of the nuclear disaster prevention organization at the power station

Chief who oversees and manages the ERC: Nuclear disaster preparedness manager (Site superintendent)

Team	Duties
Information Team	1. Receiving information from and delivering information to the ERC at the Headquarters 2. Collecting information of each team
Notification Team	1. Reporting to external relevant organizations
PR Team	1. Response to media
Engineering Team	1. Grasping and evaluating accident conditions 2. Estimate of the area of accident impact 3. Examining measures to prevent the spread of accident impact
Health Physics Team	1. Grasping the radiation / radioactivity status inside and outside the power station 2. Exposure management / contamination management 3. Estimate of the area of radioactivity impact
Restoration Team	1. Drawing up and implementing the emergency recovery plan 2. Drawing up the accident restoration plan 3. Firefighting activities
Plant Operation Team	1. Grasping accident status 2. Implementing operational measures necessary for mitigating the impact of the accident 3. Maintaining the safety of power station facilities
Procurement Team	1. Procurement and transportation of supplies and equipments 2. Secureing transportation
Welfare Team	1. Procurement of food supplies and clothing 2. Arrangement of accommodation
Medical Team	1. Medical activities
General Affairs Team	1. Dissemination to site workers 2. Establishment and administration of the ERC 3. Calling on and transporting personnel 4. Matters that do not fall under other teams
Security Guidance Team	1. Guarding the site 2. Directing evacuation of people on-site 3. Administration of the physical protection facility

Organization structure and duties of the nuclear disaster prevention organization at the headquarters

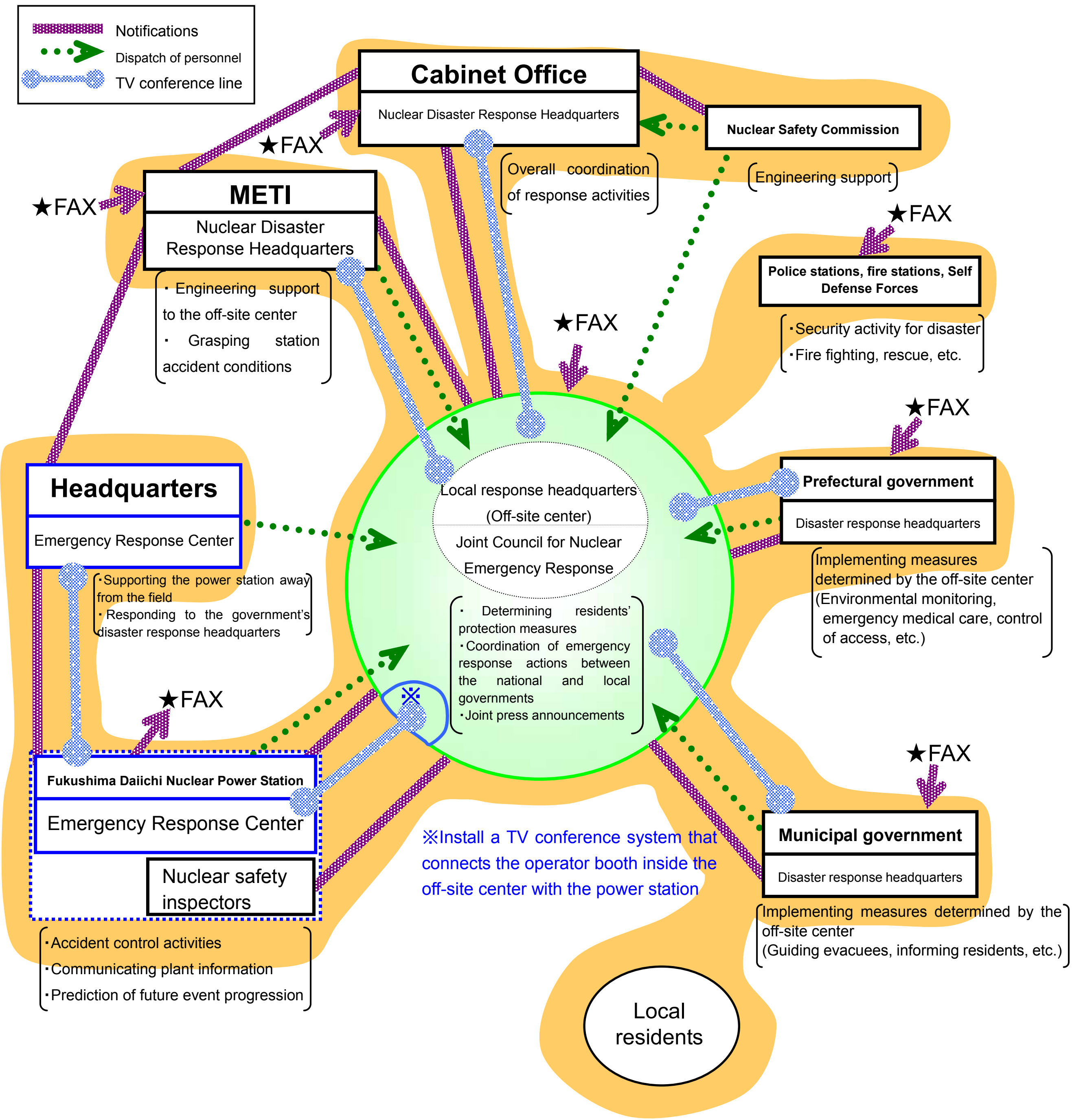
Chief who oversees and manages the ERC: President

Team	Duties
Information Team	1. Delivery of headquarters orders 2. Receiving information from and delivering information to the ERC at the power station
Government Office Notification Team	1. Reporting and notifications to central government offices
PR Team	1. Response to media 2. Response to customers
Power Supply Team	1. Operation of the power grid 2. Adjustment of supply/demand
Health Physics Team	1. Grasping the damage of the power station 2. Administering of radiation control
Engineering / Restoration Team	1. Grasping accident condition 2. Evaluation of the area of accident impact 3. Administering of immediate restoration 4. Evaluation of the mitigation measures for the accident 5. Dispatch of expert engineers to the site
Procurement Team	1. Procurement of restoration materials 2. Emergency transportation of restoration materials, doctors, etc.
Welfare Team	1. Procurement of food supplies / clothing 2. Arrangement of accommodation 3. Arrangement of medical specialists, specialized hospitals 4. Administration of medical activities
General Affairs Team	1. Establishment and administration of the ERC 2. Emergency call-up of personnel 3. Security activity of the headquarters building 4. Request of support to other nuclear operators

Transition of emergency response preparation

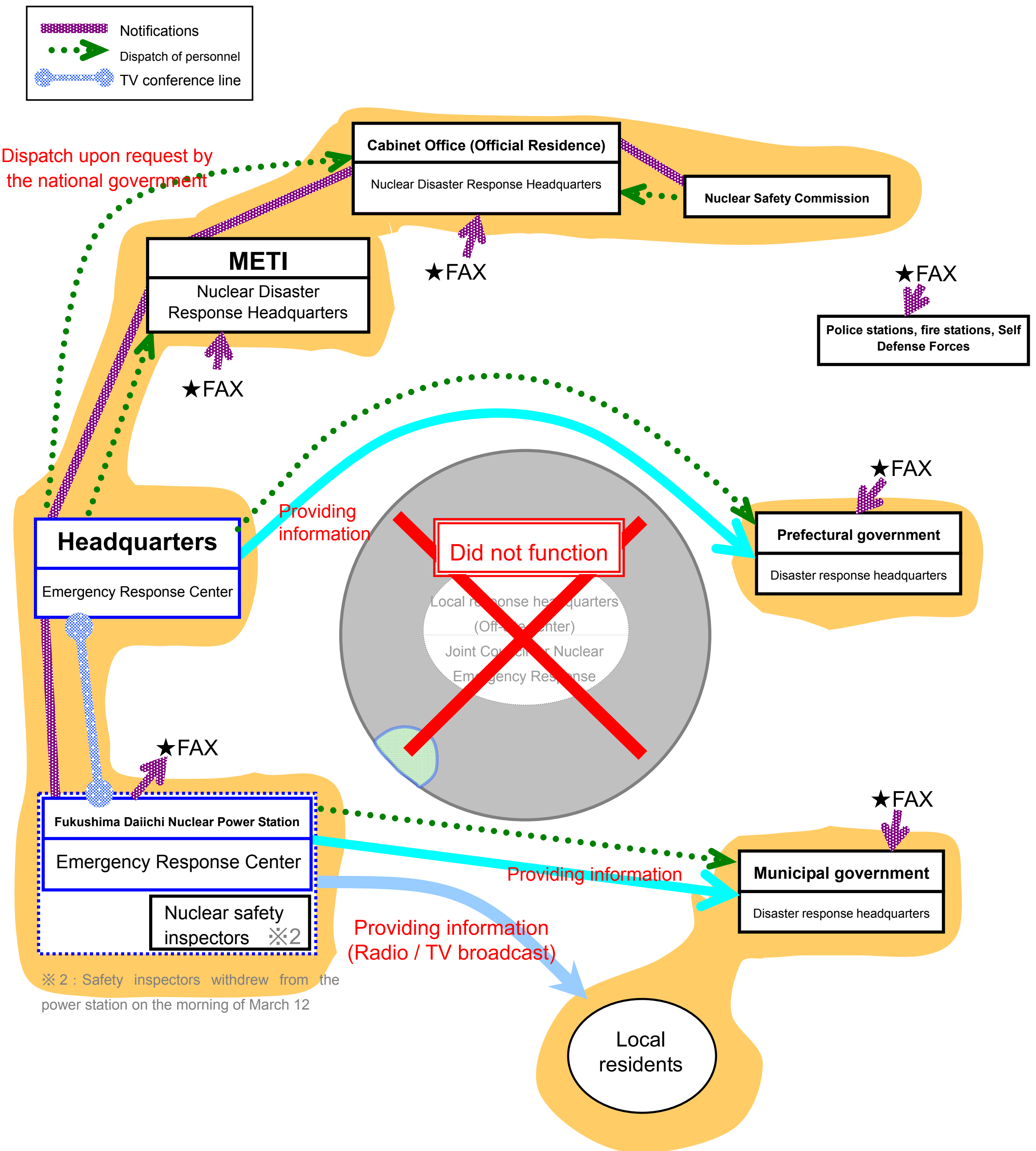
<Original response structure>

Most of the authority of the Nuclear Disaster Response Headquarters shall be delegated to the local response headquarters, and **the off-site center focuses on responding.**



Transition of emergency response preparation
<From 19:03 on March11 to early on March 12>

The Nuclear Disaster Response Headquarters was established at the Official Residence, but the off-site center could not carry out its actions due to power outage, etc.

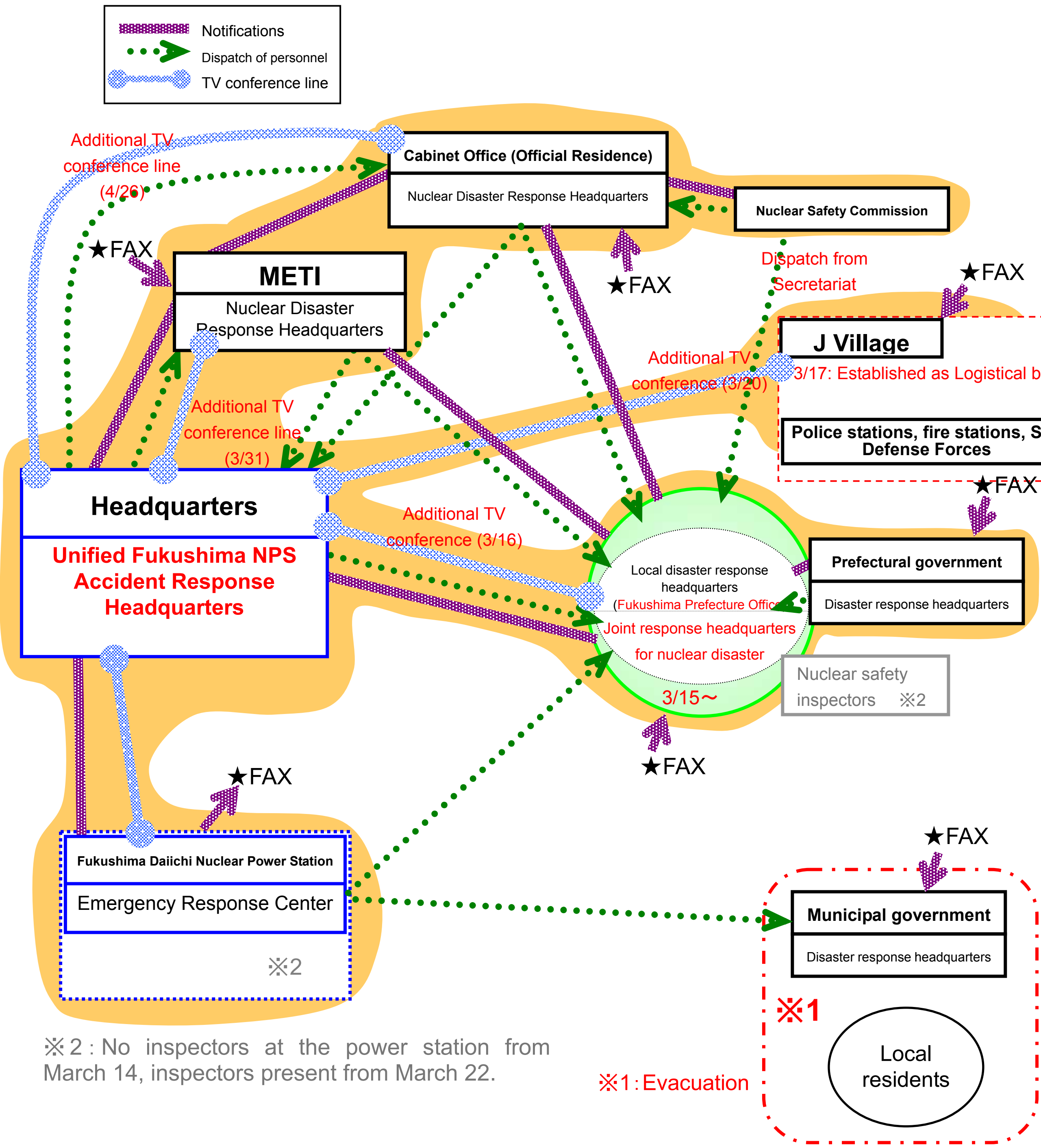


※2 : Safety inspectors withdrew from the power station on the morning of March 12

Transition of emergency response preparation

<After 5:35 on March 15>

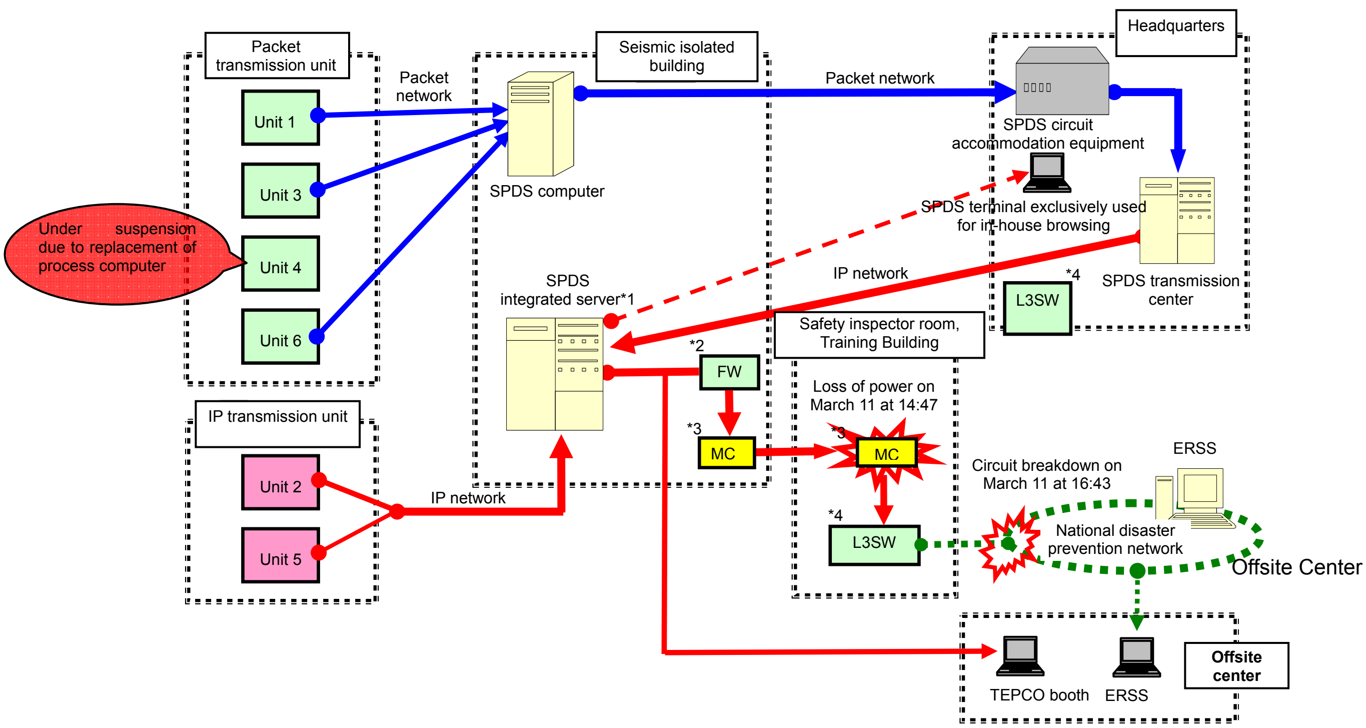
The national government announced the establishment of the Unified Fukushima NPS Accident Response Headquarters (currently National Government and TEPCO General Response Office). The Unified Headquarters was dissolved on December 16.



※2 : No inspectors at the power station from March 14, inspectors present from March 22.

Safety Parameter Display System

1. Safety Parameter Display System (SPDS) Overview
   - TEPCO's SPDS, which enables a fast response to accidents by enabling plant data to be shared in places other than the main control room (MCR) in the event of an accident at a TEPCO nuclear power station (NPS) have been established.
   - Currently the system is configured to transmit plant data to not only seismic isolated buildings (power station emergency response centers (ERC), etc.), but also to TEPCO headquarters and the central government.
   - In April 2009, the Nuclear Industrial Safety Agency (NISA) sent out a written order to nuclear operators demanding that nuclear power station plant operation data be regularly transmitted to the Emergency Response Support System (ERSS).
   - Conventionally, data from TEPCO's three NPSs SPDS would be transmitted to ERSS after first being compiled at headquarters; however this meant that all data from the three NPSs would be unable to be transmitted if there was a facility malfunction at headquarters. In order to mitigate this risk it was decided that the system would be changed so that data is sent directly from each power station.
   - At the Fukushima Daiichi NPS, transmission routes were altered in November 2010 to allow direct transmission from the power station, but only data from Unit 5 and Unit 2 could be directly sent leaving data from Unit 1, 3, 4, and 6 to be sent to headquarters via conventional facilities after which it was then sent back to the power station's server and then to the ERSS. A diagram is shown below.



*1 Backup power supplied by batteries and gas turbine generators in the seismic isolated building
*2 FW: Firewall
*3 MC (media converter): Device for mutually connecting differing conducting mediums and standards, such as fiber optic cable and copper wires, and converting signals.
*4 L3SW (layer 3 switch): Controls channels via IP addresses and forwards packets to the output port of the intended IP address

2. Fukushima Daiichi SPDS equipment

- SPDS facilities housed in the seismic isolated building includes the SPDS integrated server, SPDS computer system, firewall (FW) and media converter (MC).
- Meanwhile, the central government's disaster prevention network to which ERSS is connected is located in the Safety Inspector Room (1st Safety Inspector Room) in the training building within the power station site and has a layer 3 switch (L3SW) and a device for transmitting plant data received from TEPCO to the ERSS.
- Seismic isolated building SPDS facility uses the same AC power source as the seismic isolated building but also has CVCF battery power sources for use during power outages as a backup. The system is configured to supply the minimum amount of power necessary until

power can be supplied by the seismic isolated building facility dedicated gas turbine generator.

- In addition to receiving electricity generated by Unit 1, the 1st Safety Inspector Room in which ERSS facility is located can also receive power from the Okuma Unit 1 line (off-site power) or TEPCO genshiryoku line (backup power source) as backup power in the event that Unit 1 stops. Furthermore, ERSS are also equipped with uninterruptible power sources (UPS) owned by the government as backup power sources.

3. Background behind Fukushima Daiichi SPDS Transmission Failure

(1) Time of ERSS transmission failure

- When the integrated SPDS server in the power station's seismic isolated building was examined it was found that plant data for all units was last transmitted to the ERSS at 14:47 on March 11.
- Meanwhile, information from the Japan Nuclear Energy Safety Organization (JNES), which has been consigned by the government to maintain and manage the ERSS, indicates that plant data for each of the Fukushima Daiichi units was last transmitted to the ERSS at the following times.

Unit 1: March 11, 14:46* (data was being transmitted at 10 min. intervals at the time)
Unit 2: March 11, 14:47 (data was being transmitted at 1 min. intervals at the time)
Unit 3: March 11, 14:47 (data was being transmitted at 1 min. intervals at the time)
Unit 4: data was not being transmitted because the processing computer system was being replaced
Unit 5: March 11, 14:47 (data was being transmitted at 1 min. intervals at the time)
Unit 6: March 11, 14:40* (data was being transmitted at 10 min. intervals at the time)

*The times differ for Unit 1 and Unit 6 because plant data from these units was being transmitted at 10 min. intervals and the time from the last transmission is recorded and saved until it is updated.

- Furthermore, according to JNES information, an abnormality in the connection status with the seismic isolated building FW was detected at the L3SW located in the 1st Safety Inspector Room at 14:52 on March 11 (5 min. cycles) so it is assumed that the last transmission occurred at 14:47 and that the abnormality was detected 5 minutes later at 14:52. Also, there is information that indicates that a malfunction in the line from the L3SW to the central government's disaster prevention network, in other words the government's system, was detected at 16:43 on March 11 and stopped functioning approximately one hour after the tsunami arrived.

(2) Data transmission from the processing computer systems of Unit 2 and Unit 5 (IP line)

- A check of the log of the integrated server located in the seismic isolated building revealed that plant data was being sent from the processing computer systems of Unit 2 and Unit 5, for which an IP line had been installed, to the SPDS integrated server until the following times.
  Unit 2: March 11, 15:52
  Unit 5: March 12, 16:52

Furthermore, whereas it cannot be confirmed that the processing computer systems themselves shut down at the above times a warning issued by the processing computer system in the event of a plant abnormality was recorded at around the time when transmission ended.

(3) Data transmission from the processing computer systems of Units 1, 3, and 6 (packet transmission)

- Unlike Unit 2 and Unit 5, Units 1, 3, and 6 had not yet been equipped with an IP line for direct transmission so data was first sent from the power station processing computer systems and SPDS computer systems to the SPDS transmission server located at headquarters via packet transmission after which it was transmitted to the government system ERSS upon being returned via IP line to the integrated server located in the seismic isolated building.
- A check of the headquarter SPDS transmission server log revealed that an automatic line reset request was sent at 14:51 on March 11 in order to restore packet transmission for all units (Unit 1, 3 and 6). This happens when the line for transmitting plant data from the processing computer system to the SPDS transmission server at headquarters is momentarily interrupted and indicates that packet transmission may

have been interrupted once. It is assumed that thereafter line reset requests were issued repeatedly and the packet line became unstable.

- Therefore, when the status of the SPDS was examined in detail it was found that at 14:49 there was a transmission malfunction log that remained for Unit 1 and Unit 3. Unit 6 was transmitting plant data without any problems.

(4) Background behind Fukushima Daiichi SPDS facility changes (supplement-1)

- The actual transmission route change work that was mentioned previously took place in November 2010 at which time a line was installed from the seismic isolated building to the 1st Safety Inspector Room. Since the 1st Safety Inspector Room is quite a distance away from the seismic isolated building TEPCO decided to use fiber-optic cable which would lead into a fiber-optic connection box installed in the same office. In order to transmit plant data to the central government's ERSS an MC was newly installed in the 1st Safety Inspector Room in order to convert the data to be sent to the ERSS into an electric signal. This required that a fiber-optic cable be used to connect the fiber-optic connection box to the MC and a LAN cable be used to connect the MC to the central government's L3SW.
- As mentioned earlier, whereas the 1st Safety Inspector Room in which the MC is located has a backup power source, JNES was approached about connecting a UPS to the MC in the event of a power loss and approval was obtained (this was a voluntary request made by TEPCO that was not dictated by power source configuration specifications).
- The boundary between jurisdictions of TEPCO and government facility lies between the MC and the L3SW, so connection work up to the L3SW was implemented by TEPCO. Before work was done TEPCO department managers met with JNES in advance to discuss power connections and then a visit was made to the 1st Safety Inspector Room since confirmation from the field was indispensable.
- During the advance meeting between JNES and TEPCO, TEPCO headquarter department managers received materials with photos of

the racks that house L3SW and UPS, which is government facility, but this information was not provided to managing departments at the power station until prior to confirmation in the field.

- During the preliminary check prior to installing work at the 1st Safety Inspector Room, the location of the rack housing the L3SW for the ERSS (power connection location) was told by the safety inspector so the MC was to be installed on a TEPCO rack that was in the vicinity. On a later date after the power was connected, connection on the internal network side was confirmed.
- Thereafter, when TEPCO workers were about to install the MC and the L3SW in the 1st Safety Inspector Room in order to transmit data it was found that the manufacturer that was consigned by JNES had pointed out that the L3SW be housed in a rack that differed from the location told by the safety inspector and that the UPS power connection location was also in a different location.
- A longer LAN cable was procured and the connection to the L3SW was made. But, connecting to UPS power now required a power cable that was approximately 6m longer than the cable procured for connection from the outlet that was originally going to be the point of UPS connection.
- To solve the problem the MC could have been installed within the rack that houses the ERSS, or nearby, but this would have required a another fiber optic cable that was reinforced for exposure since the MC would then have been far from the fiber optic cable connection box, and procuring this cable and coordinating with other parties would have taken much time, so it was decided that a long power cable would be used instead.
- The UPS could not be connected to the MC for use as a backup power source, however since not connecting the UPS does not hinder operation and connection to a UPS was not required according to power configuration specifications it was decided that transmission test to the ERSS should be prioritized and transmission tests were performed with the MC power source as it was.
- This was explained to the safety inspector and it was decided that connection to the UPS would be performed at a later date upon coordinating with work parties once again.

- Furthermore, hardware stores in the vicinity of the power station were visited in order to procure a power cable but a cable of sufficient length could not be found. Thereafter procuring and connecting a longer cable was forgotten about amidst the large scale communications-related construction that was underway in the seismic isolated building and at monitoring post facilities, so as a result the UPS was still not connected on March 11, the day of the earthquake.

(5) Line connection status of TEPCO facilities and central government disaster prevention network

After it was found that data was not being transmitted to the ERSS following the earthquake, TEPCO checked the connection between the L3SW and the FW located in the seismic isolated building and learned that transmission was not possible. Information received from JNES also indicates that the L3SW located in the 1st Safety Inspector Room detected (5 min. cycles) an abnormality in the connection with the FW of the seismic isolated building at 14:52 on March 11.

Information obtained from JNES also shows that a malfunction of the line from the L3SW to the central government's disaster prevention network was detected at 16:43 on March 11.

(6) Regular transmission to ERSS after March 28 (supplement-2)

- After March 24 preparations were made to use data transmission lines via the L3SW located at headquarters that had been used conventionally. After transmission tests were completed on March 28 plant data for Unit 6 for which the processing computer system was still running was regularly transmitted from the FW of the seismic isolated building to the ERSS over the central government's disaster prevention network via the L3SW at headquarters.
- Then on May 25 the processing computer system of Unit 5 was restarted and plant data was sent to the ERSS over the same lines as Unit 6.

(7) Results of field confirmation

An inspection of the SPDS equipment located in the seismic isolated building and the 1st Safety Inspector Room revealed that housing racks were sound and that each piece of equipment was not damaged.

(8) Cause of Fukushima Daiichi SPDS data transmission failure

From the factual relationships mentioned previously it is presumed that the cause of the transmission failure of plant data for all units to the ERSS that occurred at 14:47 on March 11 is as follows.

- Due to the facts that the test of the connection between the FW in the seismic isolated building and the L3SW located in the 1st Safety Inspector Room failed, that plant data for Unit 2 and Unit 5 was being transmitted to the SPDS integrated server until 14:47, and that an abnormality between the L3SW and the central government's disaster prevention network was detected at 16:43 on March 11 it is presumed that the cause of the failure to transmit plant data from all units to the ERSS occured somewhere between the FW and the L3SW.
- Of the lines and equipment from the FW to the L3SW it was discovered that the MC located in the 1st Safety Inspector Room lost power immediately after the earthquake.
- Therefore, in consideration of the circumstances, it is considered highly possible that the loss of power to the MC located in the 1st Safety Inspector Room directly caused the transmission failure to the ERSS.

4. Background behind the Fukushima Daini SPDS transmission

(1) Time of ERSS transmission failure

When the integrated server used by the Fukushima Daini SPDS and located in the power station’s seismic isolated building was checked, it was confirmed that plant data was last transmitted to the ERSS at 16:43 on March 11. Furthermore, information obtained from JNES indicates that plant data from each unit was last transmitted to the ERSS at the following times.

Unit 1: March 11, 16:42 (data was being transmitted at 1 min. intervals at the time)
Unit 2: March 11, 16:42 (data was being transmitted at 1 min. intervals at the time)
Unit 3: March 11, 16:43 (data was being transmitted at 1 min. intervals at the time)
Unit 4: March 11, 16:42 (data was being transmitted at 1 min. intervals at the time)

(2) Data Transmission from process computing systems at each Unit
When the integrated server located in the seismic isolated building and the SPDS server located in headquarters were checked no problems were found with the internal system connections between each processing computer system and the integrated server at the Fukushima Daini Nuclear Power Station. It was confirmed that each processing computer system has continued to transmit data without problem from the time of the earthquake until present.

(3) Fukushima Daini SPDS equipment (supplement-3)

- Almost the same configuration of equipment used at Fukushima Daiichi was used at Fukushima Daini with the SPDS integrated server, FW and MC located in the isolated building, the seismic isolated building equipment dedicated emergency gas turbine generator used as a backup power source, and also power sources (batteries) on hand for use during power outages.
- During the accident whereas the emergency gas turbine generator could not be started up as a result of the impact of the tsunami power was supplied to the SPDS integrated server and MC located in the seismic isolated building from batteries on hand for use during power outages, so there was no loss of power.
- The TEPCO MC located in the Safety Inspector Room (2nd Safety Inspector Room) in the information wing of the main building uses the Unit 1 and Unit 2 emergency diesel generators as backup power sources, and also is connected to batteries (UPS) for use during power outages owned by the central government, but since there was no loss of off-site power the electricity supplied to the MC was not interrupted.

(4) Line connection status of TEPCO facilities and central government disaster prevention network
Information from JNES indicates that a line malfunction within the central government's disaster prevention network was detected at 16:43 on March 11.

(5) Regular transmission to ERSS after March 28 (supplement-4)

- After March 24 preparations were made to use data transmission lines via the L3SW located at headquarters that had been used conventionally. After transmission tests were completed on March 28 plant data for all units was regularly transmitted from the FW of the seismic isolated building to the ERSS over the central government's disaster prevention network via the L3SW at headquarters.

(6) Results of field confirmation

An inspection of the SPDS equipment located in the seismic isolated building and the 2nd Safety Inspector Room revealed that housing racks were sound and that each piece of equipment was not damaged.

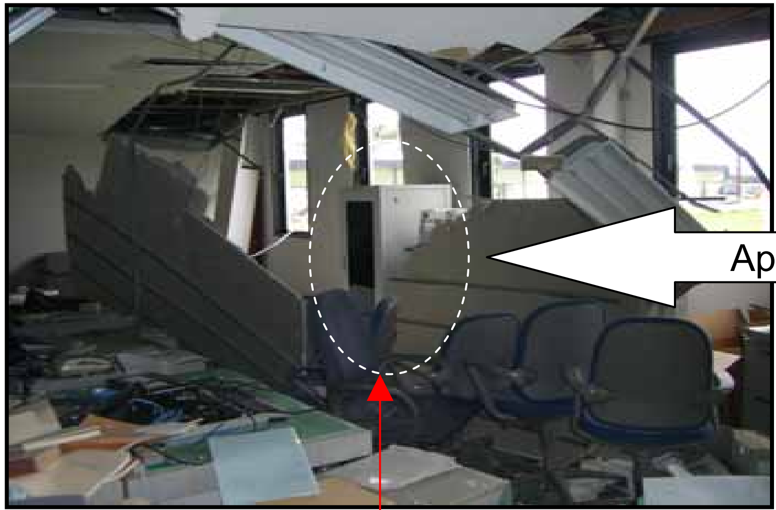
(7) Cause of Fukushima Daiichi SPDS data transmission failure

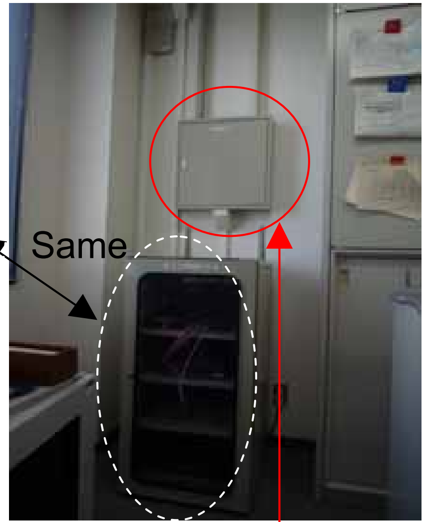
From the factual relationships mentioned previously it is presumed that the cause of the transmission failure to the ERSS that occurred at 16:43 on March 11 is as follows.

- SPDS equipment located in the seismic isolated building and the 2nd Safety Inspector Room was undamaged and supplied with power so it is considered to have been sound.
- Furthermore, an inspection of the integrated server and the SPDS transmission server located in headquarters revealed no internal system problems and it was confirmed that transmission is possible.
- On the other hand, since the time when a line malfunction was detected in the central government’s disaster prevention network is the same as the time when plant data was last sent by TEPCO to the ERSS it is presumed that the line malfunction in the central government's disaster prevention network was a direct cause of the plant data transmission failure to the ERSS from Fukushima Daini.

End

Supplement -1　Fukushima Daiichi NPS Safety Inspector Room SPDS-ERSS Equipment





⑤ Rack where L3SW and UPS were supposed to be installed

①Box in which the fiber optic cable from the seismic isolated building is connected

② TEPCO LAN connection device housing rack
Houses the MC connected by fiber optic cable

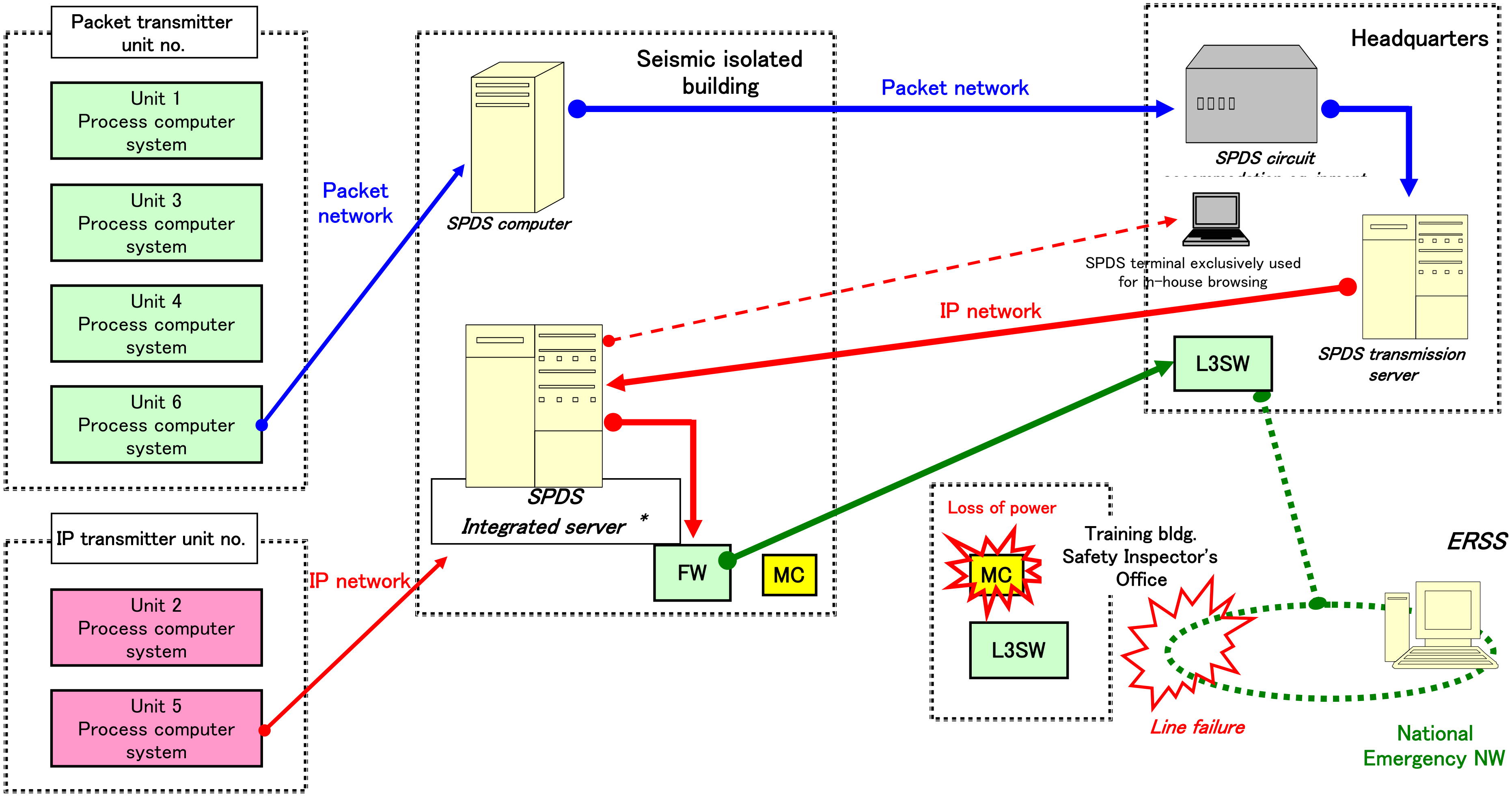
③ Housing rack where the safety inspector mistakenly said the L3SW would be housed upon prior visit for installing work.
An L3SW battery (UPS) was going to be connected to the MC as a backup power source

Inside

④ This device was mistaken for the L3SW because:

・There is an outlet behind the rack to which the device's power cable was connected.
・It was told before two outlets were available and coincidentally two outlets behind this device were also available.
・Power cable was mistakenly thought to be coupled since the power cable extended to the side of the rack where the UPS was housed (left).

Supplement-2 Fukushima Daiichi SPDS facility configuration - state of transmission after headquarters route was secured (after March 28) -



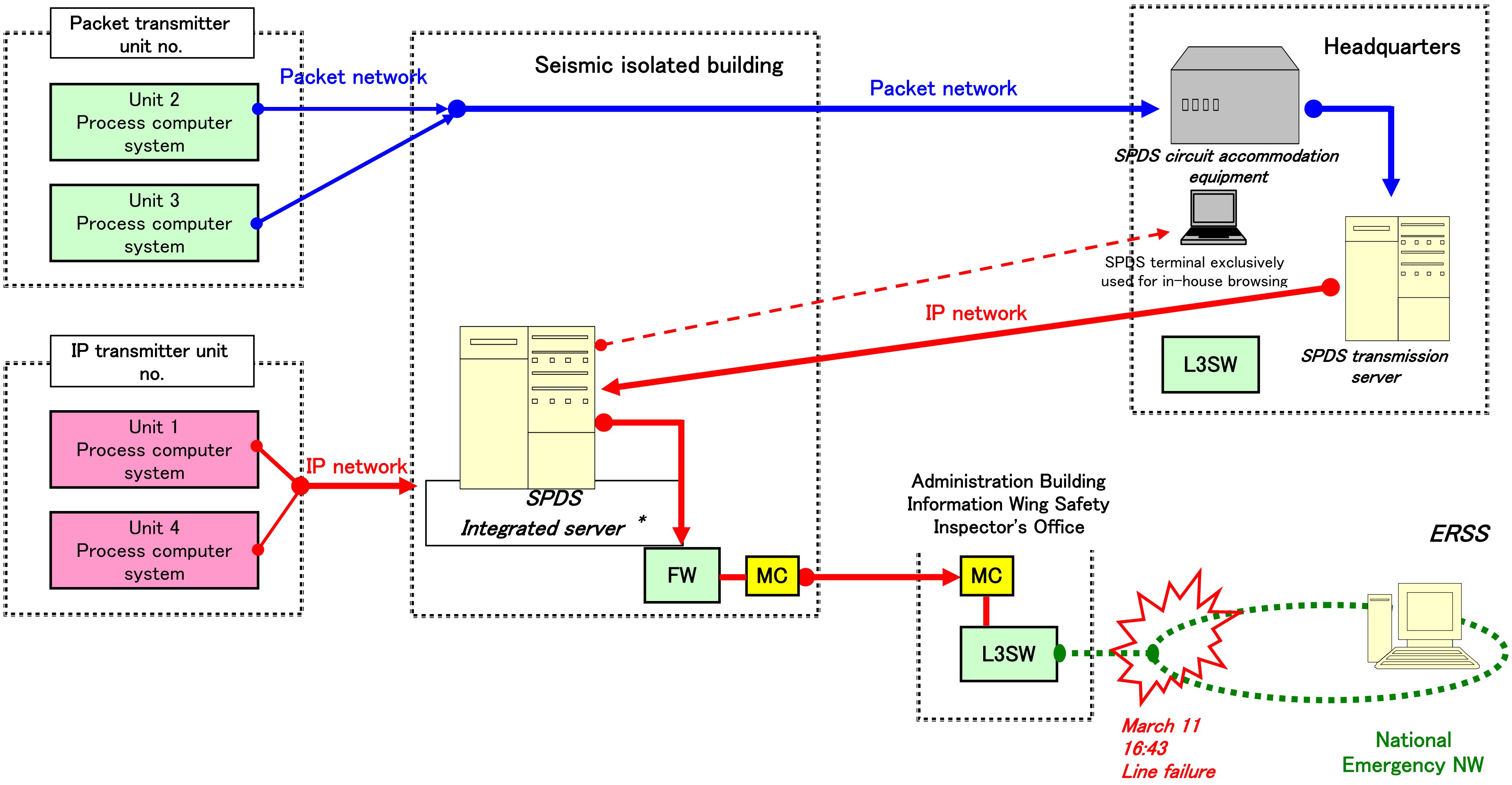
* Backup power supply was the gas turbine generator of the seismic isolated building + battery

Transmission to the ERSS was changed to the transmission route via the headquarters (green line)

Process computer system operation status
Unit 1 ... Shutdown (no power)
Unit 2 ... Shutdown (no power)
Unit 3 ... Shutdown (no power)
Unit 4 ... Shutdown (when the earthquake struck, the process computer system was undergoing replacement)
Unit 5 ... Running (was shut down after the earthquake and kept shutdown due to MCR heat load restrictions, and restarted on May 25
Unit 6 ... Running (did not shut down even during the earthquake)

Attachment 5-5 (12/14)

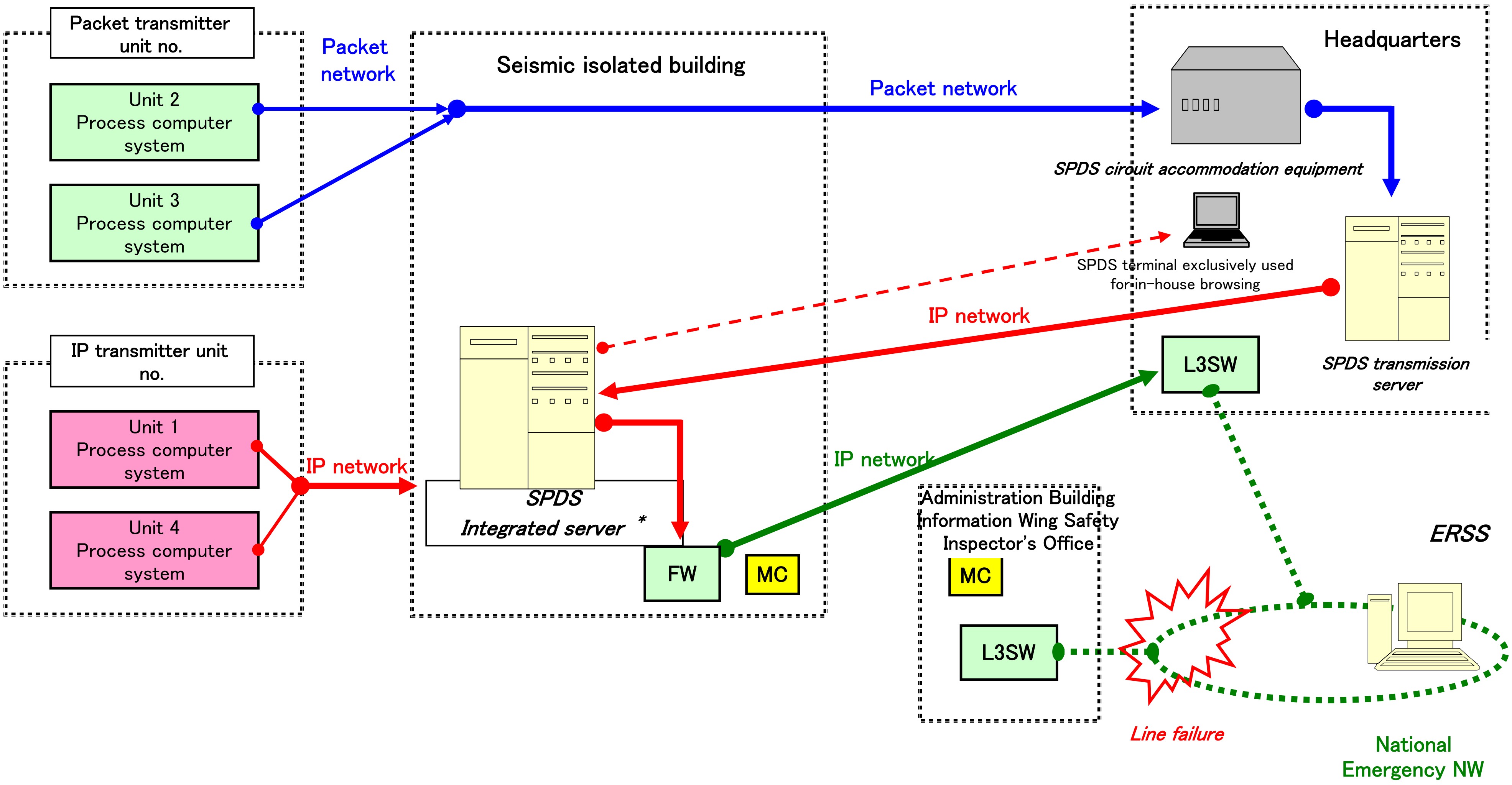
Supplement-3 Fukushima Daini SPDS facility configuration - state of transmission after the earthquake on March 11 -



* Backup power supply was the gas turbine generator of the seismic isolated building + battery

Attachment 5-5 (13/14)

Supplement-4 Fukushima Daini SPDS facility configuration - state of transmission after headquarters route was secured (after March 28) -



*** Backup power supply was the gas turbine generator of the seismic isolated building + battery**

Transmission to the ERSS was changed to the transmission route via the headquarters (green line)

Attachment 5-6

Actions taken by the Siting Team pertaining to the Tohoku-Chihou-Taiheiyo-Oki Earthquake

< Information provided to local community (other than press releases) >

① Radio broadcast

*Request to commercial radio stations in Fukushima Prefecture
(Actual broadcasts: Radio Fukushima: Total 13 times, FM Fukushima: 39 times)

№	Date/time			Content of broadcast (excerpt)
	Date	Requested	Request stopped	
1	3/11 Fri.	21:44	—	An emergency evacuation order has been issued by the central government for residents within a 3km radius around Fukushima Daiichi NPS because the emergency generators to cool the reactor are inoperable at Fukushima Daiichi Unit 2. Please act calmly under the instructions of the central and local governments. No external impact of radioactivity has been confirmed as of now.
2		22:40	3/12 2:38	(In addition to the above evacuation order) Currently, the exhaust stack monitor and monitoring car survey data, which monitors radiation, indicates no change from normal values at both Fukushima Daiichi NPS and Fukushima Daini NPS.
3	3/12 Sat.	7:07	-	An emergency evacuation order has been issued by the central government for residents within a 10km radius around Fukushima Daiichi and Fukushima Daini NPS. Please continue to act calmly under the instructions of the central and local governments.
4	3/13 Sun.	13:15	15:50	An emergency evacuation order has been issued by the central government for residents within a 20km radius from Fukushima Daiichi NPS and within a 10km radius from Fukushima Daini NPS. Please continue to act calmly under the instructions of the central and local governments.
5	3/14 Mon.	12:05	17:28	At around 11:01AM, there was a big sound and white smoke from Fukushima Daiichi Unit 3 reactor building. There is a possibility that it is a hydrogen explosion. According to the parameters, we believe that the integrity of the reactor containment vessel is maintained, but we are currently investigating the plant conditions and external radioactivity impact. We ask residents to act according to the instructions of the central and local governments.
6	3/15 Tues.	9:39	10:56	At around 6:14AM, there was an unusual sound near the suppression chamber at Fukushima Daiichi Unit 2 and a pressure drop; thus, it is determined that, possibly, some kind of unusual circumstance has occurred. However, there is no significant change in reactor pressure vessel and containment vessel parameters. We ask residents to act according to the instructions of the central and local governments.

②Television subtitles

*Requests made to commercial TV broadcasters in Fukushima Prefecture (Fukushima Chuo TV, Fukushima TV, TV-U Fukushima, Fukushima Broadcasting)

No.1 was aired on Fukushima Broadcasting. Others cannot be confirmed to be aired by other TV broadcasters.

№	Date/time			Content of broadcast (excerpt)
	Date	Requested	Request stopped	
1	3/11 Fri.	23:10	-	Currently, the exhaust stack monitor and monitoring car survey data, which monitors radiation, indicates no change from normal values at both Fukushima Daiichi NPS and Fukushima Daini NPS.
2	3/14 Mon.	13:10	18:01	There was an explosion at the reactor building of Fukushima Daiichi Unit 3. We believe that the integrity of the containment vessel is maintained, but we ask that residents act according to the instructions of the central and local governments.
3	3/15 Tues.	9:40	10:56	There was an unusual sound around the suppression chamber at Fukushima Daiichi Unit 2 and a pressure drop; thus, it is determined that, possibly, some kind of unusual circumstance has occurred. However, there is no significant change in reactor pressure vessel and containment vessel parameters.We ask residents to act according to the instructions of the central and local governments.

③PR vehicles (Fukushima Daini NPS only)

№	Date/time			Description
	Date	Start	End	
1	3/11 Fri.	—	—	Considered the dispatch of PR vehicles at the same time as starting the radio broadcast, but due to the damage of nearby roadways, this was not possible for both at Fukushima Daiichi and at Daini NPS.
2	3/12 Sat.	9:50	11:00	Fukushima Daini NPS venting planned (Tomioka Town)
3	3/12 Sat.	9:50	11:20	Fukushima Daini NPS venting planned (Naraha Town)
4	3/12 Sat.	20:15	22:00	Evacuation order made to residents within 10km radius of Fukushima Daini NPS. Request to evacuate according to government office instructions (Hirono Town)

Chronology of Responses to Media Related to the Fukushima Nuclear Accident (Headquarters)

March 11, 2011 (Friday)

Time of release	Format	Content
15:59	Press release	Status of facility damages **(hereafter, headquarters hourly update(15:30))** ・ (Nuclear related) Fukushima Daiichi Units 1 to 3, Fukushima Daini Units 1 to 4 shut down due to earthquake. Fukushima Daiichi Units 4 to 6 under outage. ・ (Power supply related) Power outage at 4.05 million households
16:54	Press release	Determined at 15:42 and notified government agencies that a specified event (station black out) under Article 10 Paragraph 1 of the Act on Special Measures Concerning Nuclear Emergency Preparedness (hereafter, "Nuclear Emergency Act") had occurred at Fukushima Daiichi Units 1 to 3.
(16:30)	Press release	Headquarters hourly update (16:30) ・ (Nuclear related) No abnormal radiation dose ・ (Power supply related) Damage to generation facilities (thermal, hydro) and distribution facilities. Support cross-feed from western areas (1 million kW).
17:40	Press release	Determined at 16:36 and notified government agencies that a specified event (emergency core cooling system water injection not possible) under Article 15 of the Nuclear Emergency Act has occurred at Fukushima Daiichi Units 1 and 2 on account of the fact that the reactor water level could not be confirmed and water injection conditions were unknown. Subsequently, water level monitoring recovered at Fukushima Daiichi Unit 1 and the special event designation was lifted temporarily, but was declared again at 17:07.
19:10	Press release	Headquarters hourly update (18:30) ・ (Power supply related) Number of blackouts updated (4.05 million households to 3.98 million households), update facility damage conditions, activated power adjustment contracts with some high volume customers* (*deleted in the 21:00 update)
19:20	Website	Fukushima Daiichi NPS on-site monitoring data ("Fukushima Daiichi NPS Current Conditions" 19:20)
19:35	Press release	Plant status notification (hereafter, Fukushima Daiichi NPS hourly update 19:00 update) ・ Fukushima Daiichi Unit 1 cooling with IC, Units 2 and 3 water injection with RCIC ・ Ensure reactor water level for Units 4 to 6 ・ No fire, no abnormal radiation
20:40	Press release	Headquarters hourly update (20:00) ・ (Power supply related) Number of blackouts updated (total -> by prefecture), following day tight power supply, request cooperation for power-saving

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

20:45	Website	Fukushima Daiichi NPS on-site monitoring data (20:45) *hereafter, added wind direction
21:20	Press release	Headquarters hourly update (21:00) ・ (Power supply) Number of blackouts updated (3.98 million households->3.8 million households)
21:55	Press release	Fukushima Daiichi NPS hourly update (21:00) ・ Unit 2 cooled with RCIC but operating conditions unknown, water level cannot be verified. Resident evacuation advisory issued (within 3km radius)
22:00	Website	Fukushima Daiichi NPS on-site monitoring data (22:00)
22:30	Press release	Headquarters hourly update (22:00) ・ (Power supply related) Number of blackouts updated (3.8 million households -> 3.44 million households)
23:20	Website	Fukushima Daiichi NPS on-site monitoring data (23:20)
23:30	Press release	Headquarters hourly update (23:00) ・ (Power supply related) Number of blackouts updated (3.44 million households -> 2.97 million households), update facility damage conditions (Higashi Oogi Thermal Power Station)

March 12, 2011 (Saturday)

Time of release	Format	Content
00:30	Press release	Headquarters hourly update (00:00) ・ (Power supply related) Number of blackouts updated (2.97 million households -> 2.58 million households)
00:30	Press release	Fukushima Daiichi NPS hourly update (00:00) ・ Water level confirmed with Unit 2 temporary power source ・ Evacuation order within 3km radius, indoor shelter instructed up to 10km ・ 2 employees whereabouts unknown
00:40	Website	Fukushima Daiichi NPS on-site monitoring data(00:40)
(01:00)	Press release	Headquarters hourly update (01:00) ・ (Power supply related)Number of blackouts updated (2.58 million households -> 2.4 million households), Goi 4 resumed operations
01:35	Press release	Fukushima Daiichi Unit 1, Article 15 notification (determined at 0:49 that there is an abnormal increase of containment pressure)
(02:00)	Press release	Headquarters hourly update (02:00) ・ (Power supply related) Number of blackouts updated (2.4 million households ->2.07 million households)
02:50	Website	Fukushima Daiichi NPS on-site monitoring data (02:50)
Around 03:00	Press release	Headquarters hourly update (03:00) ・ (Nuclear) Decided to vent Fukushima Daiichi NPS units for which

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

		water injection status is unknown. ・ (Power supply) Number of blackouts updated (2.07 million households -> 1.77 million households)
Around 03:00	Press release	Implementation of venting ・ Same content as Headquarters hourly update (03:00)
03:06 - 03:48	Joints press conference (METI)	Joint press conference by Managing Director Komori, METI Minister Kaieda, NISA Director-General Terasaka ・ Minister stated that he received a report from TEPCO that they were going to open the vent valves to release internal pressure due to increased pressure in the containment vessel ・ Senior Managing Director Komori explained that RCIC operation status could not be verified and containment internal pressure was increasing, and thus, containment venting would be conducted as an accident management measure. ・ When questioned which units will be vented first, an answer was given once that preparations will be taken for Unit 2 for which operation of pumps to feed water into the reactor had not been verified for an extended amount of time. ・ Subsequently, TEPCO employee provided an urgent update that Unit 2's RCIC operation was confirmed. Venting was planned and that conditions of both Units 1 and 2 would be checked. The press conference was concluded saying that announcement would be made when implementing.
Around 04:15	Press release	Headquarters hourly update (04:00) ・ (Power supply related) Number of blackouts updated (1.77 million households→1.62 million households), restoration of hydropower
Around 04:15	Press release	Fukushima Daiichi NPS hourly update (04:00) ・ IC was operating but is shutdown. PCV pressure is high but stable. Water level is low but stable. ・ Unit 2 RCIC operation condition is confirmed.
05:00	Press release	Headquarters hourly update (05:00) ・ (Nuclear related) Additional information on increase of radiation ・ (Power supply related) Number of blackouts updated (1.62 million households→1.44 million households)
05:10	Website	Fukushima Daiichi NPS on-site monitoring data (05:10)
06:10	Press release	Fukushima Daiichi NPS hourly update (06:00) ・ Resident evacuation order within 10km radius ・ Radiation measured by monitoring post and monitoring cars increase ・ One contractor loses consciousness, transported by ambulance
06:30	Press release	Headquarters hourly update (06:00) ・ (Power supply related)Number of blackouts updated(1.44 million households→1.24 million households)
Around 07:50	Press release	Headquarters hourly update (07:00) ・ (Nuclear related) Evacuation order for residents within 10km radius

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

		of Fukushima Daiichi and Daini NPSs. ・ (Power supply related) Number of blackouts updated (1.24 million households→1.17 million households), restoration of hydropower
07:50	Website	Fukushima Daiichi NPS on-site monitoring data (07:50)
09:05	Press release	Fukushima Daiichi Unit 1 vent ・ PCV pressure increases, decide to vent
09:20	Press release	Headquarters hourly update (08:00) ・ (Nuclear related) Correction of 7AM update (correct information was 3km radius for Fukushima Daini NPS). ・ (Power supply related) Number of blackouts updated (1.17 million households→1.09 million households), facility restoration (hydropower, substations)
11:03 - 11:42	Press conference	Vice President Fujimoto, Corporate Marketing & Sales Dept. Manager Kamakura, Marketing & Customer Relations Dept. Manager Shimada, Power System Operation Dept. GM Tayama, Nuclear Power Plant Management Dept. Manager Takahashi ・ Explained about supply/demand of power and that planned blackouts would be implemented from March 13 at the earliest. Answered that conditions would be tighter on the March 14 when factories would start up again. ・ Answer provided, “Water level at Fukushima Daiichi Unit 1 is -50cm from the top of fuel. The possibility of slight fuel damage to the top of the fuel rod cannot be denied, but judging from the radiation level in the vicinity, we determined that there is no significant damage as of yet.”
11:15	Press release	Headquarters hourly update (10:00) ・ (Nuclear related) Decided to vent Fukushima Daiichi Unit 1. Decided to prepare for venting at Fukushima Daini Units 1 to 4. ・ (Power supply related) Number of blackouts updated (1.09 million households→1.00 million households), restoration of facilities (hydropower, substations)
11:20	Press release	Fukushima Daiichi NPS hourly update (11:00) ・ Implementing venting for Unit 1. Water level is decreasing but water is being injected. ・ Preparing for vent operation at Units 2 and 3.
12:00	Press release	Fukushima Daiichi NPS on-site monitoring data (12:00)
12:30	Website	Headquarters hourly update (11:00) ・ (Nuclear related) Venting Fukushima Daiichi Unit 1, preparing for venting of Fukushima Daiichi Unit 2. ・ (Power supply related) Number of blackouts updated (1.00 million households→970,000 households), restoration of hydropower
13:20	Press release	Fukushima Daiichi NPS hourly update (13:00) ・ Same content as headquarters’ 13:00 update
13:20	Website	Fukushima Daiichi NPS on-site monitoring data (13:20)

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

13:50	Press release	Headquarters hourly update (13:00) ・ (Nuclear related) Currently Fukushima Daiichi Unit 1 IC is shutdown. Currently extended all efforts to vent. Exposure of one employee exceeded 100mSv. Preparing for vent operation at Units 2 and 3. Fukushima Daini Unit 3 in cold shutdown at 12:05. ・ (Power supply related) Number of blackouts updated (970,000 households→710,000 households)
14:40	Website	Fukushima Daiichi NPS on-site monitoring data (14:40)
15:20	Press release	Fukushima Daiichi NPS hourly update (15:00) ・ Unit 1 vented
16:00	Press release	Headquarters hourly update (15:00) ・ (Nuclear related) Determined that Fukushima Daiichi Unit 1 successfully vented at around 14:30 ・ (Power supply related) Number of blackouts updated (710,000 households→600,000 households)
16:40	Website	Fukushima Daiichi NPS on-site monitoring data (16:40)
Past 17:00	Press room	Corporate Communications Dept. employees and others ・ At around 15:36, there was major shaking right underneath. Afterwards, there was white smoke from near Fukushima Daiichi Unit 1 building. Two TEPCO employees and two contractors conducting restoration work were injured and transported to the hospital. First report was provided saying that that was all the information that was available at this time.
17:20	Press release	Determined at 16:17 that there was an Article 15 Notification event (15:29 site boundary radiation abnormal increase)
17:40	Press release	White smoke generated at Fukushima Daiichi Unit 1 ・ At around 15:36, there was a large sound and white smoke near Unit 1. Two TEPCO employees and two contractors were injured and transported to the hospital.
17:50	Press release	Headquarters hourly update (17:00) ・ (Power supply related) Number of blackouts updated (600,000 households→540,000 households)
19:30	Press release	Headquarters hourly update (19:00) ・ (Nuclear related) Evacuation order issued to residents within a 10km radius of Fukushima Daini NPS, severely injured person from Fukushima Daini NPS deceased. ・ (Power supply related) Number of blackouts updated (540,000 households→500,000 households), facility restoration (hydropower)
19:36 - 21:21	Press conference	Vice President Fujimoto, Managing Director Komori, Corporate Marketing & Sales Dept. Manager Kamakura, Marketing & Customer Relations Dept. Manager Shimada, Nuclear Power Plant Management

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

		Dept. Manager Takahashi Power System Operation Dept. GM Tayama ・ Explained that there are no side walls on the top floor of Fukushima Daiichi Unit 1 R/B and that conditions cannot be confirmed due to the high level of radiation in the pressure vessel. ・ In regard to core melting, responded that the core itself is in a condition different from the normal condition and it is understood to be in a strenuous condition, but also that there is possibility that it has not reached such conditions. ・ Water level has not changed from the value at 15:27 (-170cm). When questioned whether the water gage has failed, responded that the understanding is that there is no issue because two water gages are used for measurement and both indicate the same conditions. In regard to the explosion being outside of the containment vessel (commented in during the Chief Cabinet Secretary's press conference), explained that the determination is thought to reference TEPCO's plant data but there sufficient evaluations have not yet been completed internally.
Around 21:00	Press release	Fukushima Daiichi NPS hourly update (20:00) ・ Around 15:36, there was a large sound near Unit 1, white smoke is being emitted, and 4 people are injured. The situation is being investigated now.
21:40	Press release	Fukushima Daiichi NPS hourly update (21:00) ・ Boric acid is mixed and seawater injection has started at Unit 1 ・ Evacuation order made for residents within a 20km radius
22:10	Press release	Headquarters hourly update (21:00) ・ (Nuclear related) Boric acid and seawater injection started at 20:20 at Fukushima Daiichi Unit 1 ・ (Power supply related) Number of blackouts updated (500,000 households→450,000 households)
(23:00)	Press release	Fukushima Daiichi NPS hourly update (23:00) ・ Unit 1 seawater injection work suspended due to earthquake at 22:15

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

March 13, 2011 (Sunday)

Time of release	Format	Content
(02:00)	Press release	Fukushima Daiichi NPS hourly update (02:00) ・ Currently injecting seawater with boric acid for Unit 1
04:00	Website	Fukushima Daiichi NPS on-site monitoring data (04:00)
(05:30)	Press release	Fukushima Daiichi NPS hourly update (05:30) ・ Unit 3 high pressure water injection systems shutdown. Considering water injection methods. Plan to start venting.
06:20	Press release	Determined at 5:10 that Article 15 Notification event (Unit 3 ECCS injection inoperable) occurred
(08:00)	Press release	Fukushima Daiichi NPS hourly update (08:00) ・ For reducing containment vessel pressure in Unit 3, containment spray executed.
08:10	Website	Fukushima Daiichi NPS on-site monitoring data (08:10)
09:10	Press release	Headquarters hourly update (08:00) ・ (Nuclear related) Fukushima Daiichi Unit 3 reactor cooling function lost at 05:10. Vent valve operated and completed at 08:41. ・ (Power supply related) Number of blackouts updated (450,000 households→310,000 households), restoration of facilities (substations)
09:30	Website	Fukushima Daiichi NPS on-site monitoring data (09:30)
09:40	Press release	Fukushima Daiichi NPS hourly update (09:00) ・ Unit 3 vent operation completed. Containment spray suspended
09:40	Press release	Determined at 08:56 that Article 15 Notification event (site boundary radiation abnormal increase) occurred.
10:00	Website	Fukushima Daiichi, Fukushima Daini NPS on-site monitoring data (10:00)
11:00	Website	Fukushima Daiichi NPS on-site monitoring data (11:00)
11:20	Press release	Headquarters hourly update (10:30) ・ (Nuclear related) 8:56, Article 15 Notification event (site boundary radiation abnormal) occurred, 9:01 Notification, decided to vent Fukushima Daiichi Unit 2, Fukushima Daiichi Unit 3 successfully vented at 09:20, start injection of water with boric acid at 09:25. ・ (Power supply related) Number of blackouts updated (310,000 households→280,000 households), support supply of 600MW from north main interconnection line
12:00	Website	Fukushima Daiichi, Daini NPS on-site monitoring data (12:00)
12:35	Press release	Fukushima Daiichi NPS hourly update (12:00) ・ Decision to vent Unit 2 ・ After opening Unit 3 SRV, inject boric acid water into reactor

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

14:00	Website	Fukushima Daiichi NPS on-site monitoring data (14:00)
14:40	Press release	Headquarters hourly update (13:00) ・ (Power supply related) Number of blackouts updated (280,000 households→260,000 households)
15:10	Press release	Fukushima Daiichi NPS hourly update (14:00) ・ Trying to inject seawater into Unit 3 ・ Coordinate with related parties on cooling methods for Unit 1 spent fuel pool
15:10	Press release	Determined at 14:15 that Article 15 Notification event (site boundary radiation abnormal increase) occurred
16:30	Press release	Headquarters hourly update (15:00) ・ (Nuclear related) 14:15, Article 15 Notification event (site boundary radiation abnormal) occurred, Notification at 14:43, coordinated with related organizations regarding cooling of Fukushima Daiichi Unit 1 spent fuel pool, completed vent valve operation of Fukushima Daiichi Unit 2 at 11:00, possibility of hydrogen explosion of Fukushima Daiichi Unit 3, considering explosion prevention measures. ・ (Power supply related) Oi Unit 3 restoration
18:00	Website	Fukushima Daiichi NPS on-site monitoring data (18:00)
18:15	Press release	Fukushima Daiichi NPS hourly update (18:00) ・ Indicated as being the same content as the previous update (14:00 update), but text on attempts to inject seawater in Unit 3 was deleted.
20:20 - 23:13	President's Press Conference	・ President Shimizu, Vice President Fujimoto, Managing Director Komori, Corporate Marketing & Sales Dept. Manager Kamakura, Marketing & Customer Relations Dept. Manager Shimada, Power System Operation Dept. GM Hanai ・ Explained that planned outages will begin on 3/14 ・ In regard to nuclear issues, when questioned about the casual relationship between ageing and the accident, the explanation was provided that "The cause was tsunami that exceeded expectations and that ageing is not a contributor. In regard to preparations against tsunami, it was explained that "Tsunami measures for levels that have been expected had been taken. This tsunami was beyond expectations, and how to handle measures that correspond to such is a major issue." In regards to management responsibility including for insufficient expectations and training, responses were provided that "Backup systems have been developed based on various expectations, but the tsunami at this time was beyond expectations. Currently, all efforts are being put into ensuring nuclear safety, and we are not at the stage where we can discuss responsibility."
21:10	Press release	Fukushima Daiichi NPS hourly update (21:00) ・ Indicated that it is the same content as the previous update (18:00 update)

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

22:00	Website	Fukushima Daini NPS on-site monitoring data (22:00)
22:41	Website	Fukushima Daiichi NPS on-site monitoring data (22:41)
23:00	Website	Fukushima Daini NPS on-site monitoring data (23:00)

March 14, 2011 (Monday)

Time of release	Format	Content
(00:00)	Press release	Fukushima Daiichi NPS hourly update (00:00) ・ Indicated to be the same content as the update before the previous update (18:00 update)
00:41	Website	Fukushima Daiichi NPS on-site monitoring data (00:41)
01:50	Website	Fukushima Daiichi NPS on-site monitoring data (01:50)
03:00	Website	Fukushima Daini NPS on-site monitoring data (03:00)
(03:00)	Press release	Fukushima Daiichi NPS hourly update (03:00) ・ Due to shortage of water in the seawater pit, decided to shut down injection pumps for Units 1 and 3 and to resupply water to the pit. ・ Preparing seawater injection for Unit 2
05:00	Press release	Determined that Article 15 Notification (site boundary radiation abnormal increase) occurred at 03:50, 04:15
06:00	Press release	Fukushima Daiichi NPS hourly update (05:00) ・ Confirmed that there is still a sufficient amount of water in the seawater pit and resumed water injection for Unit 3
06:01	Website	Fukushima Daiichi NPS on-site monitoring data (06:01)
08:00	Website	Fukushima Daini NPS on-site monitoring data (08:00)
10:30	Press release	Article 15 Notification (Fukushima Daiichi Unit 3 containment pressure abnormality), resumed venting due to decrease in containment pressure
Around 11:30	Press room	Corporate Communications Dept. employee ・ Communicated initial report that there was an explosion at Fukushima Daiichi Unit 3 at around 11:01 and that the location and cause of the explosion is being confirmed.
Around 11:40	Press room	Corporate Communications Dept. employee ・ Communicated that the Unit 3 explosion at around 11:01 was a hydrogen explosion
11:50	Press release	White smoke emitted at Fukushima Daiichi Unit 3 ・ At around 11:01, there was a large sound and white smoke was emitted. Possibility of a hydrogen explosion.

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

		・ Based on parameters, the containment vessel is thought to have retained its integrity. ・ Worker is injured and an ambulance is being requested.
12:08 - 12:54	Press conference	Managing Director Komori, Nuclear Asset Management Dept. Manager Kuwahara and others ・ As of 11:48, confirmed that two TEPCO employees and one contractor were bruised. Total of 7 persons are missing including one contractor and 6 self-defense force members. Their safety is being verified. ・ As of 11:35, the reactor water level at Fukushima Daiichi Unit 3 is -1,800mm from the top of fuel, reactor pressure is 0.17MPa for subsystem A, 0.18MPa for subsystem B, and containment vessel pressure in D/W is 360kPa, and 380kPa at liquid phase region. ・ Though recognizing the possibility of fuel melting, the response was provided that even if the top of fuel rods are exposed, the steam generated at the bottom cools it and, therefore, it is difficult to assess fuel damage conditions.
12:45	Press release	Fukushima Daiichi Unit 3 white smoke emitted (second report) ・ 4 TEPCO employees, 2 contractor injured ・ No significant change in radiation
14:25	Press release	Fukushima Daiichi Unit 3 white smoke generated (third report) ・ 4 TEPCO employees, 3 contractor injured ・ No significant change in radiation in Fukushima Daini NPS located in the downwind area ・ Considering explosion countermeasures for Fukushima Daiichi Unit 2
14:30	Website	Fukushima Daiichi NPS on-site monitoring data (14:30)
16:00	Website	Fukushima Daini NPS on-site monitoring data (16:00)
16:30	Press release	Article 15 Notification (Fukushima Daiichi Unit 2 loss of reactor cooling function) ・ At 13:25, Fukushima Daiichi Unit 2 RCIC shutdown, reactor cooling function lost
17:20	Website	Fukushima Daiichi NPS on-site monitoring data (17:20)
17:35	Press release	Fukushima Daiichi Unit 3 white smoke emitted (fourth report) ・ Radioactive material found to be adhered to 6 out of 7 people, among which 5 were decontaminated. ・ Added apology text (siting community + general public)
18:00	Website	Fukushima Daini NPS on-site monitoring data (18:00)
Around 20:40 - 21:45	Press conference	Vice President Muto ・ For Fukushima Daiichi Unit 2 water level, explained that the water level dropped to top of fuel at 17:17 and downscaled at 18:22 ・ When asked whether it is downscaling at Fukushima Daiichi Unit 2 and is in a boiled-dry condition, responded that hunting of the water gage was confirmed at 19:54, and that it is determined that

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		seawater is being injected into the reactor. ・ In regard to the possibility of fuel melting, responded that though there is need to see subsequent parameters, it is understood that fuel has been damaged from the high level of radiation being observed. ・ Also explained during the press conference that when the SRVs were opened at 21:20 to depressurize the reactor, the water level which was -3,400mm at 21:21 rose to -2,000m at 21:34, which is understood to mean that seawater inflow volume increased due to lowered pressure in the reactor.
21:00	Website	Fukushima Daini NPS on-site monitoring data (21:00)
22:35	Website	Fukushima Daiichi NPS on-site monitoring data (22:35)
23:35	Press release	Fukushima Daiichi NPS hourly update (23:30) ・ Due to RCIC shutdown at Unit 2, water level dropped and pressure increased. It was vented and seawater was injected, which improved both water level and pressure. ・ Currently, Unit 3 seawater injection work has been suspended. ・ 11 people were injured due to a hydrogen explosion of Unit 3. Transporting to Fukushima Daini ・ Notification provided that all of the “site boundary radiation abnormal increase” Article 15 Notification would be compiled and information would be provided if the same event occurs again.

March 15, 2011 (Tuesday)

Time of release	Format	Content
Past 00:00	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ At Fukushima Daiichi Unit 2, safety valve closed and reactor pressure increased slightly. This caused difficulty for water injection and reactor water level started to downscale again at 23:20. ・ Currently, implementing work to open safety valves to resume water injection into the reactor
01:00	Website	Fukushima Daini NPS on-site monitoring data (01:00)
01:05	Website	Fukushima Daiichi NPS on-site monitoring data(01:05)
06:00	Website	Fukushima Daini NPS on-site monitoring data (06:00)
08:10	Press release	Transport of workers ・ Possibility of abnormality in suppression chamber from an abnormal sound at Fukushima Daiichi Unit 2 followed by pressure drop. ・ Workers not directly involved in water injection work were temporarily transported to a safe place.
Around 08:30	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ Explanation provided that it was determined that there may have

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		been some abnormality from the fact that there was a sound near the suppression chamber at Fukushima Daiichi Unit 2 followed by suppression chamber pressure drop. Therefore, the transport of workers, other than about 50 workers involved in water injection work, has started.
09:45	Press release	Fukushima Daiichi Unit 4 building damage (first report) ・ A large sound was heard at around 06:00. Found damage near 5F roof of R/B of Fukushima Daiichi Unit 4
10:50	Press release	Fukushima Daiichi Unit 4 building damage (second report) ・ Around 9:38, found fire near 4F northwest area
Around 11:00	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ In relation to the release regarding Fukushima Daiichi Unit 4 building damage, the explanation was provided that "It cannot be identified whether there was one or two explosions including for Unit 2." ・ In regard to the fire, explained that the first priority is to extinguish it and requests were made to the self-defense force to extinguish it.
12:00	Website	Fukushima Daini NPS on-site monitoring data (12:00)
13:15	Press release	Fukushima Daiichi Unit 4 building damage (third report) ・ Around 11:00, found that fire naturally extinguished itself
13:30	Website	Fukushima Daiichi NPS on-site monitoring data(13:30)
14:25	Press release	Fukushima Daiichi NPS hourly update (13:00) ・ There was abnormal sound with drop in suppression chamber pressure in Unit 2. The transport of workers has started, excluding those directly involved in work. ・ Resumed seawater injection for Unit 3 at 02:30. ・ Found damages near 5F of Unit 4 R/B. Subsequently found fire on northwest area of 4F, but confirmed that it naturally extinguished itself at around 11:00. ・ Updated data on Article 15 Notification (site boundary radiation abnormal increase)
Around 15:45	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ In regard to damaged locations of Fukushima Daiichi Unit 4, responded that walls and roof of R/B 4F, 5F northwest areas have collapsed.
16:00	Press release	Fukushima Daiichi NPS hourly update (15:30) ・ Indoor shelter order to people in 20 to 30km radius
(16:00)	Press release	Headquarters hourly update (16:00) ・ (Power supply related) All substations restored. Number of blackouts updated(7,300 households)
16:30	Website	Fukushima Daiichi NPS on-site monitoring data (16:30)

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

17:30	Press release	Fukushima Daiichi NPS hourly update (17:00) ・ Verified that it was 400mSv on land side of Unit 3 R/B at around 10:00 and 100mSv on land side of Unit 4 R/B ・ Data updated on Article 15 Notification (site boundary radiation abnormal increase)
18:00	Website	Fukushima Daiichi, Fukushima Daini NPS on-site monitoring data (18:00)
Around 20:30	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ In regard to possibility of Fukushima Daiichi Unit 4 hydrogen explosion, responded that it has not been possible to check the field yet and causes were not yet identified, but the possibility cannot be denied.
23:35	Website	Fukushima Daiichi NPS on-site monitoring data (23:35)
Around 23:40	Press room	Corporate Communications Dept., Nuclear Asset Management Dept. employees ・ In regard to Fukushima Daiichi Unit 4 spent fuel pool water injection, explanation was provided that [they] would like to start it tomorrow or the day after, though radiation is high and rubble is scattered in the field.

End

(Note) For items where time of announcement is unknown, the time when information was compiled is written in parenthesis.

Structure for Coordination of Public Communications between NISA and TEPCO

March 21, 2011
Nuclear and Industrial Safety Agency

1. Basic understanding

Regarding public communications for the Fukushima Daiichi Nuclear Power Station accident, Nuclear and Industrial Safety Agency (NISA), the regulator, and TEPCO, the operator are expected to conduct integrated public communications as the unified headquarters based on objective facts, although parties are in different positions.

Therefore, the following coordination will be implemented for public communication activities.

2. Coordination measures

(1) Confirmation of facts for press releases

① Information is currently being shared within the unified headquarters, but the times and locations of press conferences by NISA and TEPCO (at two locations: at headquarters and at Fukushima Prefectural Office) are different for each, and the channels through which information is obtained is also different. Therefore, there is concern that the content of press releases might be perceived as inconsistent in its factual understanding.

② Therefore, NISA's PR team will receive an explanation of TEPCO's press release materials from an appropriate person of the TEPCO's section manager level before disclosure by TEPCO so as to gain a common understanding of the facts between the two parties.

*It is not appropriate to conduct prior confirmation with respect to NISA press release materials because it may contain regulatory statements.
*It is imperative that press releases would not be delayed due to the prior confirmation mentioned above.

(2) Building contact structure for activities

① Hold liaison meetings between NISA PR officer (Deputy-Director General

Nishiyama) and TEPCO's main press conference representative (Vice President Muto) as appropriate to confirm notable items, etc. considering the circumstances such as how it would be covered in the media.

② Close communications between NISA Director of Nuclear Safety Public Relation (response headquarters secretariat PR team leader) and TEPCO Public Relations General Manager is to be established. Responses against criticism related to public relations of the unified headquarters shall be considered, and specific solutions shall be implemented.

(Reference) TEPCO's coordination suggestions

- The section manager level TEPCO personnel will explain press material to NISA prior to press release.
- Vice President Muto will be TEPCO's main press conference representative.

Major articles regarding TEPCO's information disclosure
(Major newspapers from March 12 to 16)

Event	Article
3/12 Press conference on venting	・ **"TEPCO executives reluctant"** (3/12 Mainichi Shimbun, Evening Edition) (Because the timing for venting and applicable unit was unclear)
3/12 Unit 1 explosion	・ **'NISA, TEPCO repeating "We're verifying"'** (3/13 Asahi Shimbun, Morning Edition) ・ **"Quickly provide accurate information"** (3/13 Asahi Shimbun, Morning Edition) ・ **"Prime Minister says TEPCO is slow to report"** (3/14 Mainichi Shimbun, Morning Edition) (Because of repeatedly saying "we're verifying" and "we do not know" as well as because it took time for disclosure)
3/12 Press conference	・ **"Dead end for energy policy. People's distrust reignited"** (3/13 Mainichi Shimbun, Morning Edition) (Regarding the attitude in the press conference of repeating actions for the time being that "we are working on maintaining cooling water")
-	・ **"Nuclear information, fast and promptly"** (3/14 Asahi Shimbun, Morning Edition) (Referring to TEPCO and government public communications up to that point)
3/14 Planned outages	(From 3/14 to 15, much criticism that the announcement was just immediately before implementation, insufficient explanation beforehand, policy changed twice and three times, lack of coordination with the government, many mistakes, etc.)
3/14 Unit 3 explosion	・ **"Nuke plant, planned outages, TEPCO's sloppy actions"** (3/15 Yomiuri Shimbun, Morning Edition) (Because sufficient explanation could not be provided, just repeating that "we will check" immediately after the explosion and actions were delayed)
-	・ **"Information is the key to crisis management"** (3/15 Mainichi Shimbun, Morning Edition) (Because there was a time difference and differences in information provided at the press conference by the Official Residence, NISA, and TEPCO)

Event	Article
3/15 Unit 2 explosion sound	・ **"TEPCO's obscure explanations"** (3/15 Asahi Shimbun, Evening Edition) ・ **"Explanations are obscure"** (3/15 Nikkei , Evening Edition) ・ **"I do not know" "We will check" Showing TEPCO's confusion"** (3/15 Asahi Shimbun, Evening Edition) ・ **"TEPCO fails to give details"** (3/15 Yomiuri Shimbun, Evening Edition) ・ **"Empty apologies, lack of explanation TEPCO executives nowhere in sight"** (3/16 Sankei, Morning Edition) (Because of repeating "that is unknown" "we will check," important facts are ambiguous; executives not holding press conferences indicates lack of a sense of responsibility, etc.)
3/15 Unit 4 fire	・ **"TEPCO gives obscure explanation"** (3/15 Asahi Shimbun, Evening Edition) ・ **"TEPCO sticks with ambiguous explanation"** (3/16 Nikkei, Morning Edition) ・ **"Government: perilous crisis management, coordination with TEPCO delayed"** (3/16 Nikkei, Morning Edition) (Repeated that "it has not been verified" regarding the relation between fire and explosion, repeated that "details are being confirmed," even though the government had already released radiation dose levels, government and TEPCO views differ (Government: there is a high possibility of hydrogen explosion" TEPCO: "The possibility cannot be rejected," etc.)
-	・ **"TEPCO Cover-up culture still strong"** (3/16 Asahi Shimbun, Morning Edition) (Saying that TEPCO does not voluntarily disclose detrimental numbers, the attitude of trying to cover facts up is not something new)
-	・ **"TEPCO, poor risk management"** (3/16 Yomiuri Shimbun, Morning Edition) (Saying that many problems can be pointed out from the perspective of risk communication)
-	・ "**Condemns poor information disclosure, CNN says TEPCO lied again"** (3/16 Sankei Shimbun, Morning Edition) (Saying that criticism from the international community regarding poor information disclosure was becoming apparent)

Evacuation Procedures

1. Procedures

①Decision to evacuate

②Contact contractors (request cooperation for buses)

③Notification to central government and local government (government office notification team)

④Announcements

-Evacuation has been decided. All members (excluding emergency response members) are to take immediate evacuation actions.

-Buses and cars are parked in front of the seismic isolated building. Buses and cars with the maximum number of passengers as possible will start departing to quickly evacuate all members.

⑤Terminate security and radiation control check gates

⑥All members to gather at the emergency response center

⑦Start evacuation

⑧Reception of evacuated members

Healthy individuals: Daini gymnasium

Injured individuals: Daini Visitors Center

2. Prepare in advance

-List of on-site personnel (create from site entry records?)

-Bus list (contact person, phone number)

-Organize to receive evacuated members

5 buses, 100 people/bus

Attachment 5-10 (2/2)

Fukushima Daiichi Unit 1 Plant Data

[Scram・All Control Rods Fully Inserted]

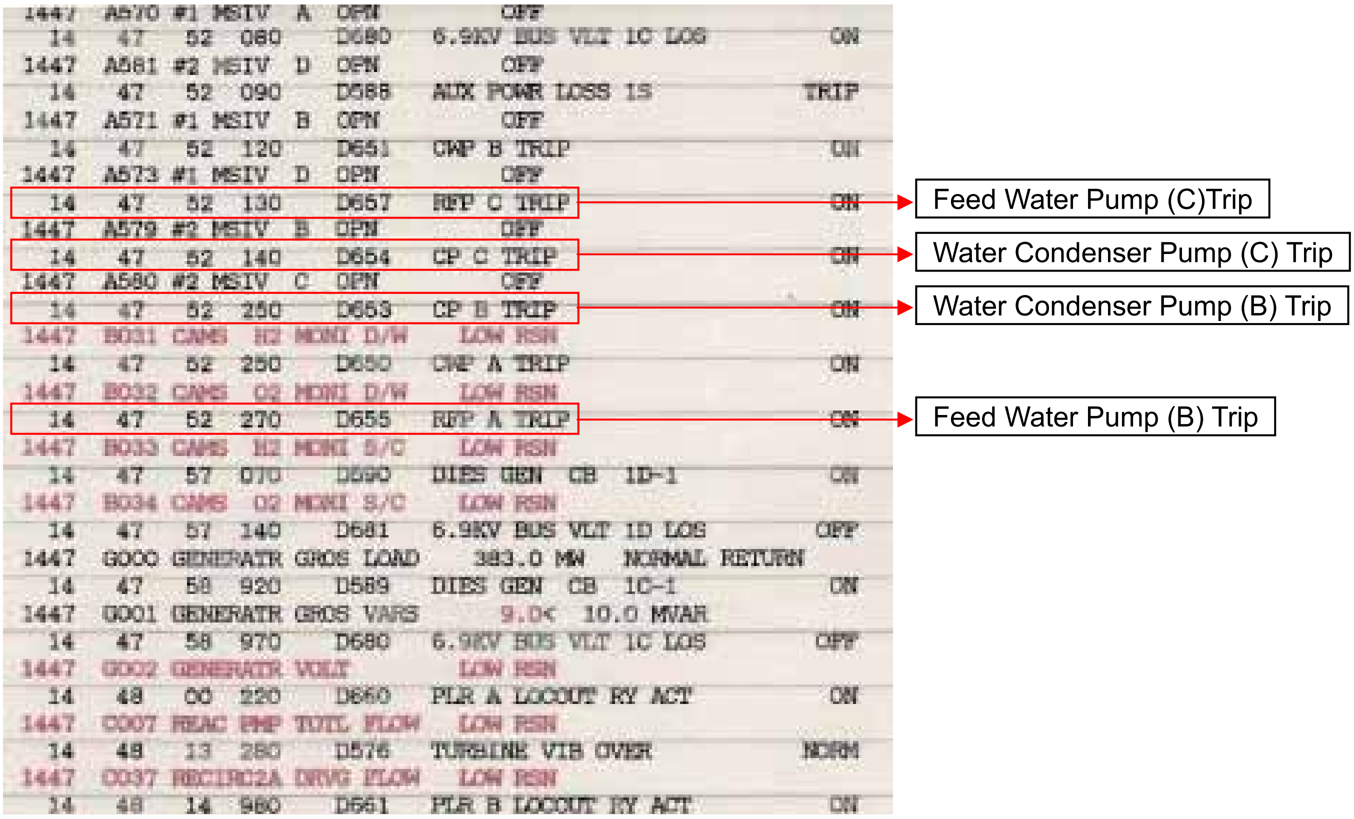
H	MIN	SEC	MSEC	PID	ABBREVIATION	STATUS
14	46	46	400	D564*	SEISMIC TRIP C	TRIP
14	46	46	410	D534	REACTOR SCRM A	TRIP
14	46	58	420	D563	SEISMIC TRIP B	TRIP
14	46	58	430	D535	REACTOR SCRM B	TRIP
1446				A538	RBM BYPS	ON
1446				B500	CONT ROD DRFT ALRM	ON
14	47	00	020	D562	SEISMIC TRIP A	TRIP
14	47	00	030	D565	SEISMIC TRIP D	TRIP
1447				C020	SUPPRESSION LEVL	-40.8< -20.0 MM
1447				A523	APRM DOWN SCAL	TRBL
1447				A539	RWM ROD BLOK	ON
1447				A553	ALL CR FULL IN	ON
1447				G002	GENERATR VOLT	18.56> 18.50 KV
1447				C000	CONT ROD SYST FLOW	OVR FLW
1447				C020	SUPPRESSION LEVL	16.0 MM NORMAL RETURN
14	47	09	140	D520	REAC WTR LEVL A	LOW
1447				C004	REACTOR WATR LEVL	516< 800 MM
14	47	09	150	D521	REAC WTR LEVL B	LOW
1447				E004	SWCHGEAR BUS 1A	7217> 7200 V
14	47	10	910	D523	REAC WTR LEVL D	LOW
1447				C020	SUPPRESSION LEVL	21.6> 20.0 MM
14	47	10	910	D522	REAC WTR LEVL C	LOW
1447				A549	LOW POWR ALRM POINT	UNDER
14	47	20	620	D522	REAC WTR LEVL C	NORM
1447				D622	PCIS ISO IN TRIP	ON
14	47	20	620	D523	REAC WTR LEVL D	NORM

Automatic Scram Triggered by Earthquake

All Control Rods Fully Inserted

Fukushima Daiichi Unit 1 Alarm Data Logger

[Feed Water Pumps and Condenser Pumps Trip]



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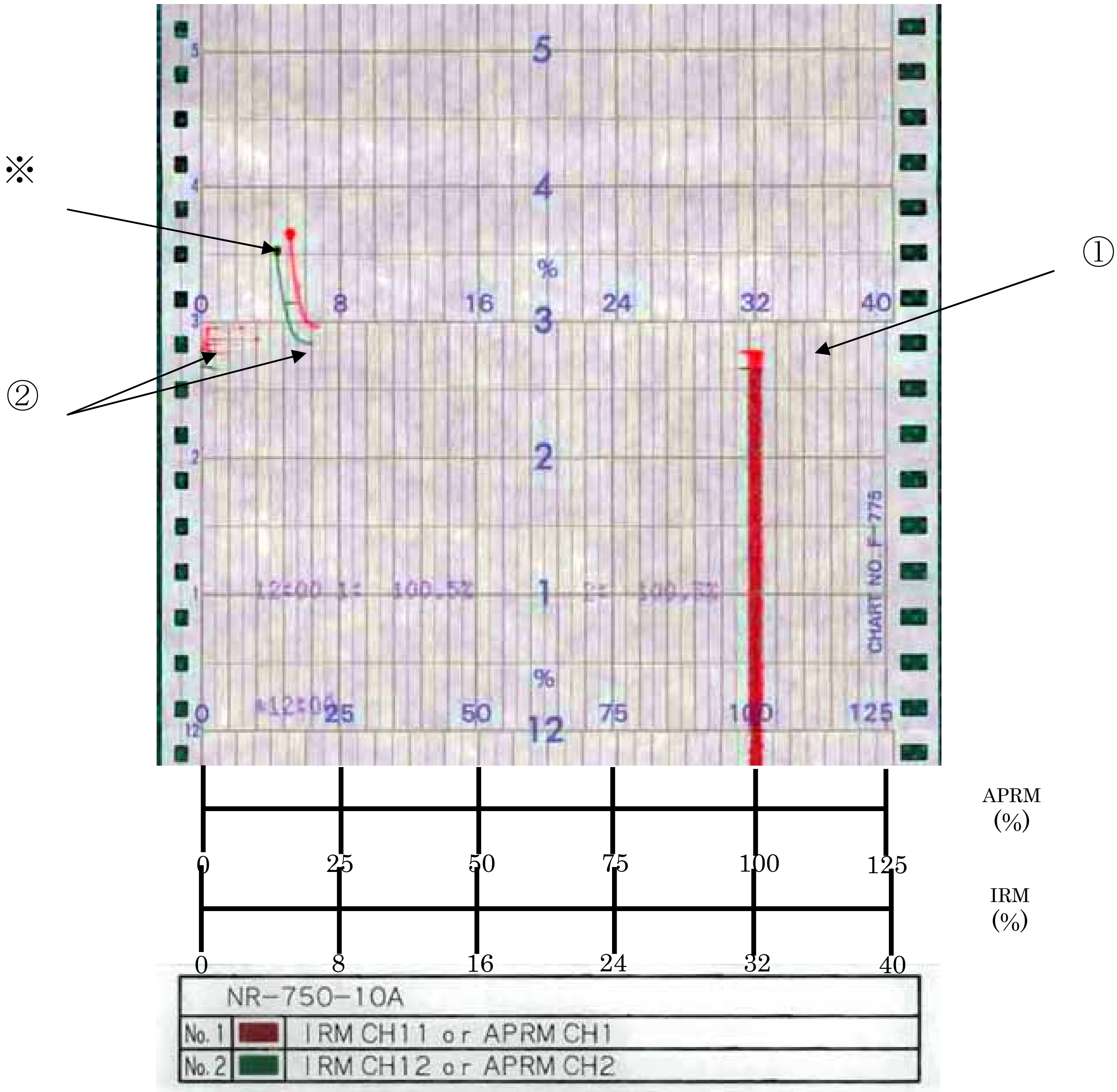
1447  A570 #1 MSIV  A  OPN          OFF
  14    47   52  080     D680   6.9KV BUS VLT 1C LOS         ON
1447  A581 #2 MSIV  D  OPN          OFF
  14    47   52  090     D588   AUX POWR LOSS 1S           TRIP
1447  A571 #1 MSIV  B  OPN          OFF
  14    47   52  120     D651   CWP B TRIP                   ON
1447  A573 #1 MSIV  D  OPN          OFF
  14    47   52  130     D657   RFP C TRIP                   ON
1447  A579 #2 MSIV  B  OPN          OFF
  14    47   52  140     D654   CP C TRIP                    ON
1447  A580 #2 MSIV  C  OPN          OFF
  14    47   52  250     D653   CP B TRIP                    ON
1447  B031 CAMS  H2 MONI D/W     LOW RSN
  14    47   52  250     D650   CWP A TRIP                   ON
1447  B032 CAMS  O2 MONI D/W     LOW RSN
  14    47   52  270     D655   RFP A TRIP                   ON
1447  B033 CAMS  H2 MONI S/C     LOW RSN
  14    47   57  070     D690   DIES GEN  CB  1D-1           ON
1447  B034 CAMS  O2 MONI S/C     LOW RSN
  14    47   57  140     D681   6.9KV BUS VLT 1D LOS        OFF
1447  G000 GENERATR GROS LOAD    383.0 MW   NORMAL RETURN
  14    47   58  920     D589   DIES GEN  CB  1C-1           ON
1447  G001 GENERATR GROS VARS       9.0<  10.0 MVAR
  14    47   58  970     D680   6.9KV BUS VLT 1C LOS        OFF
1447  G002 GENERATR VOLT         LOW RSN
  14    48   06  220     D660   PLR A LOCOUT RY ACT          ON
1447  C007 REAC PMP TOTL FLOW    LOW RSN
  14    48   13  280     D576   TURBINE VIB OVER           NORM
1447  C037 RECIRC2A DRVG FLOW    LOW RSN
  14    48   14  980     D661   PLR B LOCOUT RY ACT          ON
```


Fukushima Daiichi Unit 1 Alarm Data Logger

[Intermediate Range Monitor (IRM), Average Power Range Monitor (APRM)],



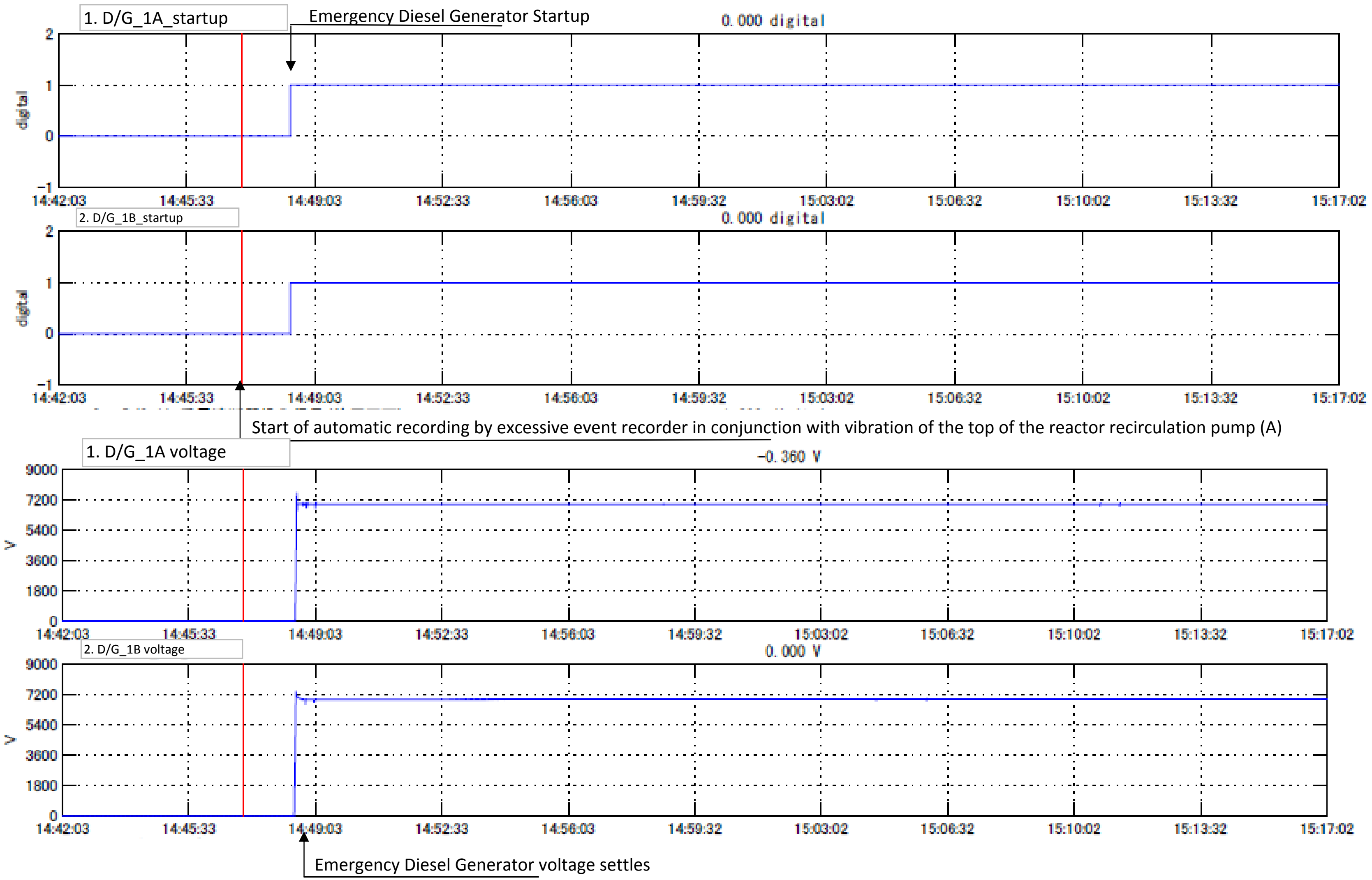
①Scram triggered by Earthquake at 14:46 and fall in output due to scram.
②Below the range of Average Power Range Monitor (APRM) and changed to Intermediate Range Monitor (IRM)
* It is assumed that the tsunami arrived at 15:30.
It is supposed that the record stopped due to the impact of the tsunami.

[Diesel Generator (D/G) Circuit Breaker On]

```
1447 B033 CAMS  H2 MONI S/C    LOW RSN
  14   47   57  070     D590  DIES GEN  CB  1D-1           ON
1447 B034 CAMS  O2 MONI S/C    LOW RSN
  14   47   57  140     D681  6.9KV BUS VLT 1D LOS        OFF
1447 G000 GENERATR GROS LOAD    383.0 MW   NORMAL RETURN
  14   47   58  920     D589  DIES GEN  CB  1C-1           ON
1447 G001 GENERATR GROS VARS      9.0<  10.0 MVAR
  14   47   58  970     D680  6.9KV BUS VLT 1C LOS        OFF
1447 G002 GENERATR VOLT        LOW RSN
  14   48   00  220     D660  PLR A LOCOUT RY ACT          ON
1447 C007 REAC PMP TOTL FLOW   LOW RSN
  14   48   13  280     D576  TURBINE VIB OVER           NORM
```

D/G 1B Circuit Breaker On

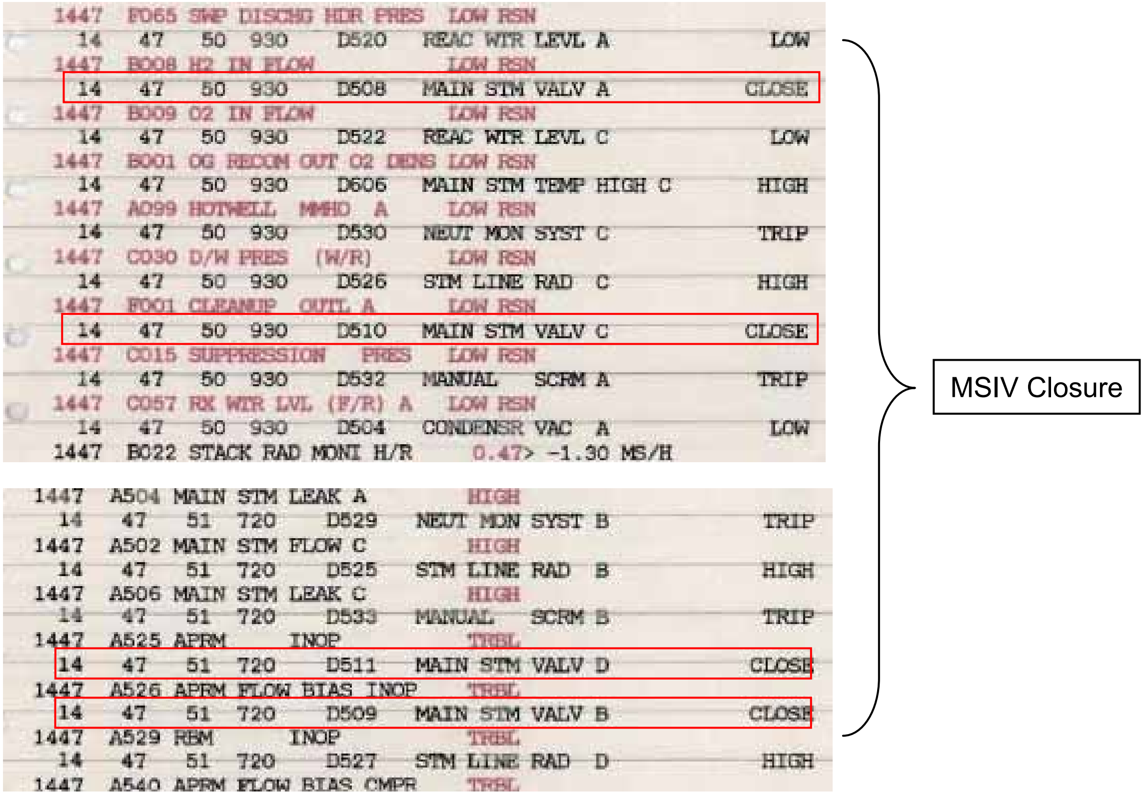
D/G 1A Circuit Breaker On

<table>
<tr><th>Parameter</th><th>Notes</th></tr>
<tr><td>
</td><td>At 14:47 the emergency diesel generator starts up and voltage settles.</td></tr>
</table>

Attachment 6-1 (3) (2/2)

Fukushima Daiichi Unit 1 Transient Recorder Trends

[Main Steam Isolation Valve (MSIV) Closure]

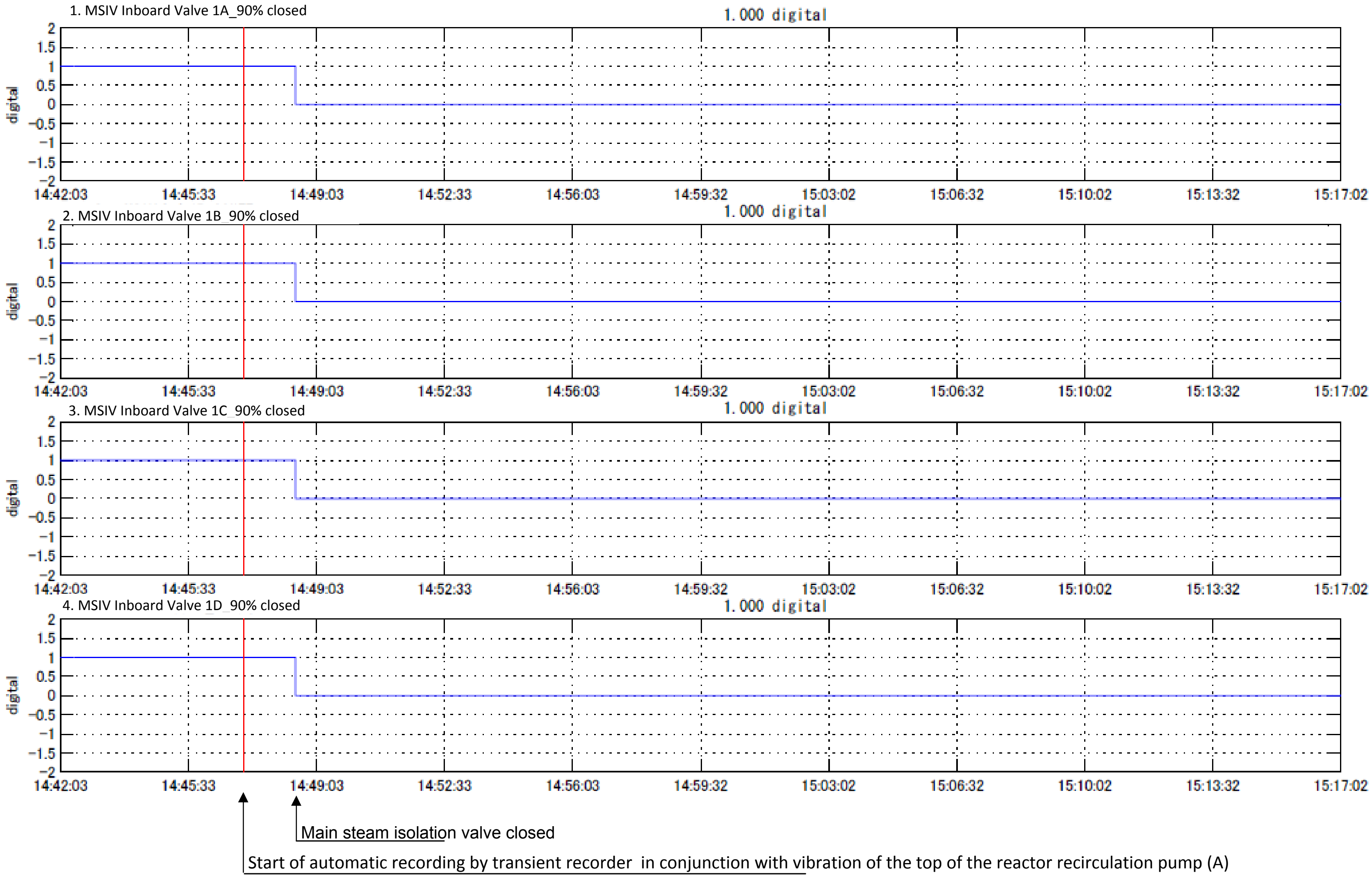


```
1447  F065 SWP DISCHG HDR PRES  LOW RSN
  14   47   50  930    D520   REAC WTR LEVL A            LOW
1447  B008 H2 IN FLOW           LOW RSN
  14   47   50  930    D508   MAIN STM VALV A          CLOSE
1447  B009 O2 IN FLOW           LOW RSN
  14   47   50  930    D522   REAC WTR LEVL C            LOW
1447  B001 OG RECOM OUT O2 DENS LOW RSN
  14   47   50  930    D606   MAIN STM TEMP HIGH C      HIGH
1447  A099 HOTWELL  MMHO  A     LOW RSN
  14   47   50  930    D530   NEUT MON SYST C           TRIP
1447  C030 D/W PRES  (W/R)      LOW RSN
  14   47   50  930    D526   STM LINE RAD  C           HIGH
1447  F001 CLEANUP  OUTL A      LOW RSN
  14   47   50  930    D510   MAIN STM VALV C          CLOSE
1447  C015 SUPPRESSION   PRES   LOW RSN
  14   47   50  930    D532   MANUAL   SCRM A           TRIP
1447  C057 RX WTR LVL (F/R) A   LOW RSN
  14   47   50  930    D504   CONDENSR VAC  A            LOW
1447  B022 STACK RAD MONI H/R      0.47> -1.30 MS/H

1447  A504 MAIN STM LEAK A          HIGH
  14   47   51  720    D529   NEUT MON SYST B           TRIP
1447  A502 MAIN STM FLOW C          HIGH
  14   47   51  720    D525   STM LINE RAD  B           HIGH
1447  A506 MAIN STM LEAK C          HIGH
  14   47   51  720    D533   MANUAL   SCRM B           TRIP
1447  A525 APRM        INOP         TRBL
  14   47   51  720    D511   MAIN STM VALV D          CLOSE
1447  A526 APRM FLOW BIAS INOP      TRBL
  14   47   51  720    D509   MAIN STM VALV B          CLOSE
1447  A529 RBM         INOP         TRBL
  14   47   51  720    D527   STM LINE RAD  D           HIGH
1447  A540 APRM FLOW BIAS CMPR      TRBL
```

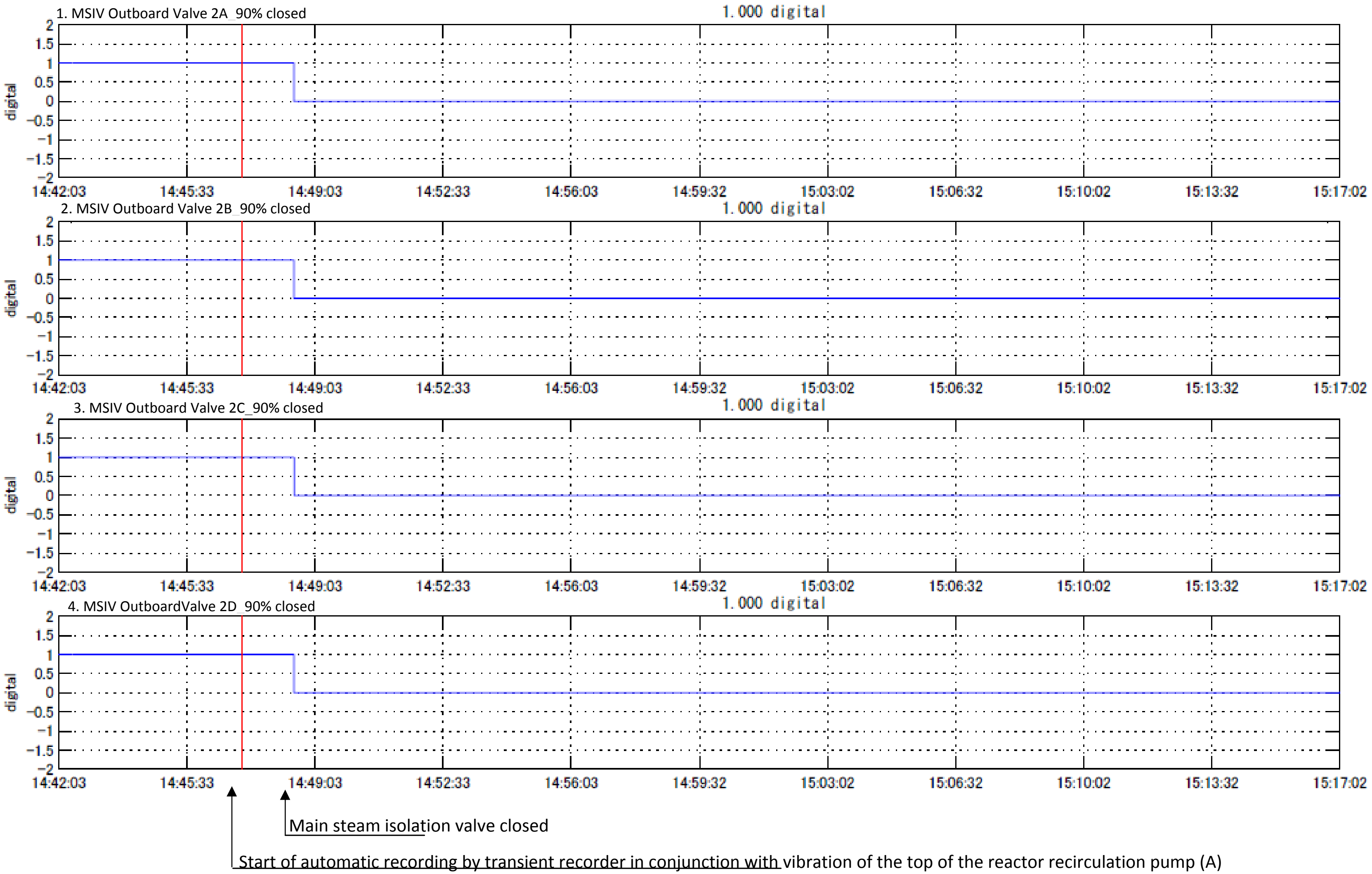

(Note) Before and after MSIV closure, abnormal signals such as rupture detection have been recorded, but it is observed that these abnormal signals were sent as a fail safe measure following the loss of power for the instruments due to the loss of off-site power as a result of the earthquake. Signs of abnormalities, such as the increase in steam flow rates, are not seen in the process of closing the MSIV.

Fukushima Daiichi Unit 1 Alarm Data Logger

Parameter	Notes
	The main steam isolation valve (intboard) is closed.

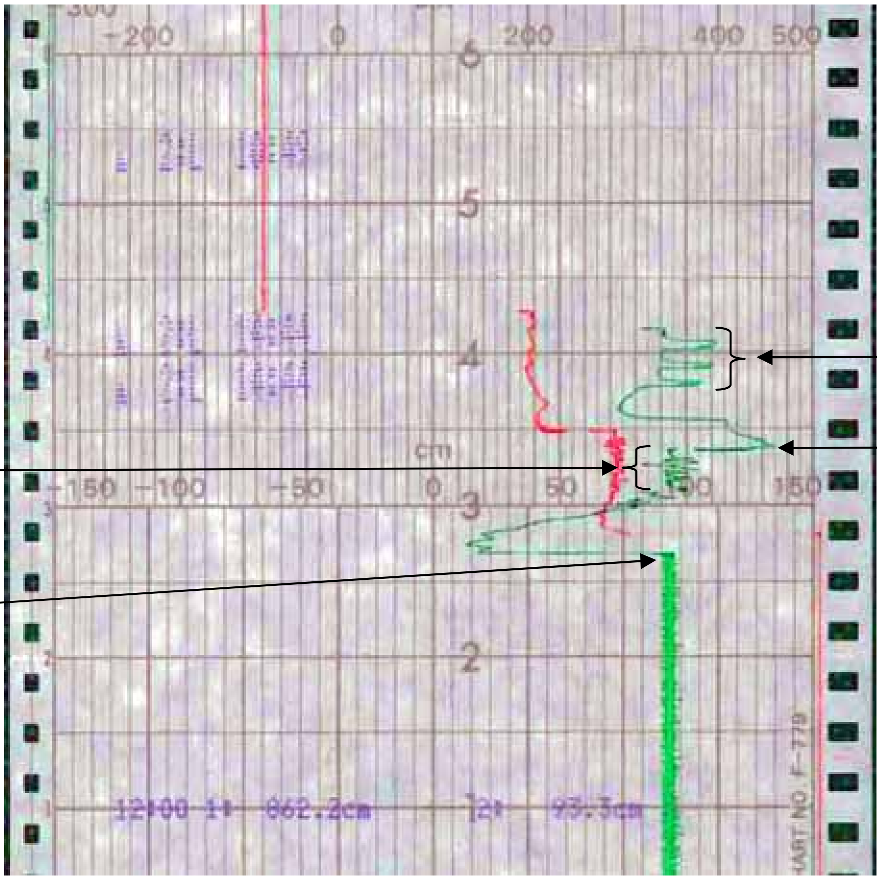
Attachment 6-1 (4) (2/3)

Fukushima Daiichi Unit 1 Transient Recorder Trends

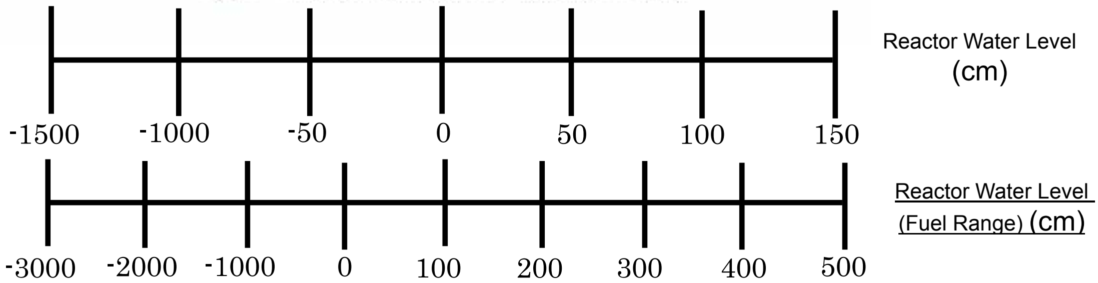
Parameter	Notes
	The main steam isolation valve (outboard) is closed.

Fukushima Daiichi Unit 1 Transient Recorder Trends

[Reactor Water Level]



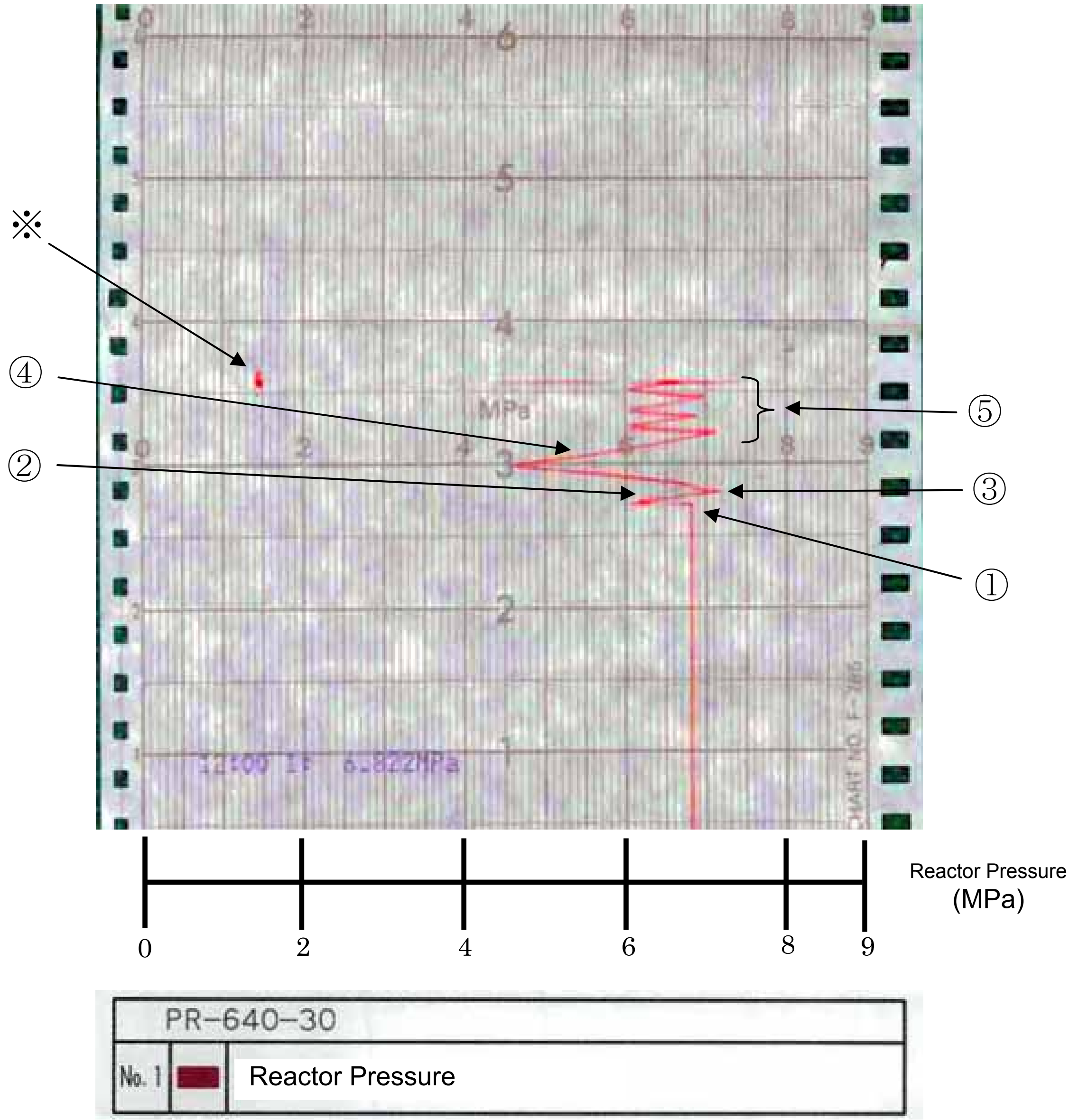
Green Reactor water level
Red Reactor water level (fuel range)



① Scram triggered by earthquake at 14:46 (Chart fast forwarded: 60 times the speed, 1 hour = 1 minute)
② Loss of off-site power around this time, MSIV closed (Chart fast forwarding reset due to loss of power)
③ Automatic IC startup
④ Change in water level supposedly due to IC operations

Fukushima Daiichi Unit 1 Chart

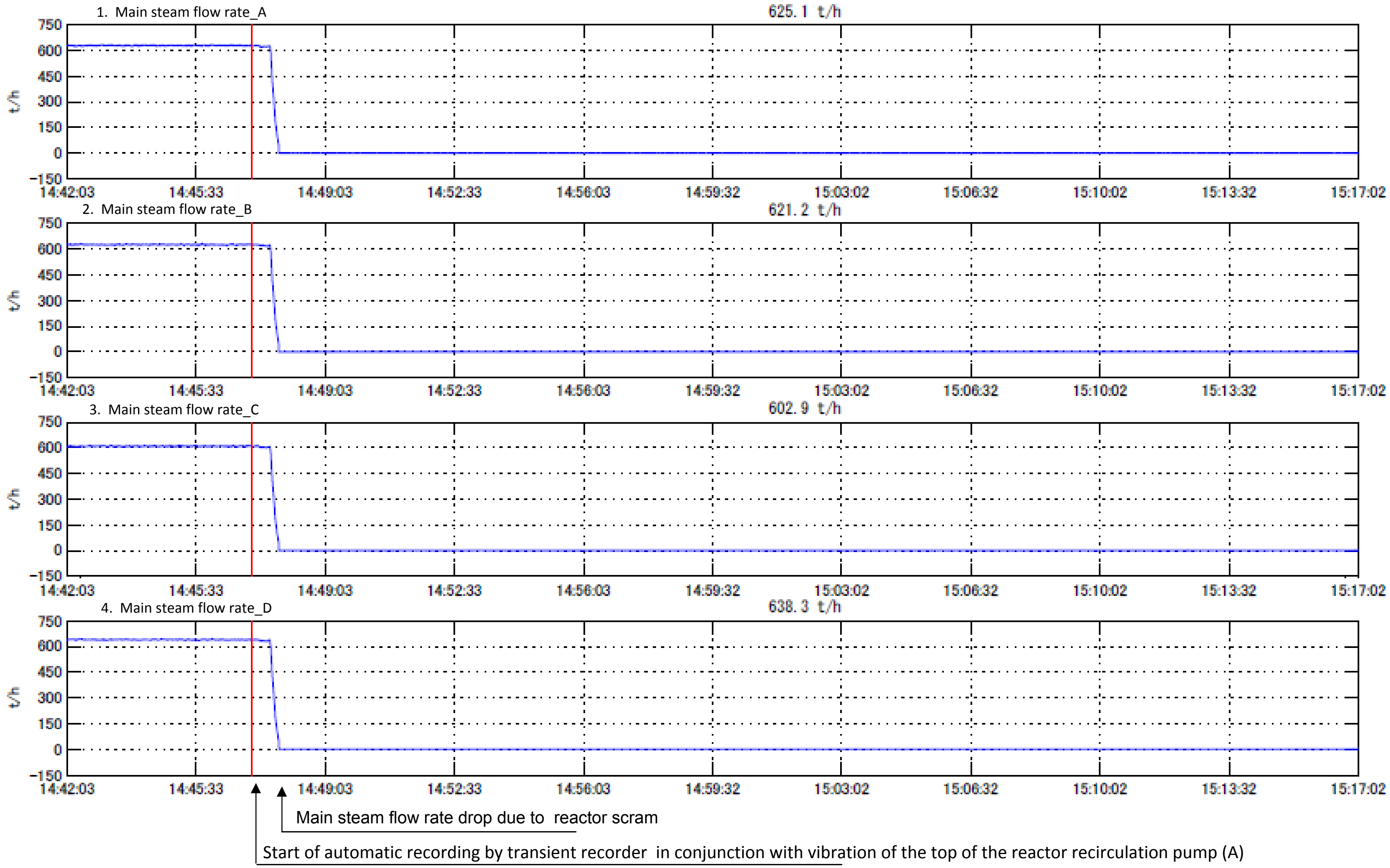
[Reactor Pressure]



① Scram triggered by earthquake at 14:46
② Rise in pressure due to the closing of MSIV
③ IC activation and consequent drop in pressure at 14:52
④ Rise in pressure due to IC shutdown
⑤ Change in pressure supposedly caused by IC

* It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

Fukushima Daiichi Unit 1 Chart

<table>
<tr><th>Parameter</th><th>Notes</th></tr>
<tr><td>


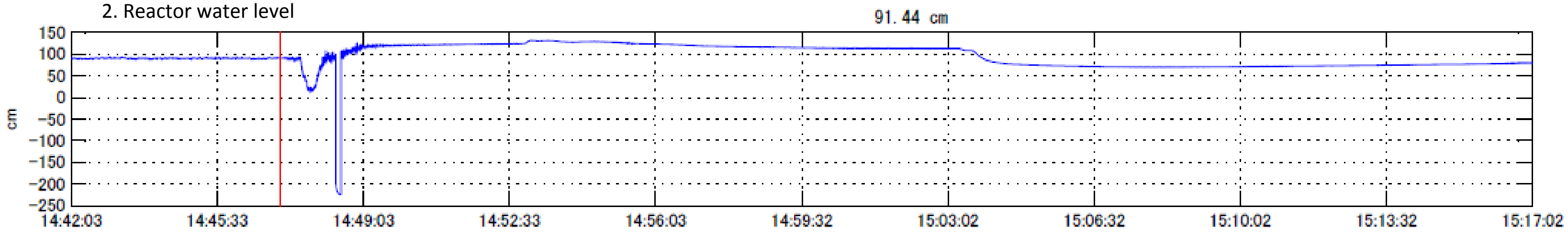
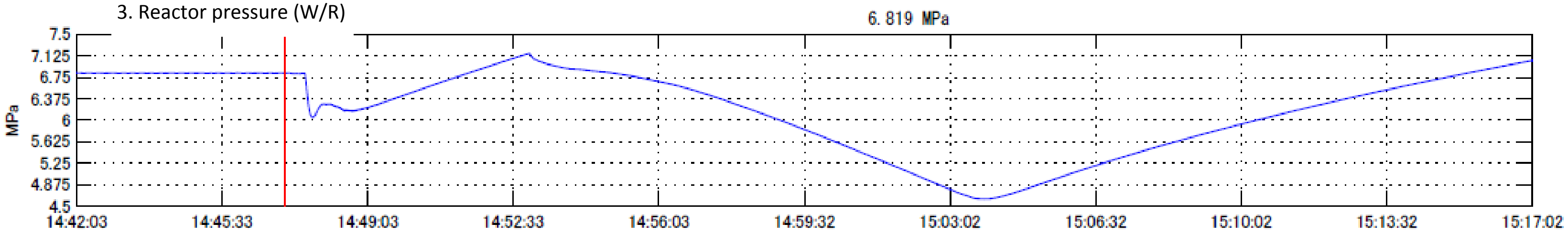
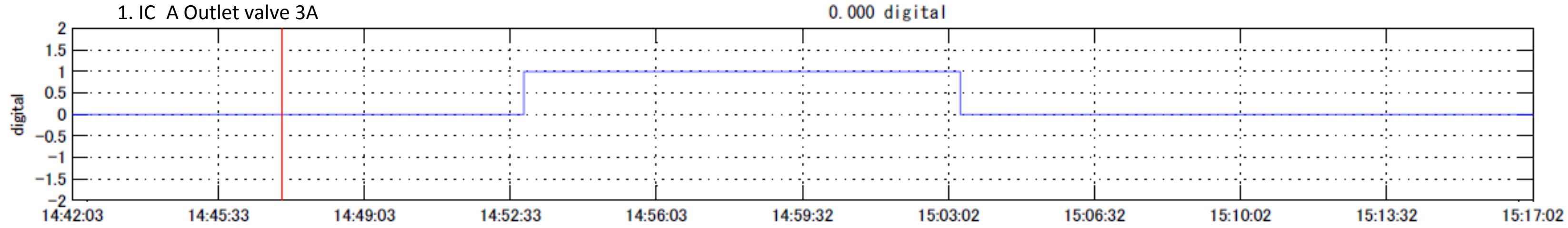
</td><td>The main steam flow rate drops in tandem with reactor scram.</td></tr>
</table>

Attachment 6-1 (7)

Fukushima Daiichi Unit 1 Transient Recorder Trends

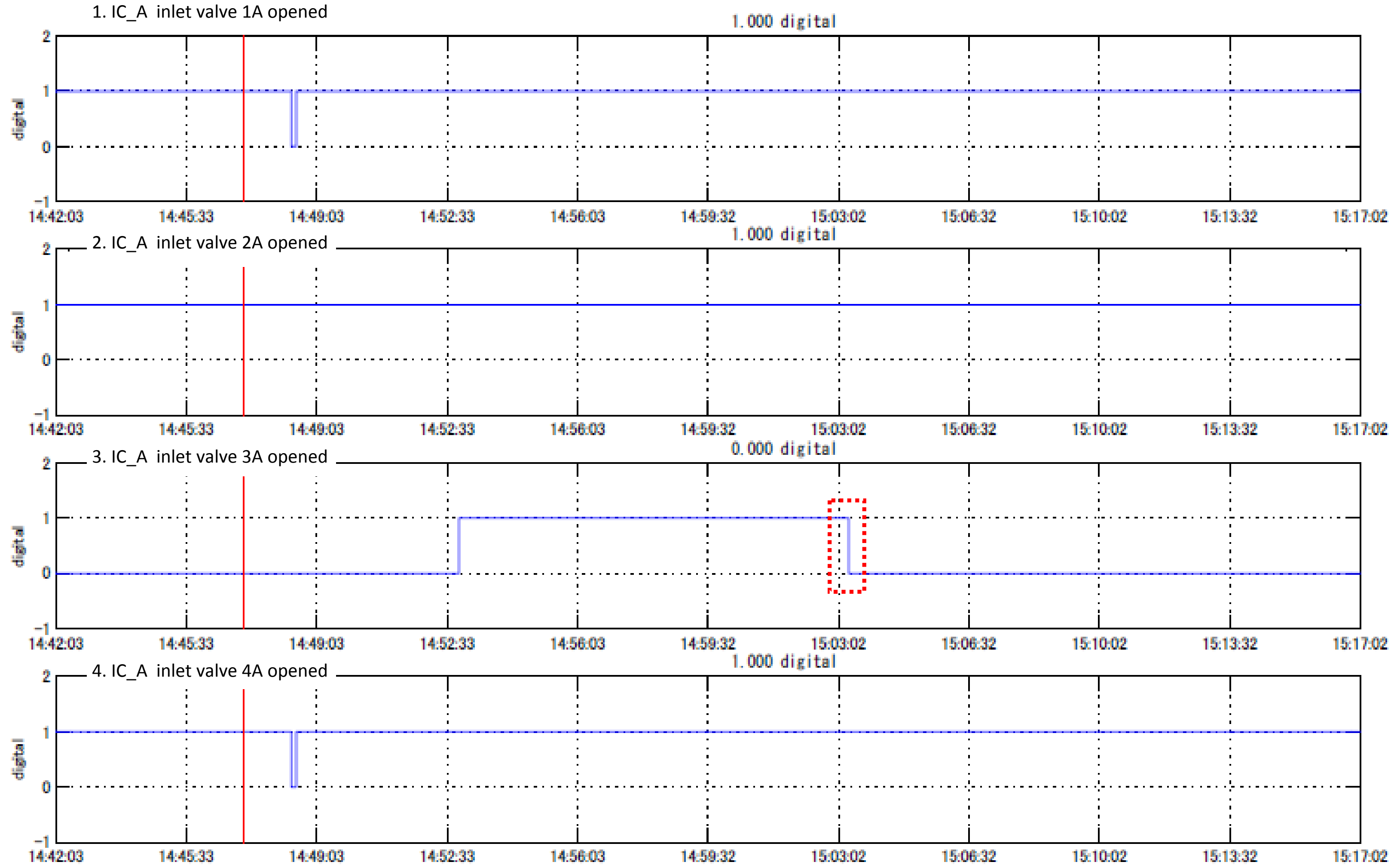
[Isolation Condenser System (IC) Operation]

1452	A567	RX MODE SW REFUEL		OFF		
1452	C020	SUPPRESSION	LEVL	16.8 MM	NORMAL RETURN	
1452	C020	SUPPRESSION	LEVL	37.6>	20.0 MM	
1452	B526	ISO-CON VLV B	OPN	ON		IC Operation
1452	B525	ISO-CON VLV A	OPN	ON		IC Operation
1452	C020	SUPPRESSION	LEVL	14.0 MM	NORMAL RETURN	
1452	A516	SRM DET	POS	IN		
1452	C020	SUPPRESSION	LEVL	35.2>	20.0 MM	

Parameters	Notes
2. Reactor water level  Automatic reactor scram in conjunction with earthquake Start of automatic recording by transient recorder in conjunction with vibration of the top of the reactor recirculation pump (A)	Reactor water level momentarily fluctuated in conjunction with the collapse of voids (bubbles) immediately after the scram and then stabilized at normal water levels.
3. Reactor pressure (W/R)  Automatic reactor scram in conjunction with earthquake Start of automatic recording by transient recorder in conjunction with vibration of the top of the reactor recirculation pump (A)	Reactor pressure dropped immediately after the scram but then increased due to closing of the main steam isolation valve and decay heat. At 14:52 pressure decreased in conjunction with startup of the isolation condenser system (IC) and then increased in conjunction with shutdown of the isolation condenser system (IC).
1. IC A Outlet valve 3A  Isolation condenser system startup Isolation condenser system shutdown	The isolation condenser system (IC) started up at 14:52 and shut down at 15:03.

Fukushima Daiichi Unit 1 Transient Recorder Trends

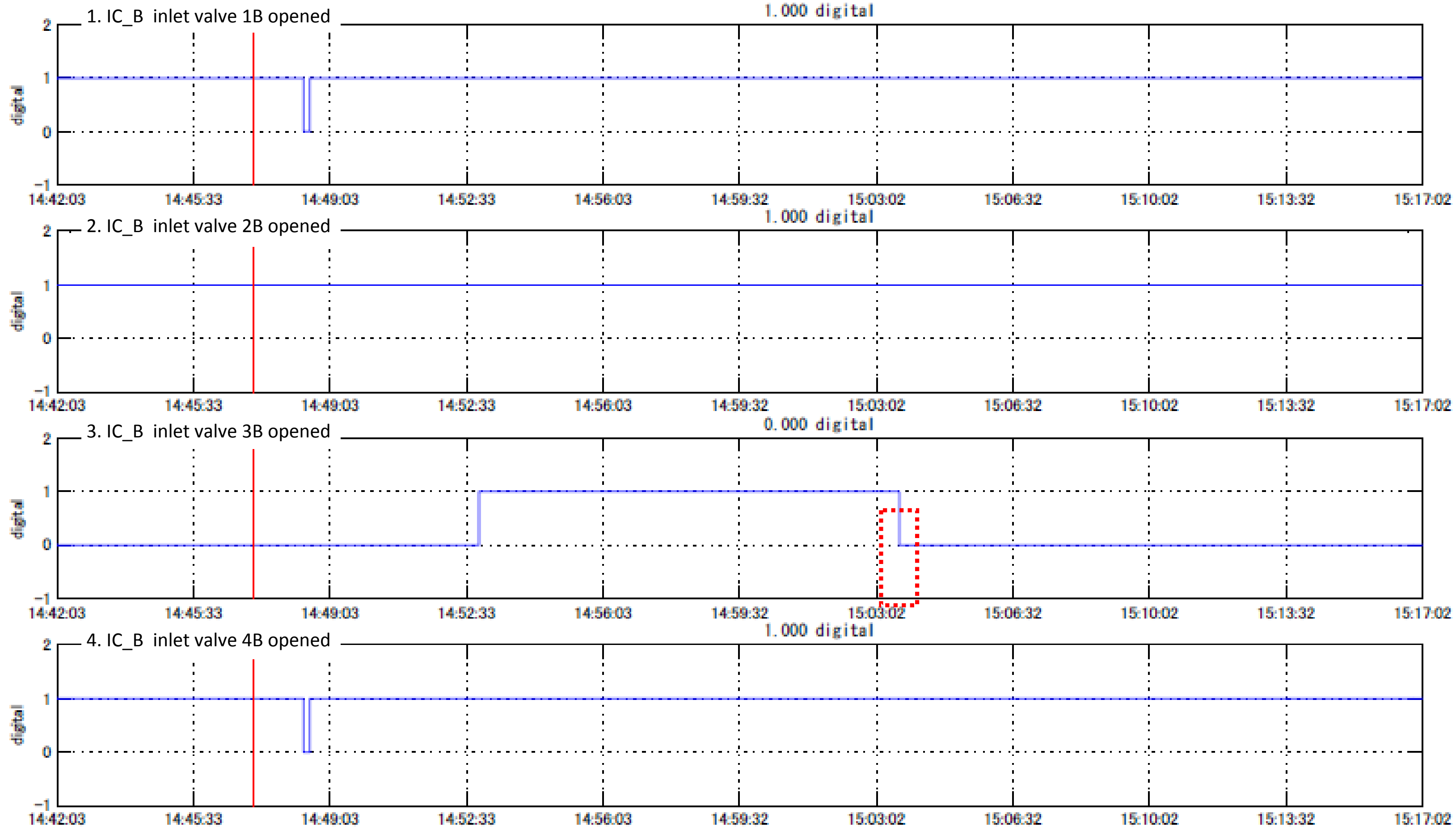
Parameters	Notes
Fukushima Daiichi Nuclear Power station Unit 1 Display of event data / timeline data Display of data from 14:42:03 on March 11, 2011 to 15:17:02 on March 11, 2011 File name 1F1_Cy24_EVF_DET_2011_03_11_Fri_14_47_04.dat Data period 0.01 sec. (1— Time of event: 14:47:03.9 on March 11, 2011	



Fukushima Daiichi Unit 1 Transient Recorder Trends

Attachment 6-1 (8) (3/4)

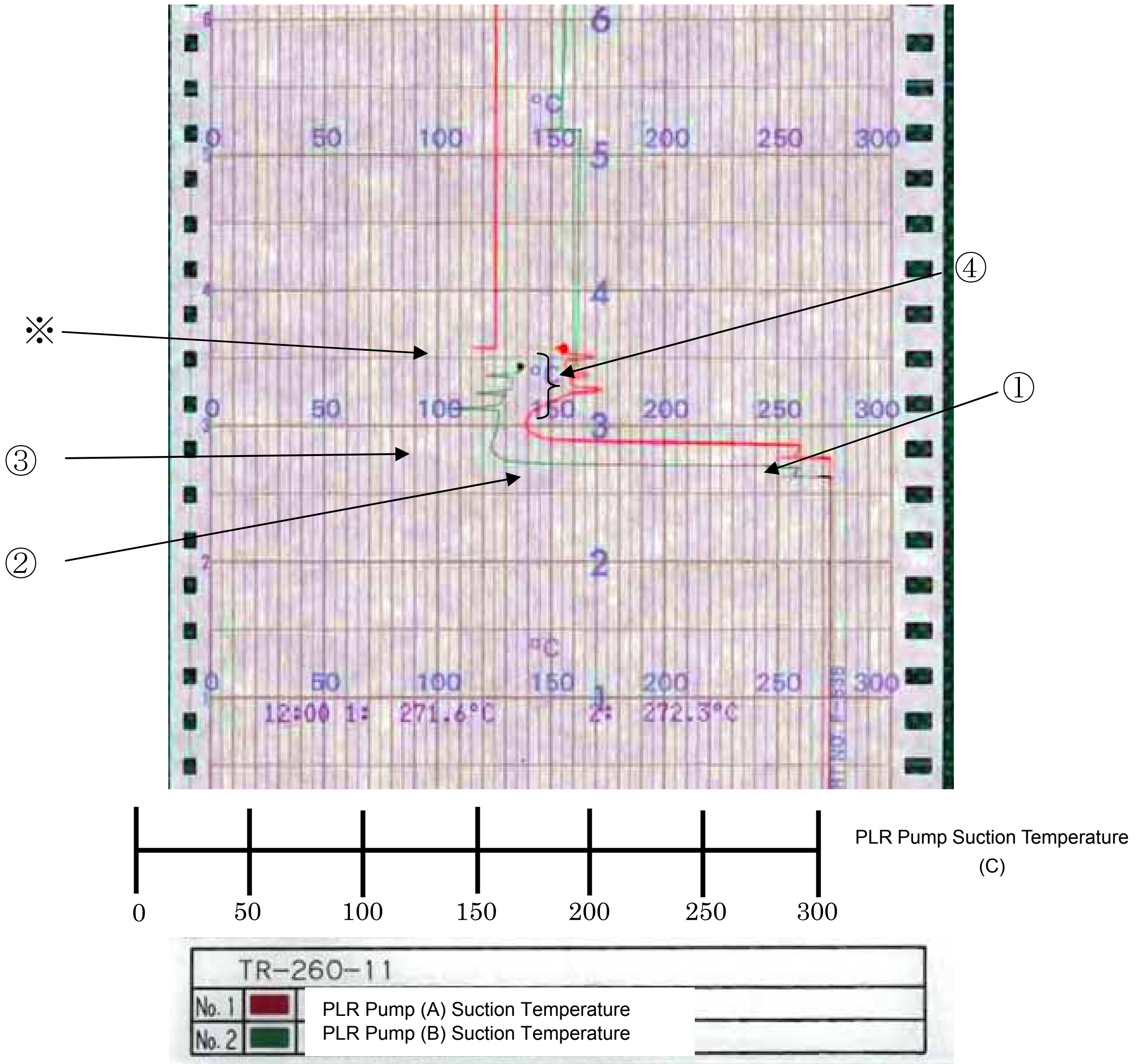
Parameters	Notes
Fukushima Daiichi Nuclear Power station Unit 1 Display of event data / timeline data Display of data from 14:42:03 on March 11, 2011 to 15:17:02 on March 11, 2011 File name 1F1_Cy24_EVF_DET_2011_03_11_Fri_14_47_04.dat Data period 0.01 sec. (1— Time of event: 14:47:03 on March 11, 2011 900 millisec.	



Attachment 6-1 (8) (4/4)

Fukushima Daiichi Unit 1 Transient Recorder Trends

[Primary Loop Recirculation (PLR) Pump Suction Temperature]



① Scram Triggered by Earthquake at 14:46

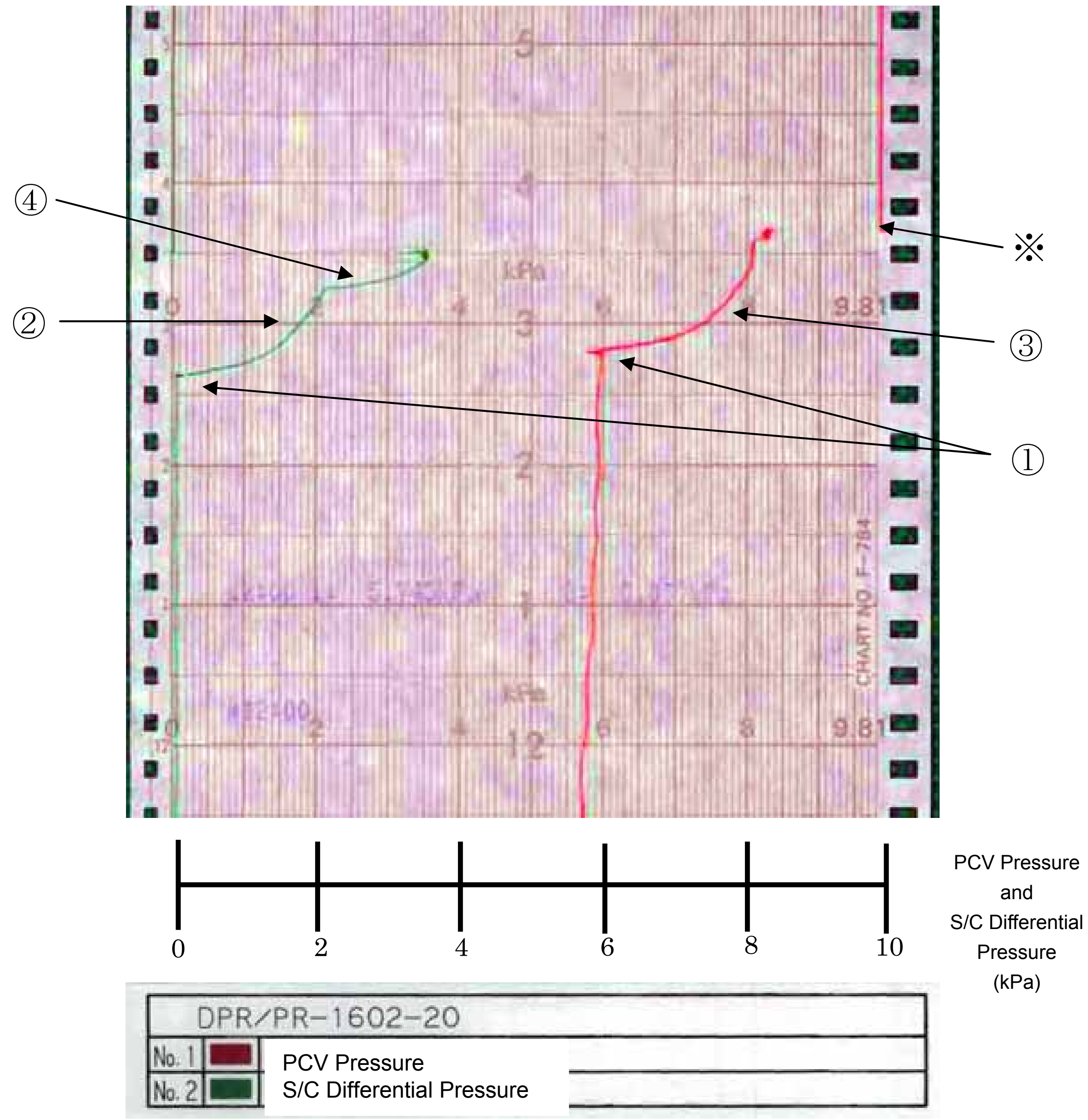
② Drop in output due to scram, decrease in pressure due to IC activation, decrease in temperature because of low temperature water injection.

③ Shutdown of automatically activated IC

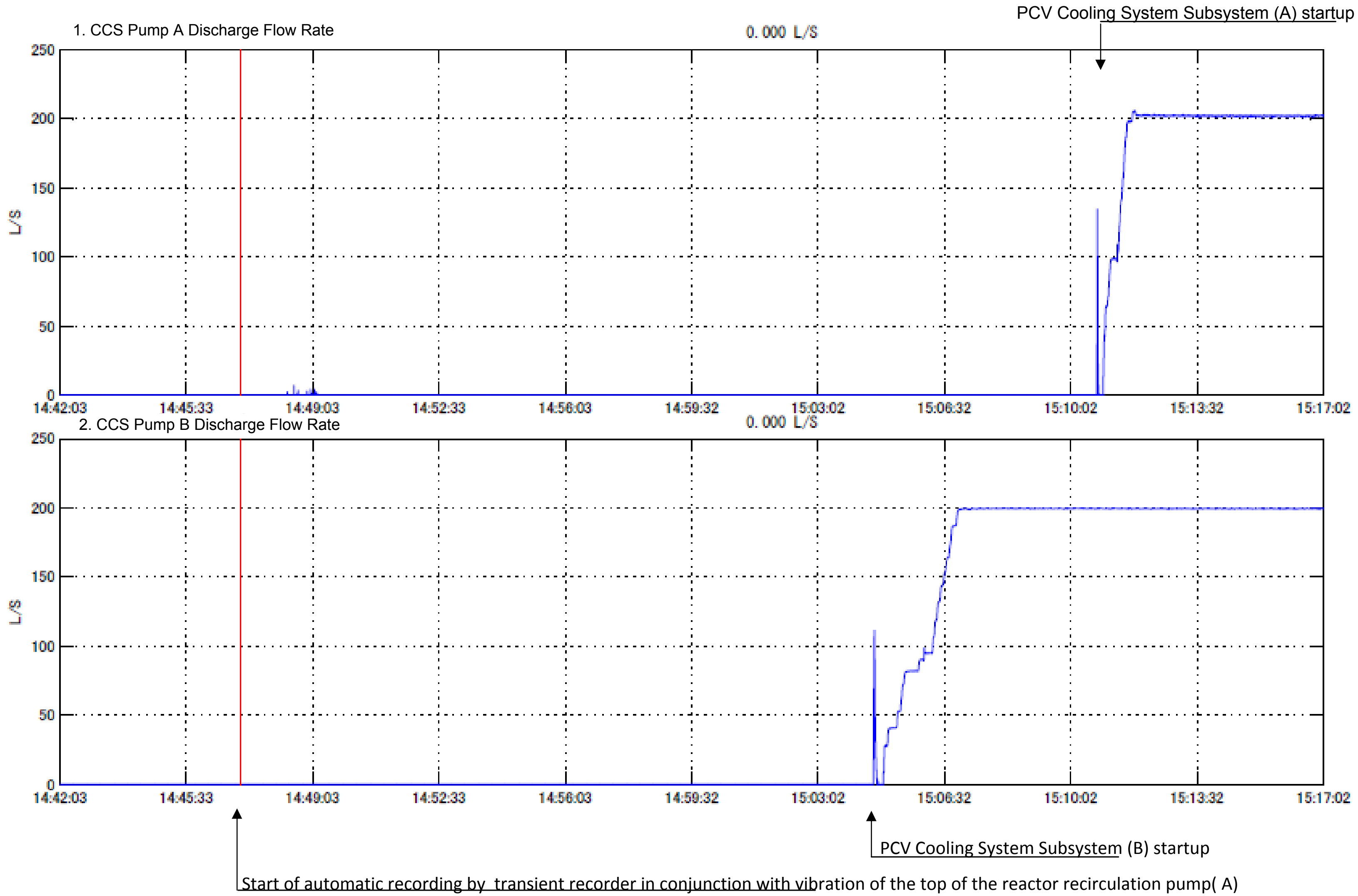
④ Change resulting from pressure control with IC (A) (PLR pump (B) suction temperature dropped dramatically due to cooled water from IC operation flowing directly into the PLR loop (B) suction. The cooled water flowed toward PLR Loop (A) on the opposite side of PLR loop (B) while slowly being warmed, and PLR pump (A) temperature gently dropped slightly after)

* Loss of power for recorders shortly after 15:30 due to arrival of tsunami, resulting in the recorder to stop temporarily. It is assumed that it restarted afterwards.

[Primary Containment Vessel (PCV) Pressure, Suppression Chamber (S/C) Differential Pressure]



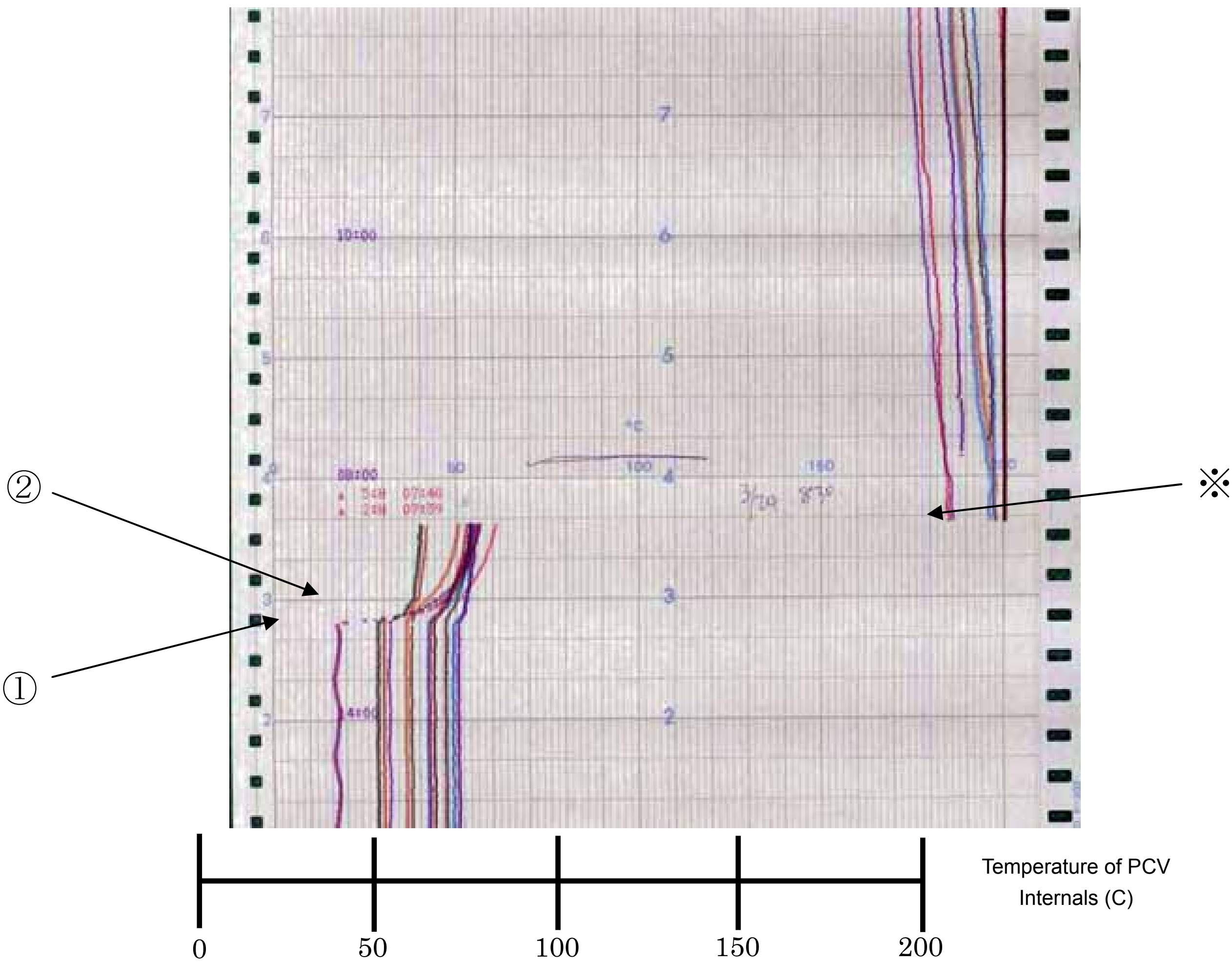
① Scram triggered by earthquake at 14:46
② Rise in S/C Differential Pressure following rise in PCV pressure
③ Rise in PCV pressure due to PCV air conditioning shutdown
④ Decrease in S/C pressure following S/C cooling
(indicates further increase in differential pressure)= inflection point
* It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the chart no longer gives an accurate reading due to the impact of the tsunami.

Parameter	Notes
	PCV Cooling System Pump Subsystem B has started up around 15:05. Similiarly, PCV Cooling System Pump Subsystem A has started up around 15:11. The startup is thought to have been occurred in order to perform cooling of the the suppression chamber pool water. *"Torus Cooling (A) has become in service at 15:07" and "Torus Cooling (B) has become in service at 15:10" are recorded in the journal of shift workers.

Attachment 6-1 (10) (2/2)

Fukushima Daiichi Unit 1 Transient Recorder Trends

[Temperature of Primary Containment Vessel (PCV) Internals]



TR-1602-5

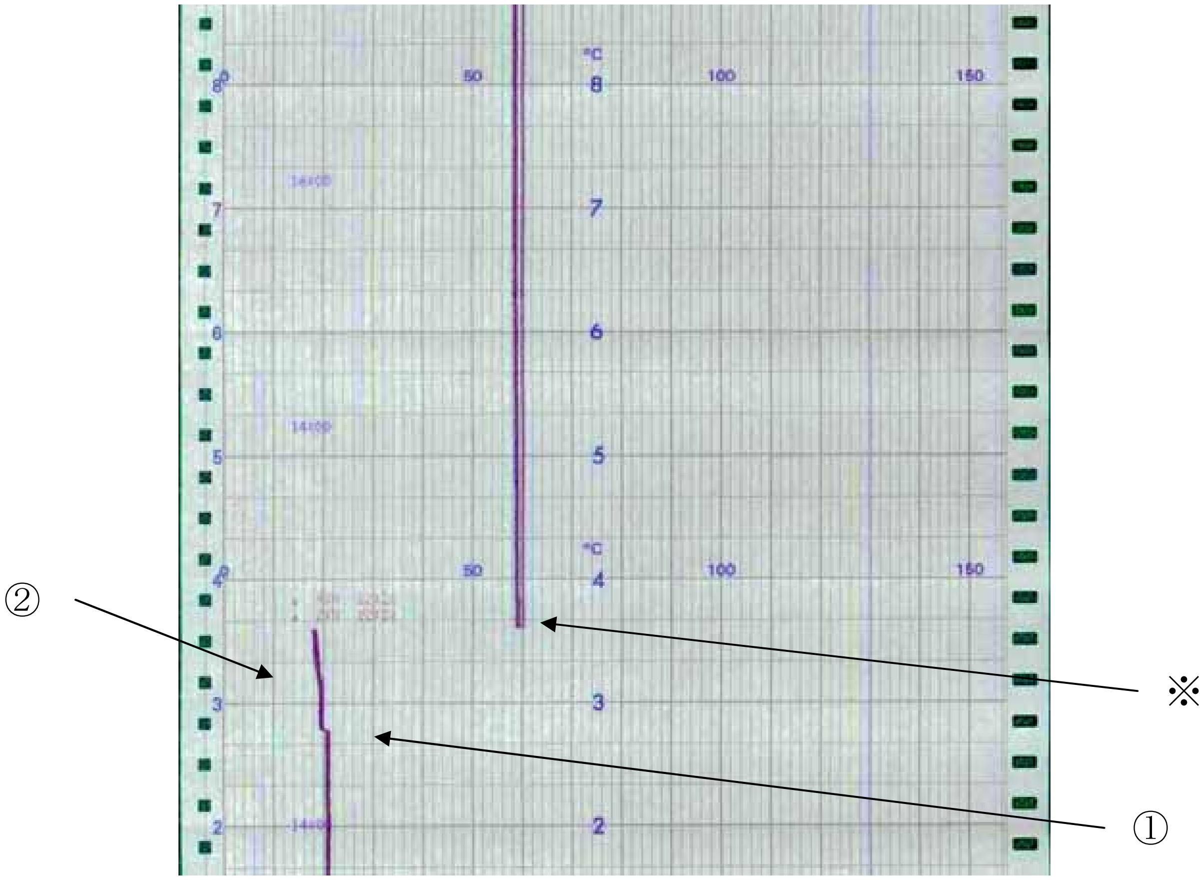
No	色	打点	測定名称	No	色	打点	測定名称
1		●	RETURN AIR DUCT HVH-12A	13		+	EQ AROUND CIRCUM RPV BELLOWS TE-1625N
2		●	RETURN AIR DUCT HVH-12B	14		+	EQ AROUND CIRCUM RPV BELLOWS TE-1625P
3		●	RETURN AIR DUCT HVH-12C	15		+	EQ AROUND CIRCUM RPV BELLOWS TE-1625R
4		●	RETURN AIR DUCT HVH-12D	16		+	
5		●	RETURN AIR DUCT HVH-12E	17		+	
6		●	SUPPLY AIR DUCT HVH-12A	18		+	
7		○	SUPPLY AIR DUCT HVH-12B	19		Y	
8		○	SUPPLY AIR DUCT HVH-12C	20		Y	
9		○	SUPPLY AIR DUCT HVH-12D	21		Y	
10		○	SUPPLY AIR DUCT HVH-12E	22		Y	
11		○	EQ AROUND CIRCUM RPV BELLOWS TE-1625L	23		Y	
12		○	EQ AROUND CIRCUM RPV BELLOWS TE-1625M	24		Y	

① Scram triggered due to Earthquake at 14:46

② Rise in PCV Temperature following shutdown of PCV air conditioning due to loss of power.(Significant rise in pressure caused by piping ruptures was not found.)

* Loss of power for recorders shortly after 15:30 due to tsunami resulted in temporary halt in recording. Recording restarted on March 24 following restoration of power for recorders.

[Suppression Pool Water Temperature]



TRS-1601-71A

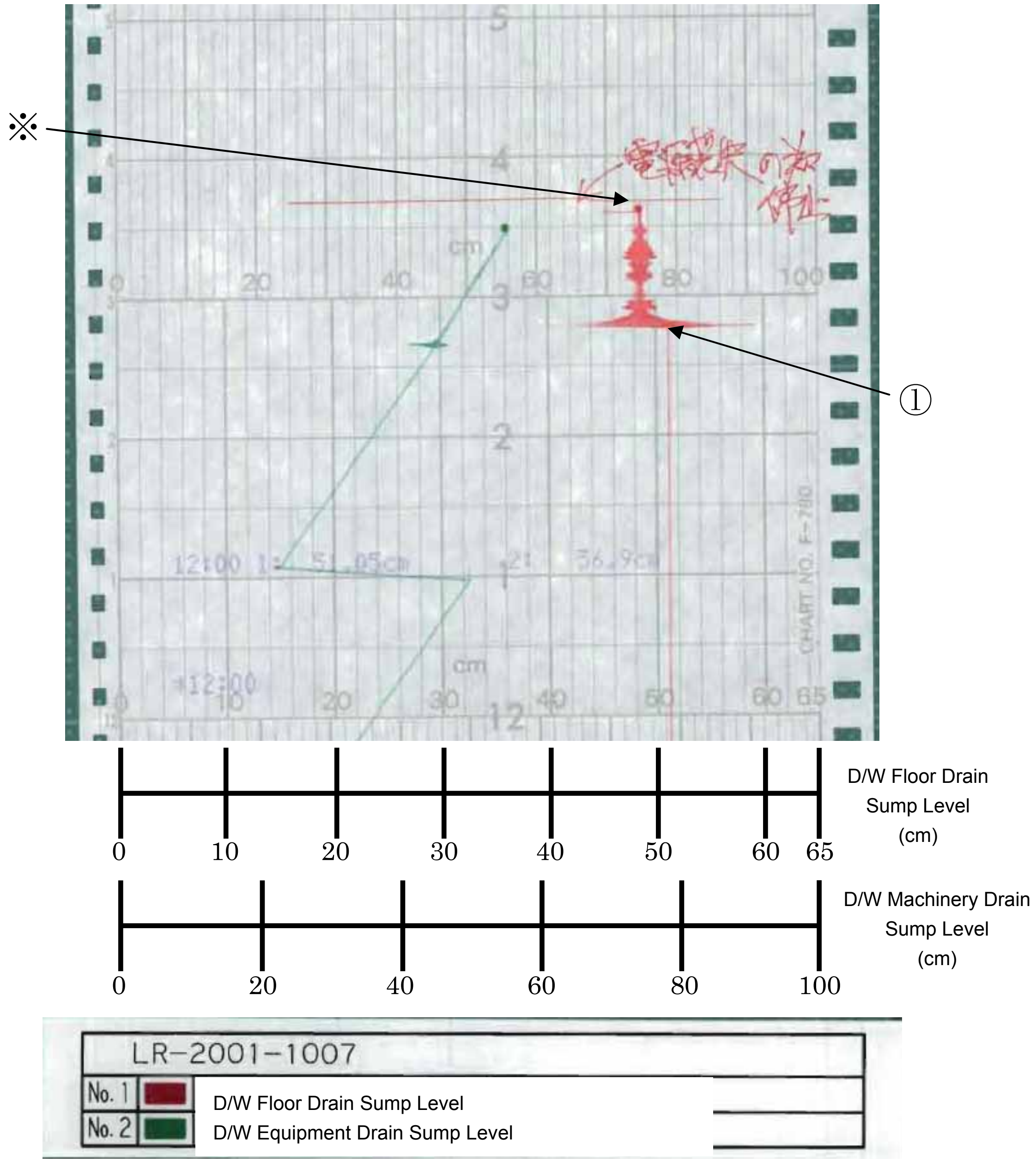
NO	色	打点	測定名称	NO	色	打点	測定名称
1		●	X-208A(35°)近傍	4		●	X-208D(325°)近傍
2		●	X-208B(145°)近傍	5		●	
3		●	X-208C(235°)近傍	6		●	

① Scram triggered by earthquake at 14:46

② Cooling by PCV spray system (CCS)

*It is assumed that the tsunami arrived shortly after 15:30. It is also assumed that correct recordings were not made due to the impact of the tsunami.

[Dry Well (D/W) Floor Drain Sump Water Level]



① Scram triggered by earthquake at 14:46

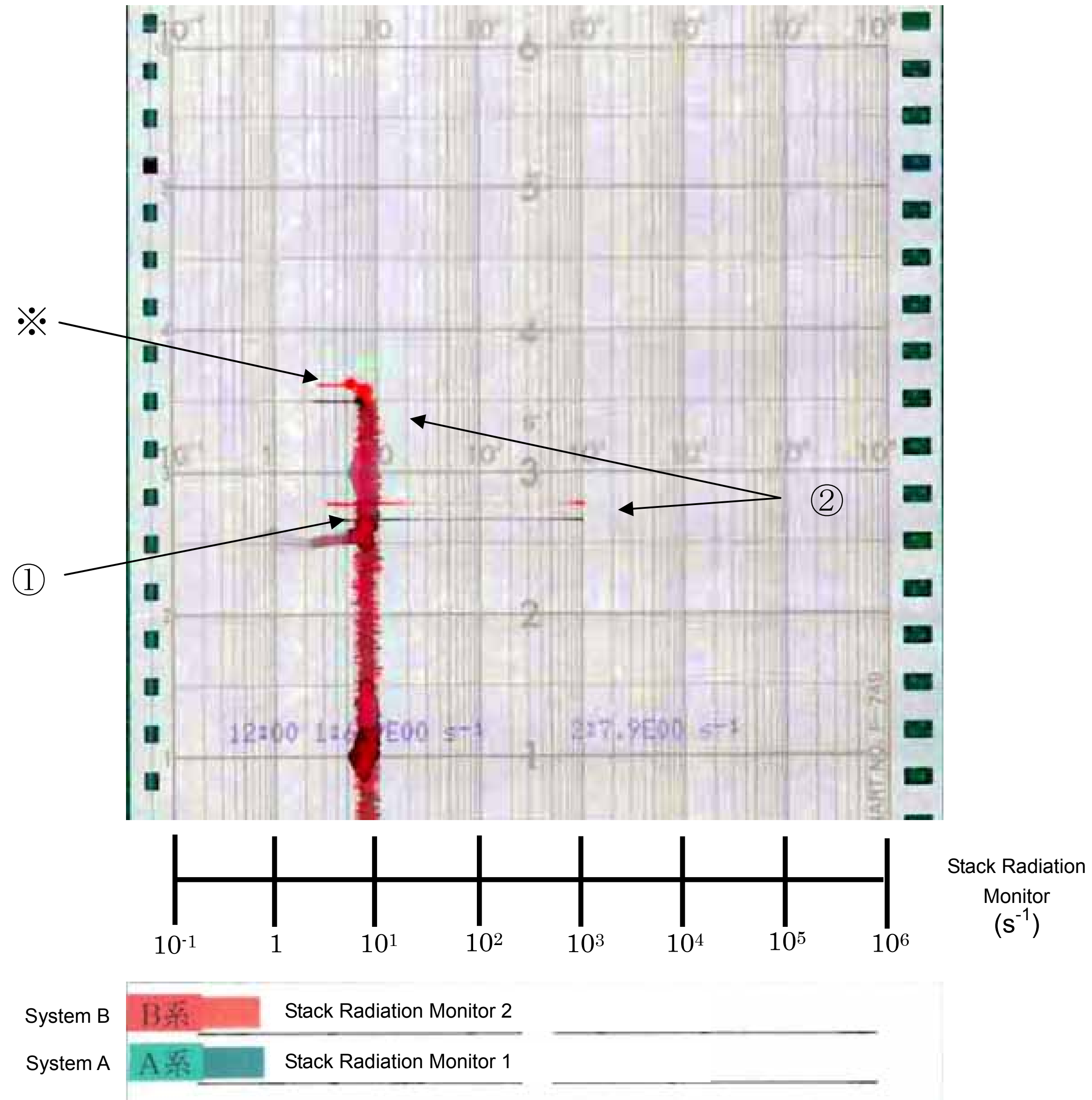
※ It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

[Standby Gas Treatment System (SGTS) Operation]

```
1447  A549 LOW POWR ALRM POINT   UNDER
 14    47   20  620     D522   REAC WTR LEVL C            NORM
1447  D622 PCIS ISO IN  TRIP        ON
 14    47   20  620     D523   REAC WTR LEVL D            NORM
1447  D623 PCIS ISO OUT TRIP        ON
 14    47   21  910     D521   REAC WTR LEVL B            NOR
1447  B519 SGTS B START             ON
 14    47   21  920     D520   REAC WTR LEVL A            NOR
1447  G001 GENERATR GROS VARS    264.0> 228.0 MVAR
 14    47   26  290     D578   DUMPTANK 2 LEVL B          HIGH
1447  C055 RX WTR LVL (W/R) A      214<    700 MM
 14    47   26  550     D502   DUMPTANK 1 LEVL C          HIGH
1447  C056 RX WTR LVL (W/R) B      276<    700 MM
 14    47   26  750     D503   DUMPTANK 1 LEVL D          HIGH
```

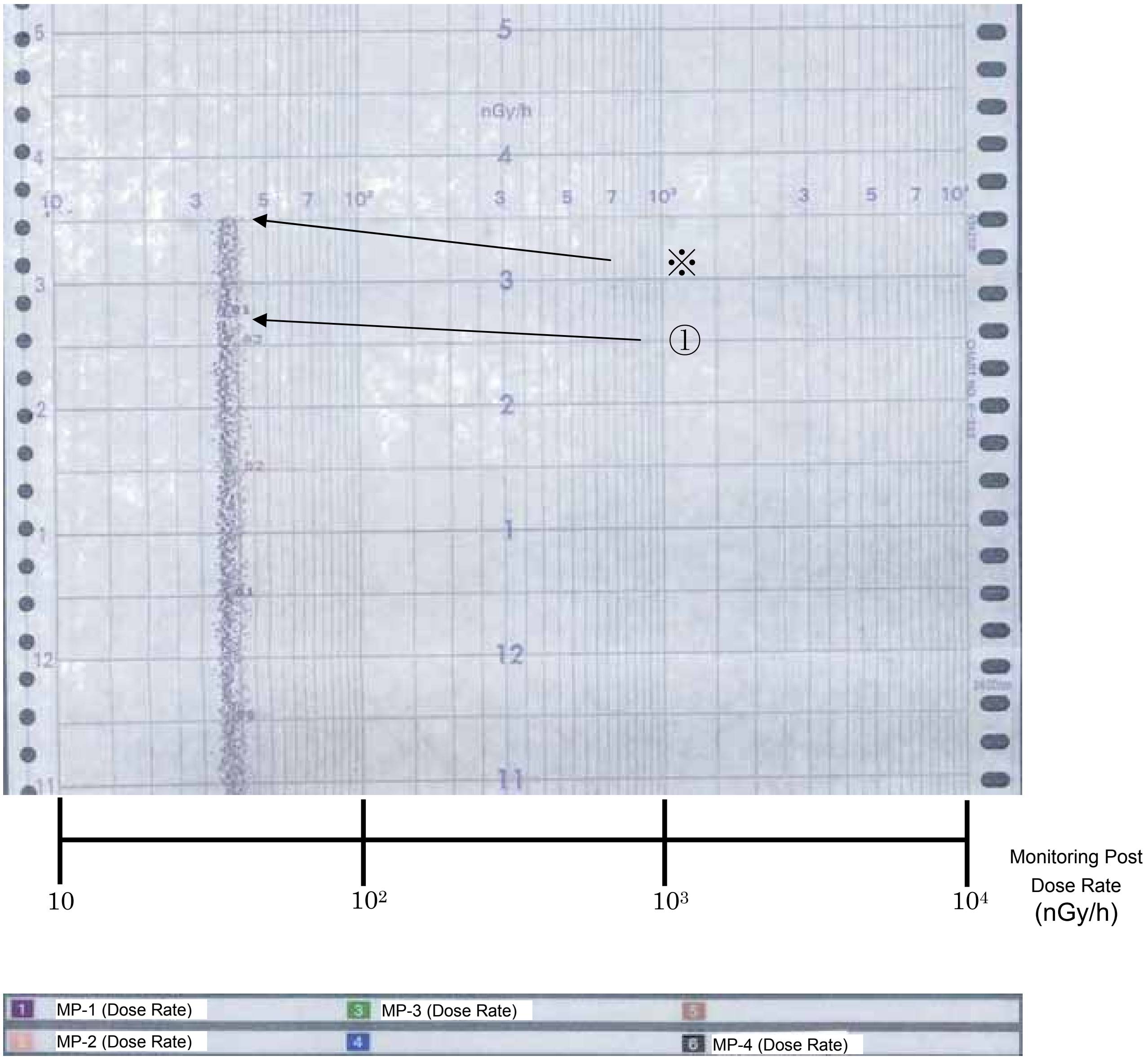
Standby Gas Treatment System (B) startup

[Stack Radiation Monitor]
(Stack Radiation Monitor is shared by Units 1 & 2)



① Scram triggered by earthquake at 14:46
② Signal thought to be noise
*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

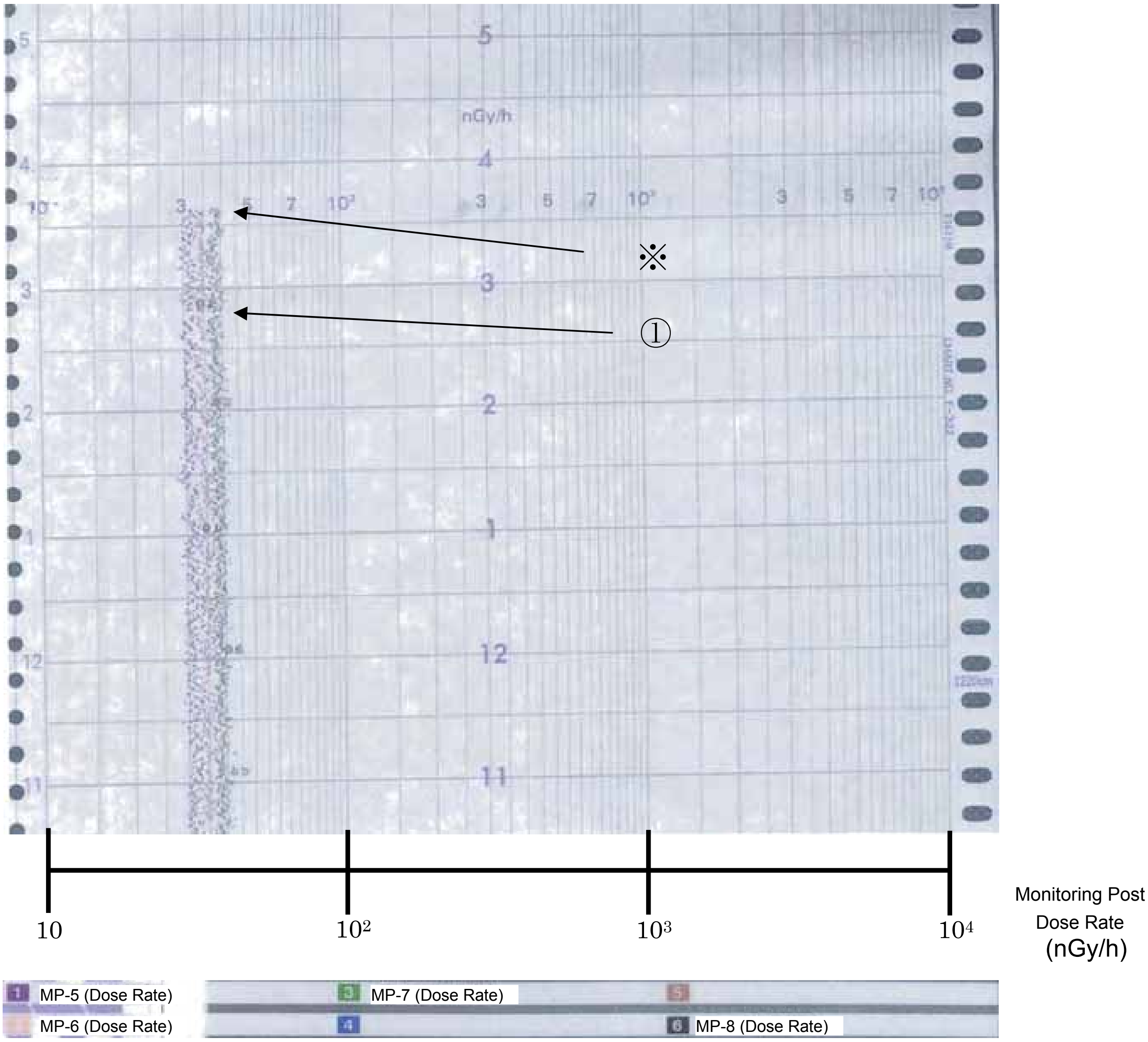
[Monitoring Post 1~4 (Low Radiation Levels)]



① Scram triggered by earthquake at 14:46

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

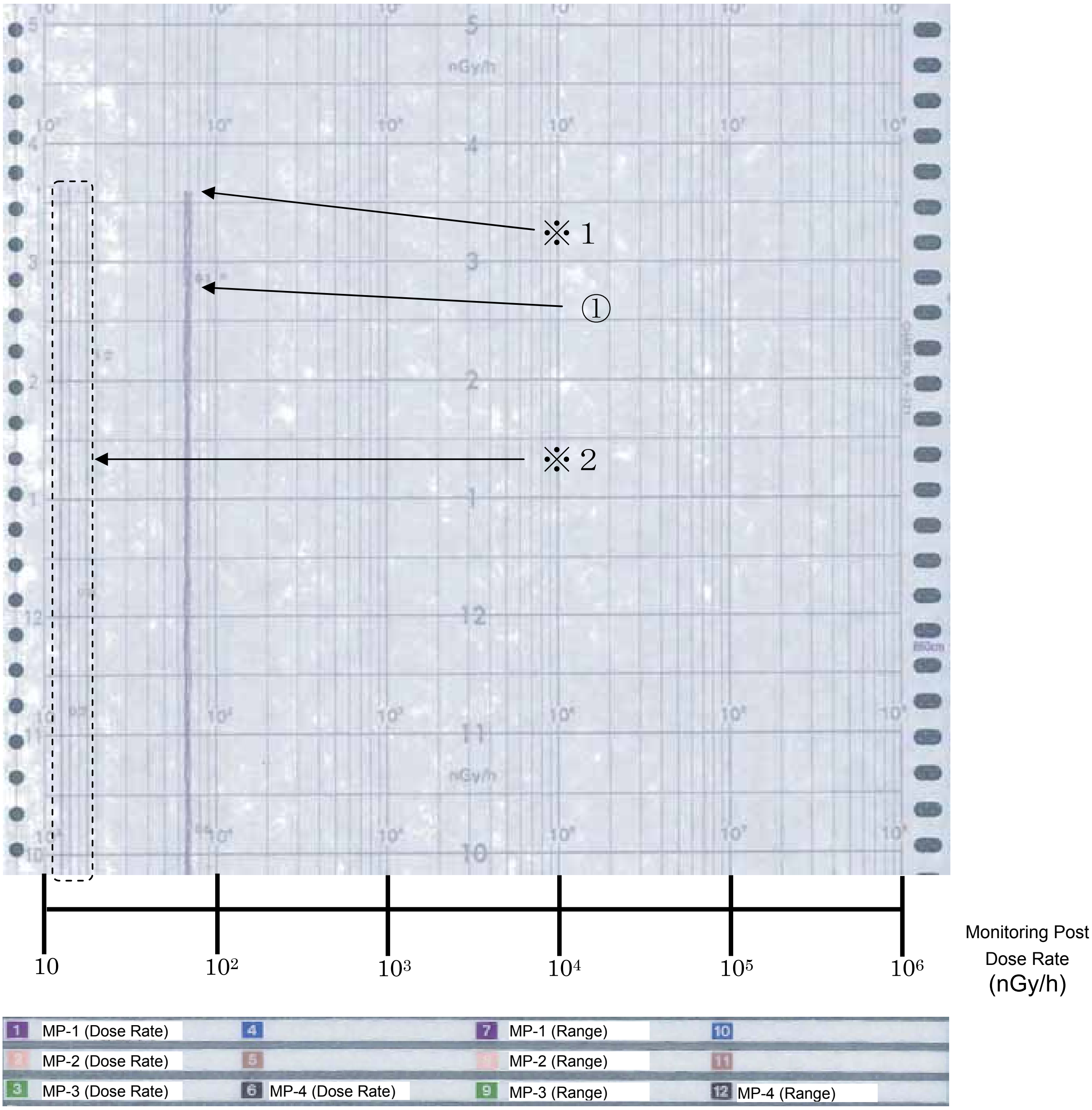
[Monitoring Post 5~8 (Low Radiation Levels)]



① Scram triggered by earthquake at 14:46

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

[Monitoring Post 1~4 (High Radiation Levels)]

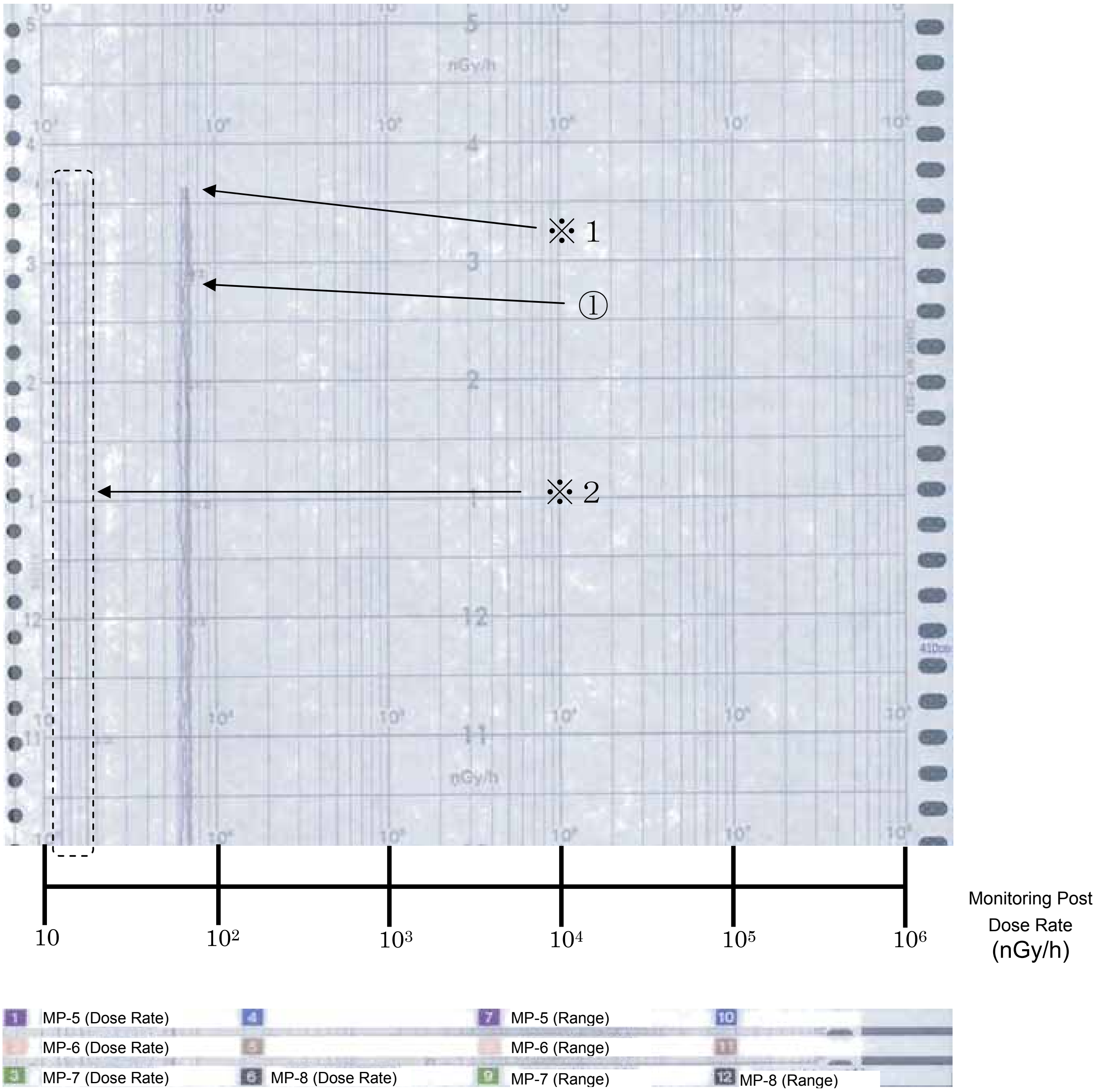


① Scram triggered by earthquake at 14:46

※1 It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

※2 This recorder can record two ranges (Low Range: $10 \sim 10^6$ nGy/h, High Range: $10^3 \sim 10^8$ nGy/h). Indication of the range here means that Low Range is being recorded. (For High Range, records are plotted on the right side of the chart.)

[Monitoring Post 5~8 (High Radiation Levels)]



① Scram triggered by earthquake at 14:46

※1 It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

※2 This recorder can record two ranges (Low Range: $10 \sim 10^6$ nGy/h, High Range: $10^3 \sim 10^8$ nGy/h). Indication of the Range here means that Low Range is being recorded. (For High Range, records are plotted on the right side of the chart.)

Fukushima Daiichi Unit 2 Plant Data

[Scram・All Control Rods Fully Inserted]

*	2011/03/11	14:47	A524	APRM 中性子束 高			
*	2011/03/11	14:47	D535	原子炉 自動スクラム B			
*	2011/03/11	14:47	D565	地震トリップ CH-D			
	2011/03/11	14:47	C028	圧力抑制室 水位			
*	2011/03/11	14:47	D534	原子炉 自動スクラム A			
*	2011/03/11	14:47	D562	地震トリップ CH-A			
	2011/03/11	14:47	未選択制御棒	位置変化	18-03	99pos	ドリフト
	2011/03/11	14:47	未選択制御棒	位置変化	22-03	99pos	ドリフト
	2011/03/11	14:47	未選択制御棒	位置変化	26-03	99pos	ドリフト
	2011/03/11	14:47	未選択制御棒	位置変化	30-03	99pos	ドリフト
	2011/03/11	14:47	未選択制御棒	位置変化	34-03	99pos	ドリフト
	2011/03/11	14:47	未選択制御棒	位置変化	10-07	99pos	ドリフト

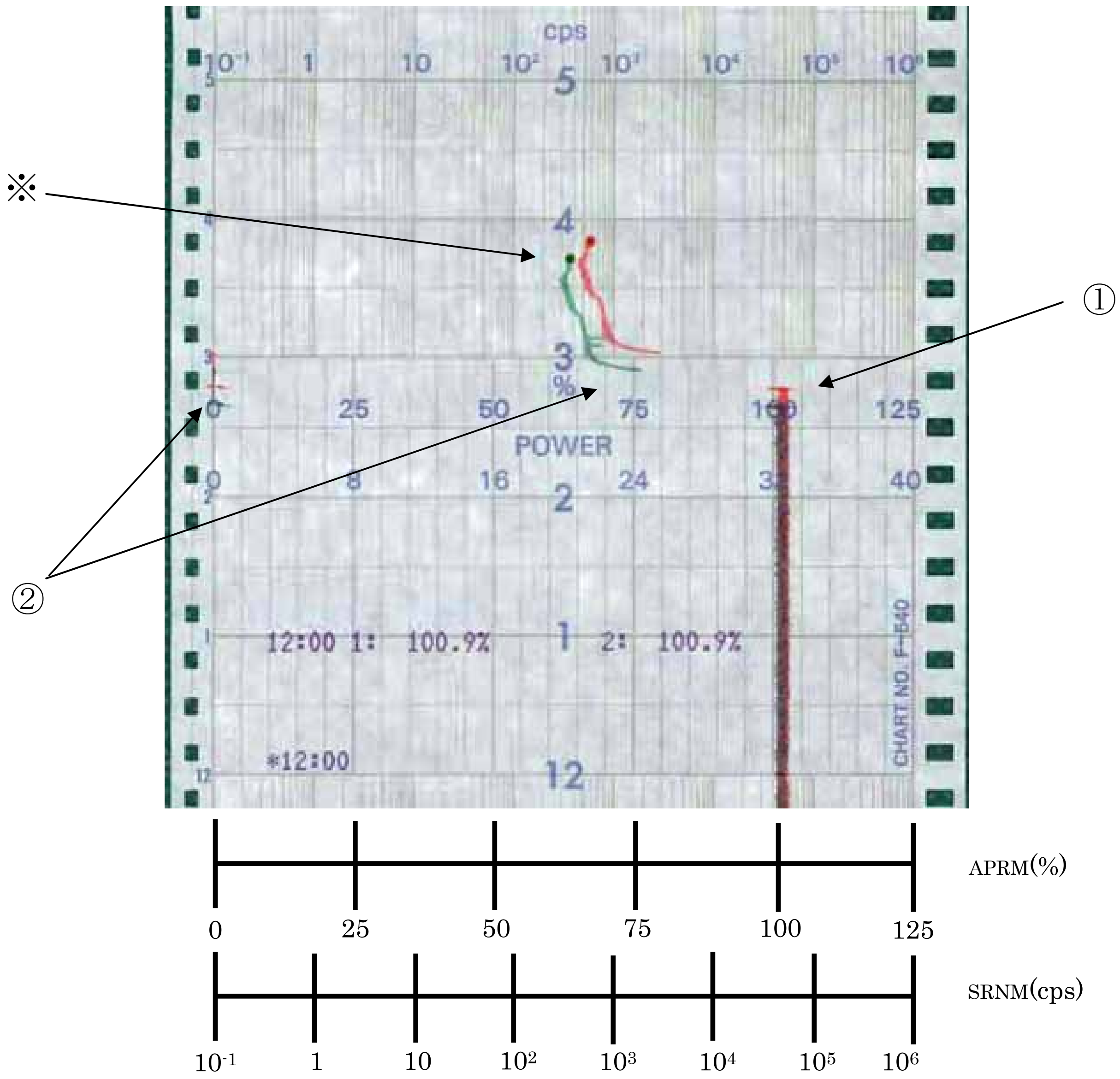
Automatic Scram Triggered by Earthquake

	2011/03/11	14:47	A545	全制御棒 全挿入
*	2011/03/11	14:47	C002	原子炉 給水流量 B
*	2011/03/11	14:47	T006	タービン グランドシール 蒸気圧力
*	2011/03/11	14:47	P608	EHC負荷要求偏差信号
	2011/03/11	14:47	G004	発電機 励磁 電圧
*	2011/03/11	14:47	B033	運転領域制限逸脱
	2011/03/11	14:47	G003	発電機 無効電力
	2011/03/11	14:47	G005	発電機 励磁 電流
	2011/03/11	14:47	C028	圧力抑制室 水位
*	2011/03/11	14:47	T008	タービン 潤滑油 レベル

All Control Rods Fully Inserted

Fukushima Daiichi Unit 2 Alarm Data Logger

[Start-Up Range Neutron Monitor (SRNM), Average Power Range Monitor (APRM)]



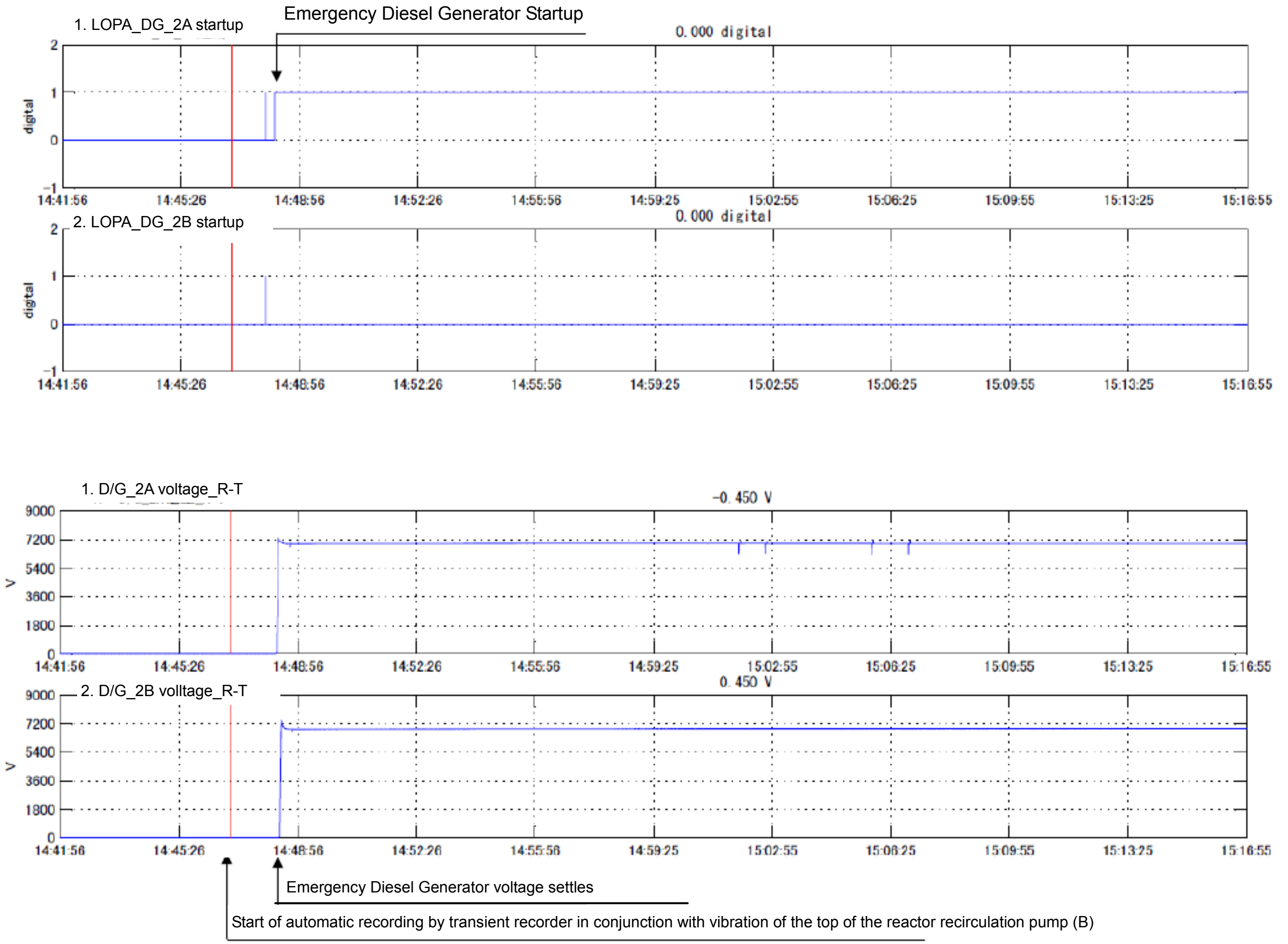
NR-7-46A	
Red	SRNM ch.A/APRM ch.A Output Level
Green	SRNM ch.C/APRM ch.C Output Level

① Scram triggered by earthquake at 14:47, and fall in output due to scram

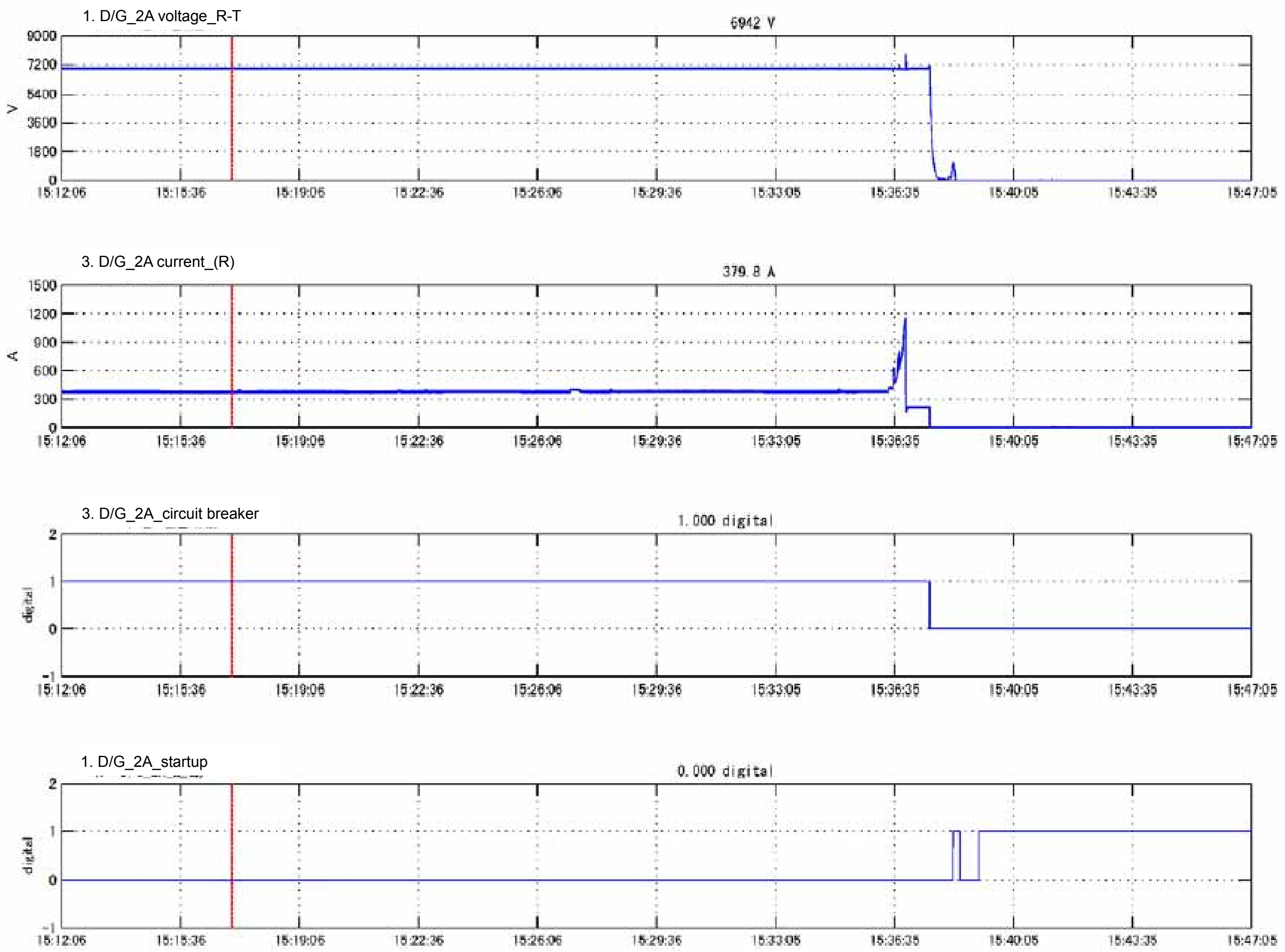
② Below the range of Average Power Range Monitor (APRM) and switch to Start-Up Range Neutron Monitor (SRNM)

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

Fukushima Daiichi Unit 2 Chart

<table>
<tr><th>Parameters</th><th>Notes</th></tr>
<tr><td>
</td><td>At 14:47 the emergency diesel generator starts up and voltage settles.</td></tr>
</table>

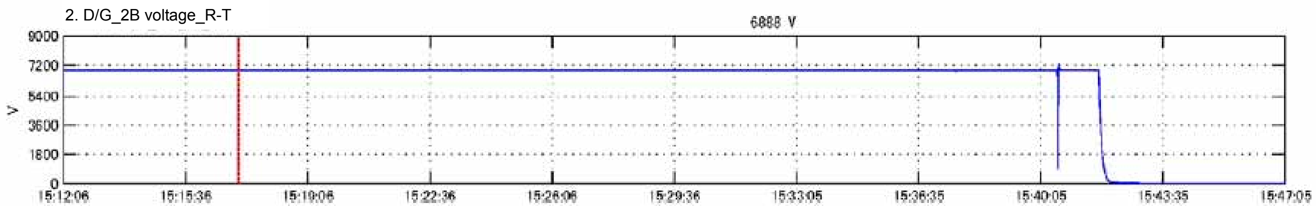
Fukushima Daiichi Unit 2 Transient Recorder Trends

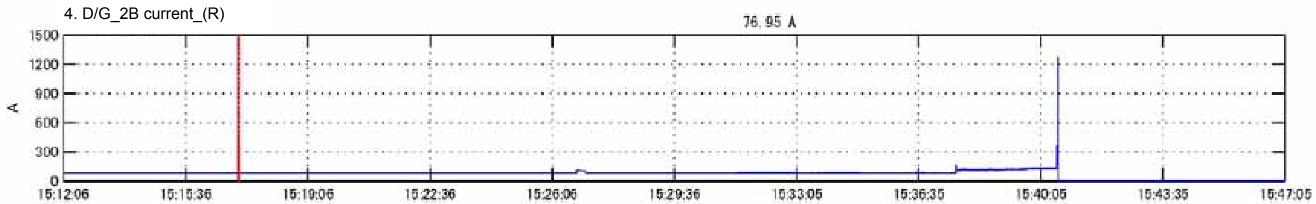
Parameters	Notes
	The D/G2A had started up but was shut down by the tsunami. There are indications that at around 15:38 another startup signal was sent but it did not result in startup.

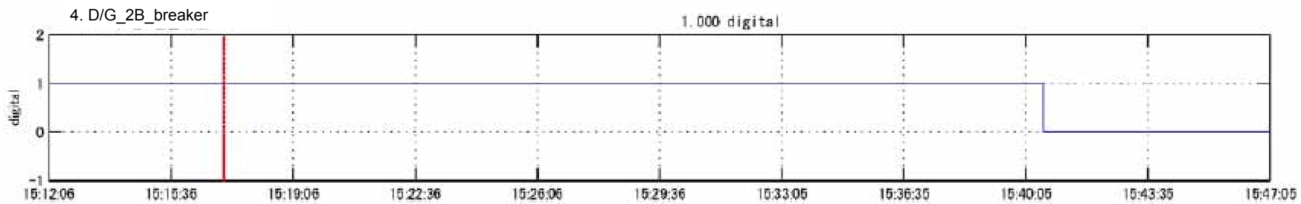
Fukushima Daiichi Unit 2 Transient Recorder Trends

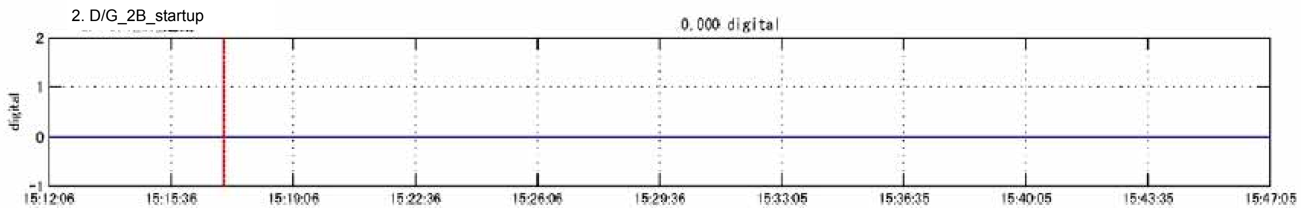
Attachment 6-2 (3) (2/3)

Parameters









Notes

The D/G2B had started up but was shut down by the tsunami. The time lag with 2A is thought to have been caused by the difference in installation location (2B is located in the shared auxiliary facility (common pool building) on the land side).

Fukushima Daiichi Unit 2 Transient Recorder Trends

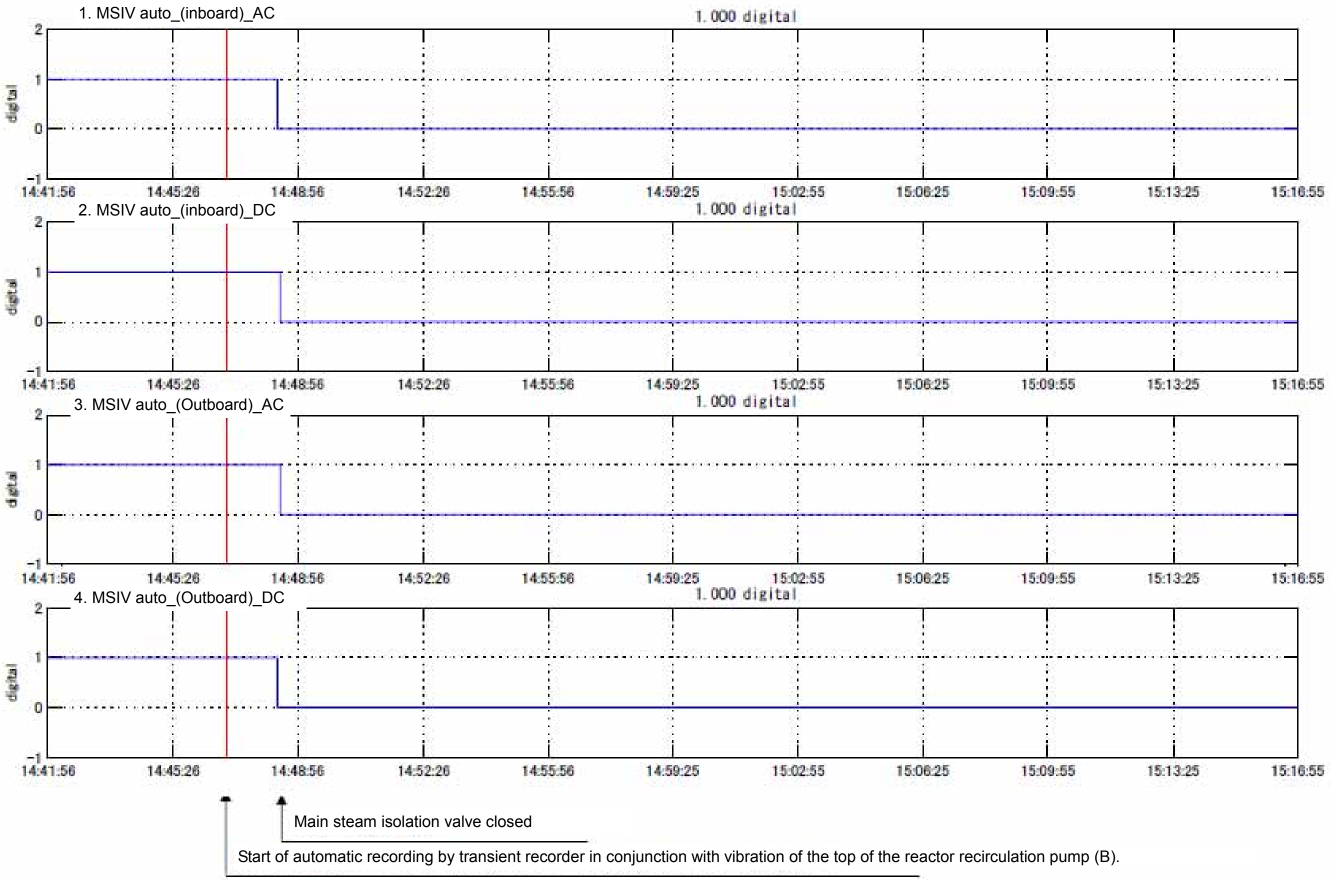
Attachment 6-2 (3) (3/3)

[Main Steam Isolation Valve (MSIV) Closure]

2011/3/11 14:48	A574	No.1 MSIV A closed	= ON	MSIV Closure
2011/3/11 14:48	A575	No.1 MSIV B closed	= ON	
2011/3/11 14:48	A576	No.1 MSIV C closed	= ON	
2011/3/11 14:48	A577	No.1 MSIV D closed	= ON	
2011/3/11 14:48	A582	No.2 MSIV A closed	= ON	
2011/3/11 14:48	A583	No.2 MSIV B closed	= ON	
2011/3/11 14:48	A584	No.2 MSIV C closed	= ON	
2011/3/11 14:48	A585	No.2 MSIV D closed	= ON	

(Note) Before and after MSIV closure, abnormal signals such as rupture detection have been recorded, but it is observed that these abnormal signals were sent as a fail safe measure following the loss of power for the instruments due to the loss of off-site power as a result of the earthquake. Signs of abnormalities, such as the increase of steam flow rates, are not seen in the process of closing the MSIV.

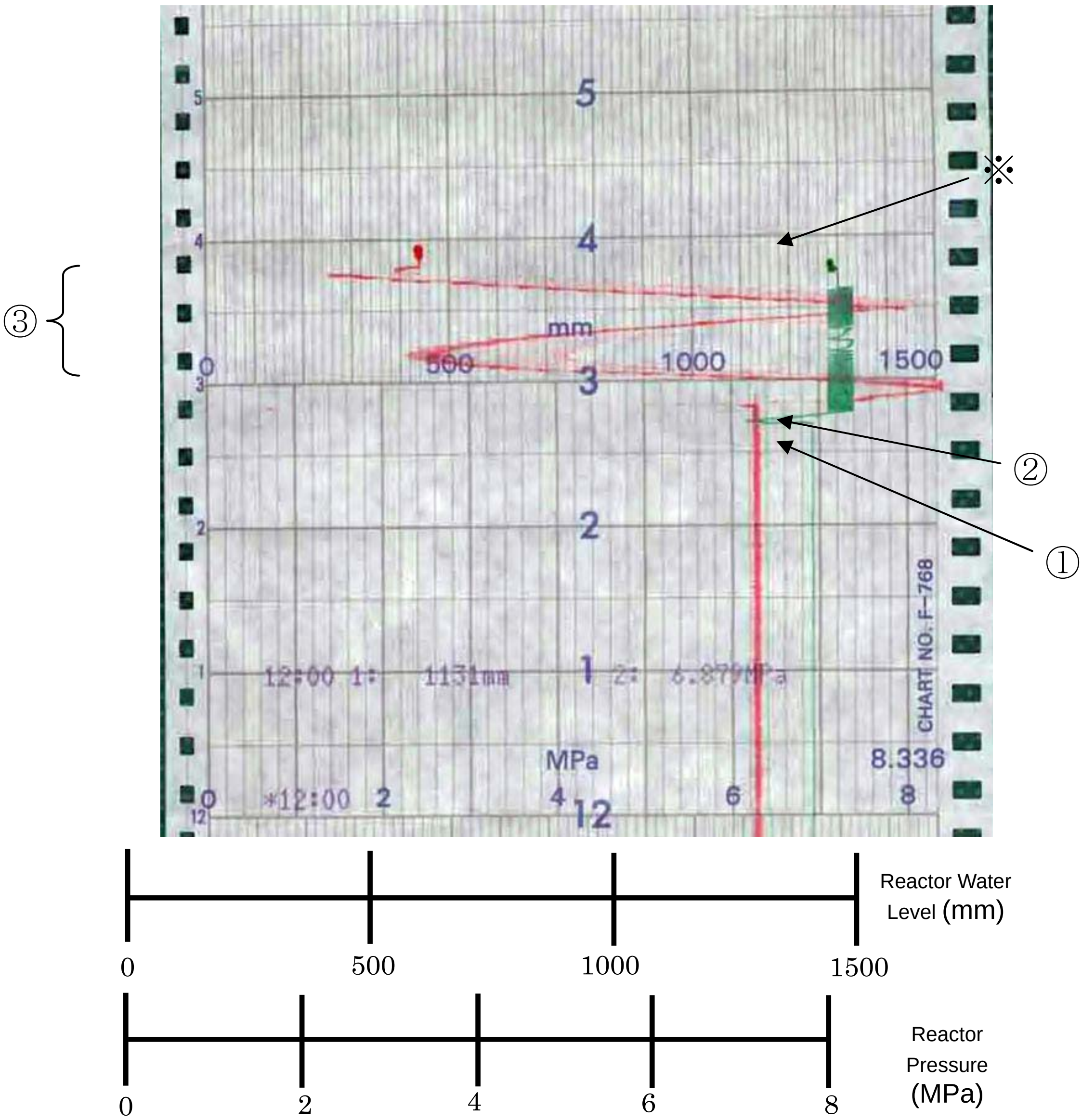
Fukushima Daini Unit 2 Alarm Data Logger

Parameters	Notes
	The main steam isolation valve (inboard/outboard) (MSIV) is closed.

Fukushima Daiichi Unit 2 Transient Recorder Trends

Attachment 6-2 (4) (2/2)

[Reactor Water Level, Reactor Pressure]



LR/PR-6-97

Red Reactor Water Level

Green Reactor Pressure

① Scram triggered by earthquake at 14:47

② Rise in pressure due to closing of MSIV, and pressure control due to the opening and closing of SRV that followed

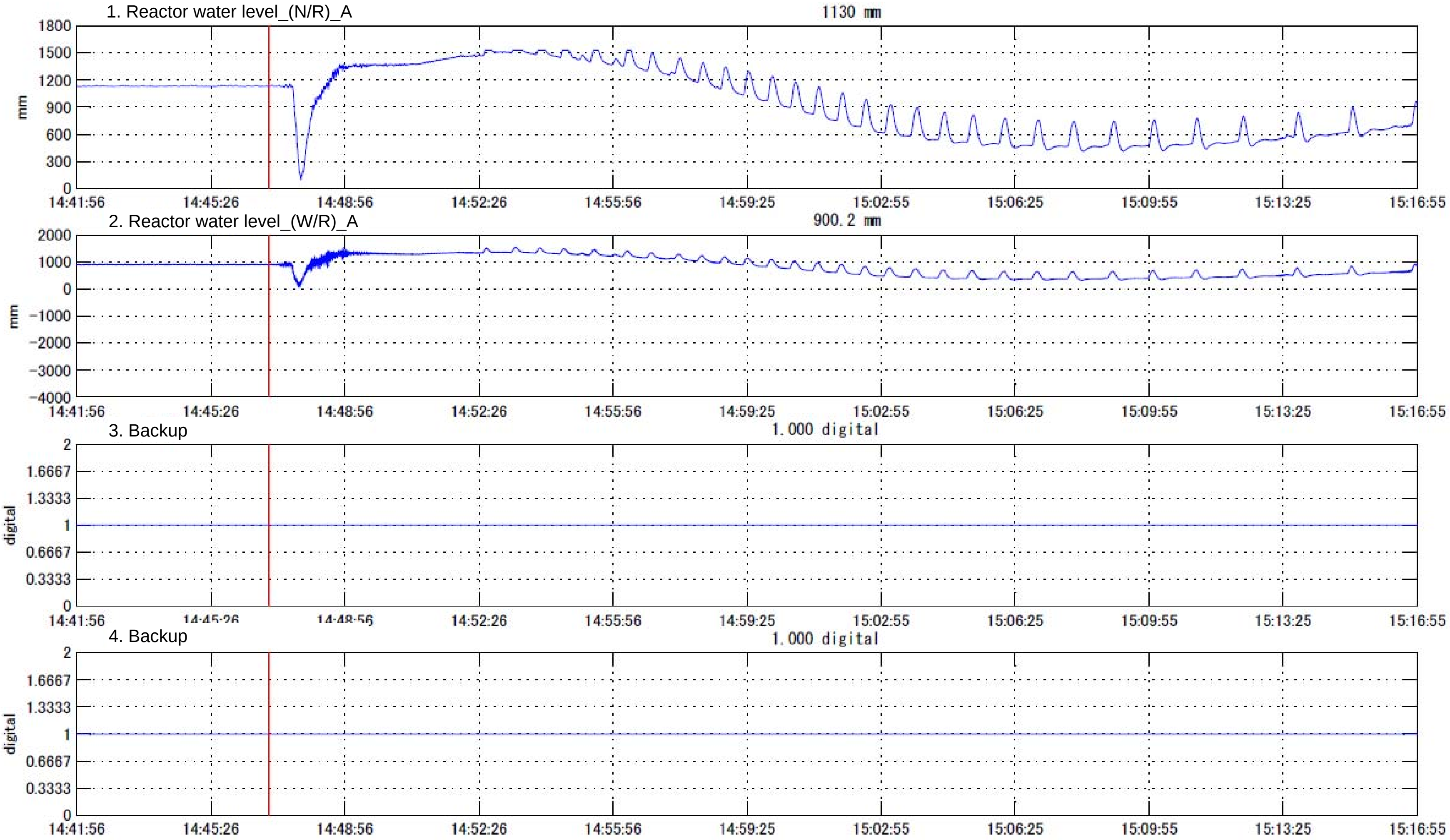
③ Adjustment of water level due to RCIC startup and shutdown

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

Fukushima Daichi Unit 2 Chart

Fukushima Daiichi Nuclear Power Station Unit 2Display of event data / timeline data
Display of data from 14:41:56 on March 11, 2011 to 15:16:55 on March 11, 2011
Group name: 1F-2 (1) Reactor water level

File name 1F2_Cy26_EVF_DET_2011_03_11_14_46_56_400.dat
Time of event: 14:46:56 on March 11, 2011 400 millisec.
Data period 0.01sec.



Fukushima Daiichi Unit 2 Transient Recorder Trends

Attachment 6-2 (5) (2/2)

[Reactor Core Isolation Cooling System (RCIC) Operation Status]

1F2プロセス計算機アラームプリンタ出力

時間	PID	名称	値	単位		
* 2011/3/11 14:50	P418	PLRポンプB 上部振動	= 157.2899933	μm	不良	
2011/3/11 14:50	P418	PLRポンプB 上部振動	= 127.4175034	μm	正常	
* 2011/3/11 14:50	C028	圧力抑制室 水位	= -64.6875	mm	低	
* 2011/3/11 14:50	P417	PLRポンプA 上部振動	= 186.2774963	μm	不良	
* 2011/3/11 14:50	D648	RCIC タービン 起動	= ON		警報	
2011/3/11 14:50	D703	RCIC 注入弁 開	= ON		正常	
2011/3/11 14:50	F066	復水器 ホットウエル レベル A	= 152.53125	mm	正常	
2011/3/11 14:50	R705	RCIC起動信号	= 起動		正常	
2011/3/11 14:50	C028	圧力抑制室 水位	= 40.9375	mm	正常	①
2011/3/11 14:51	S236	復水器 ホットウェル 水位	= 152.625	mm	正常	
* 2011/3/11 14:51	D585	原子炉 水位高	= 高		警報	
2011/3/11 14:51	C028	圧力抑制室 水位	= 25.625	mm	正常	
2011/3/11 14:51	D648	RCIC タービン 起動	= OFF		正常	
* 2011/3/11 14:51	C028	圧力抑制室 水位	= -51.25	mm	低	
2011/3/11 15:02	R734	S/R弁 F 全開	= OFF		正常	
* 2011/3/11 15:02	D648	RCIC タービン 起動	= ON		警報	
2011/3/11 15:02	R705	RCIC起動信号	= 起動		正常	
2011/3/11 15:02	R708	RHSW Cポンプ遮断器	= リセット		正常	②
* 2011/3/11 15:28	C048	D/W クーラー戻り空気温度 A	= 64.43157196	℃	高高	
* 2011/3/11 15:28	D585	原子炉 水位高	= 高		警報	
2011/3/11 15:28	D648	RCIC タービン 起動	= OFF		正常	
2011/3/11 15:28	D628	逃し安全弁 F 開	= OFF		正常	
2011/3/11 15:39	T006	タービン グランドシール 蒸気圧力	= -0.665531218	kPa	正常	
* 2011/3/11 15:39	D648	RCIC タービン 起動	= ON		警報	
* 2011/3/11 15:39	D672	発電機 モータリング トリップ	= ON		警報	
2011/3/11 15:39	D703	RCIC 注入弁 開	= ON		正常	
* 2011/3/11 15:39	C048	D/W クーラー戻り空気温度 A	= 66.72718811	℃	L3高	③
* 2011/3/11 15:39	T006	タービン グランドシール 蒸気圧力	= -0.665531218	kPa	低	
2011/3/11 15:39	R705	RCIC起動信号	= 起動		正常	
* 2011/3/11 15:39	T006	タービン グランドシール 蒸気圧力	= -0.665531218	kPa	RL下限逸脱	

① RCIC manually activated at 14:50, afterwards, shut down at 14:51 due to high reactor water levels

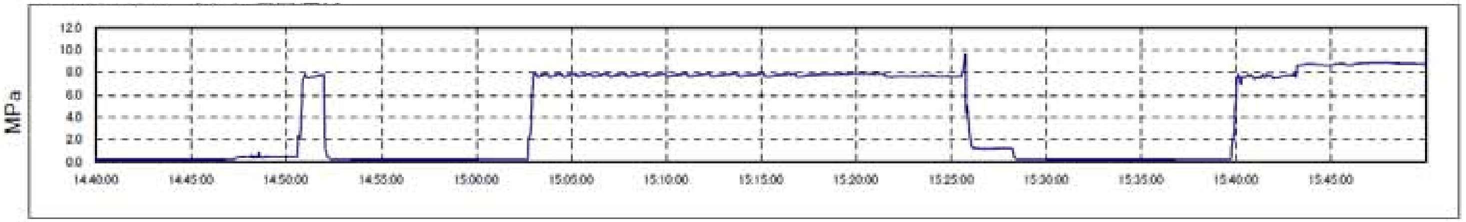
② RCIC manually activated at 15:02, afterwards, shut down at 15:28 due to high reactor water levels.

③ RCIC manually activated at 15:39

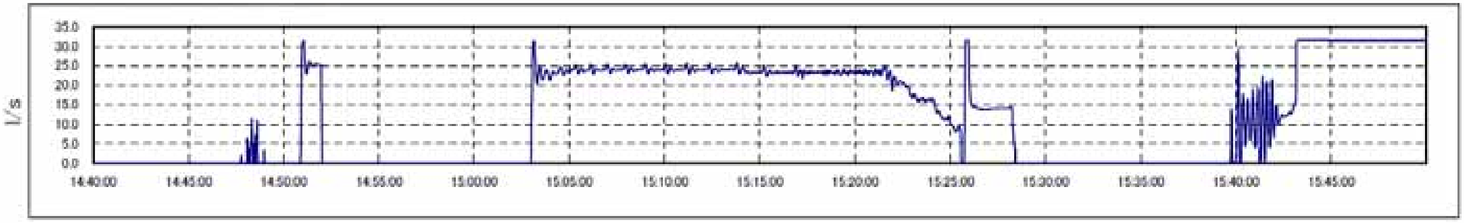
Fukushima Daiichi Unit 2 Alarm Data Logger

Fukushima Daiichi Nuclear Power Station Unit 2 process computer history data
Display of data from 14:40:00 on March 11, 2011 to 15:50:00 on March 11, 2011
Data period: 1sec.

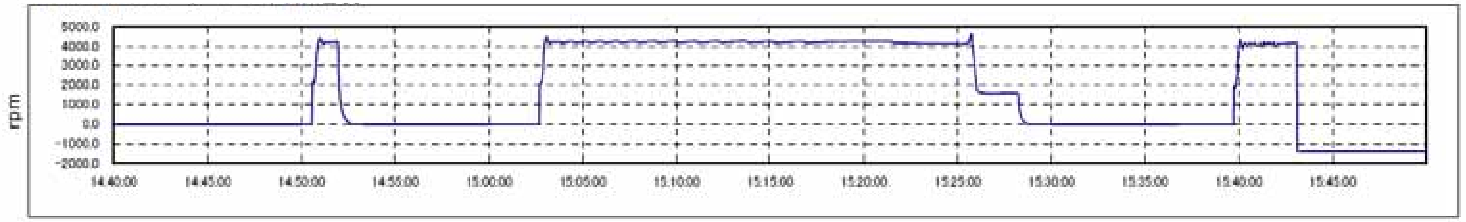
1. P750 RCIC Pump discharge pressure



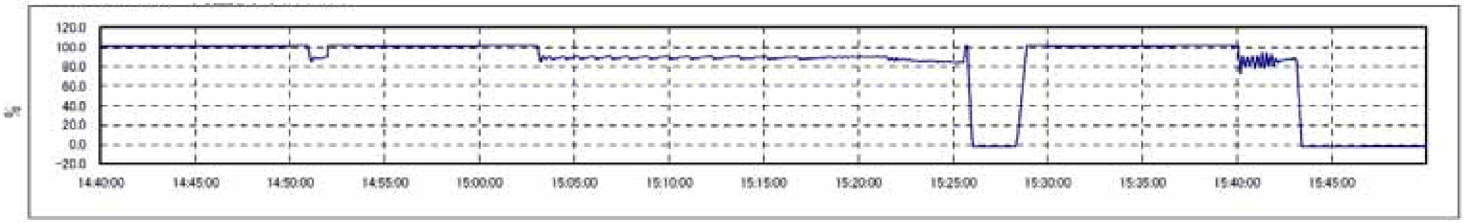
2. P751 RCIC Pump discharge flow rate



3. P752 RCIC Turbine rotation speed



4. P753 RCIC Flow rate controller output

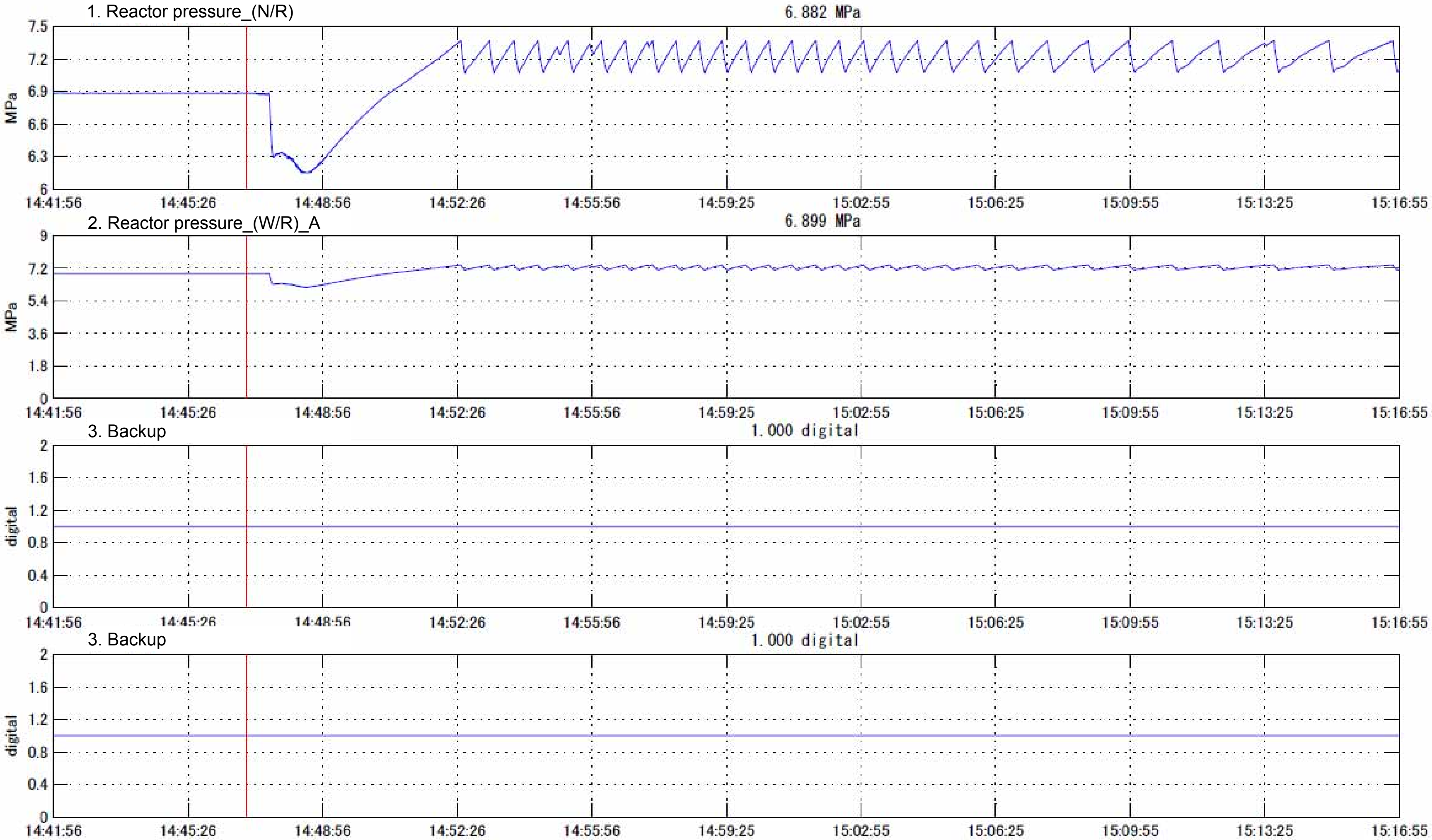


Fukushima Daiichi Unit 2 Transient Recorder Trends

Fukushima Daiichi Nuclear Power Station Unit 2Display of event data / timeline data
Display of data from 14:41:56 on March 11, 2011 to 15:16:55 on March 11, 2011
Group name: 1F-2 (1) Reactor pressure (1)

File name 1F2_Cy26_EVF_DET_2011_03_11_14_46_56_400.dat
Time of event: 14:46:56 on March 11, 2011 400 millisec.

Data period 0.01sec.



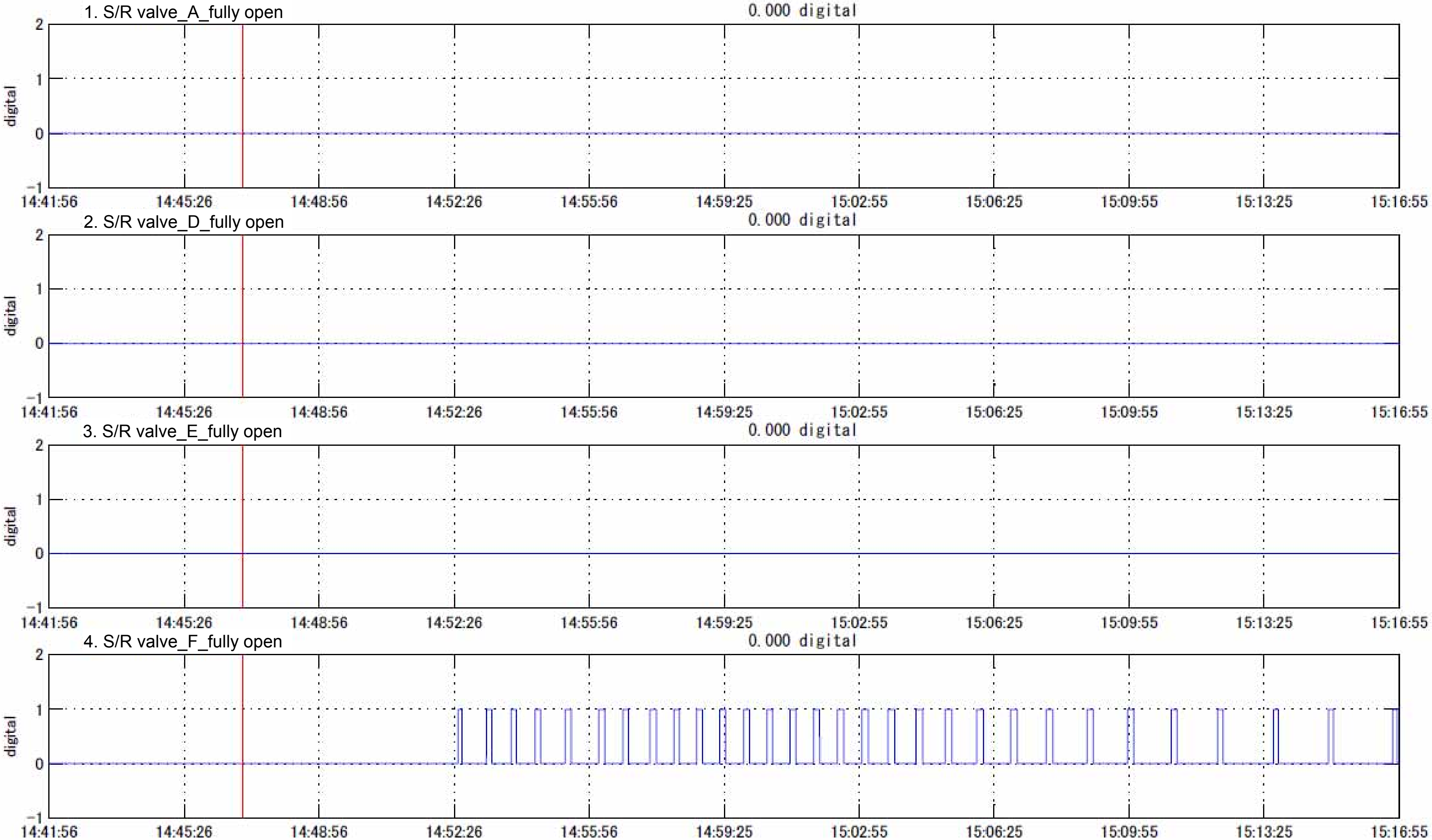
Fukushima Daiichi Unit 2 Transient Recorder Trends

Attachment 6-2 (7) (1/2)

Fukushima Daiichi Nuclear Power Station Unit 2Display of event data / timeline data
Display of data from 14:41:56 on March 11, 2011 to 15:16:55 on March 11, 2011
Group name: 1F-2 (1) Reactor pressure (2)

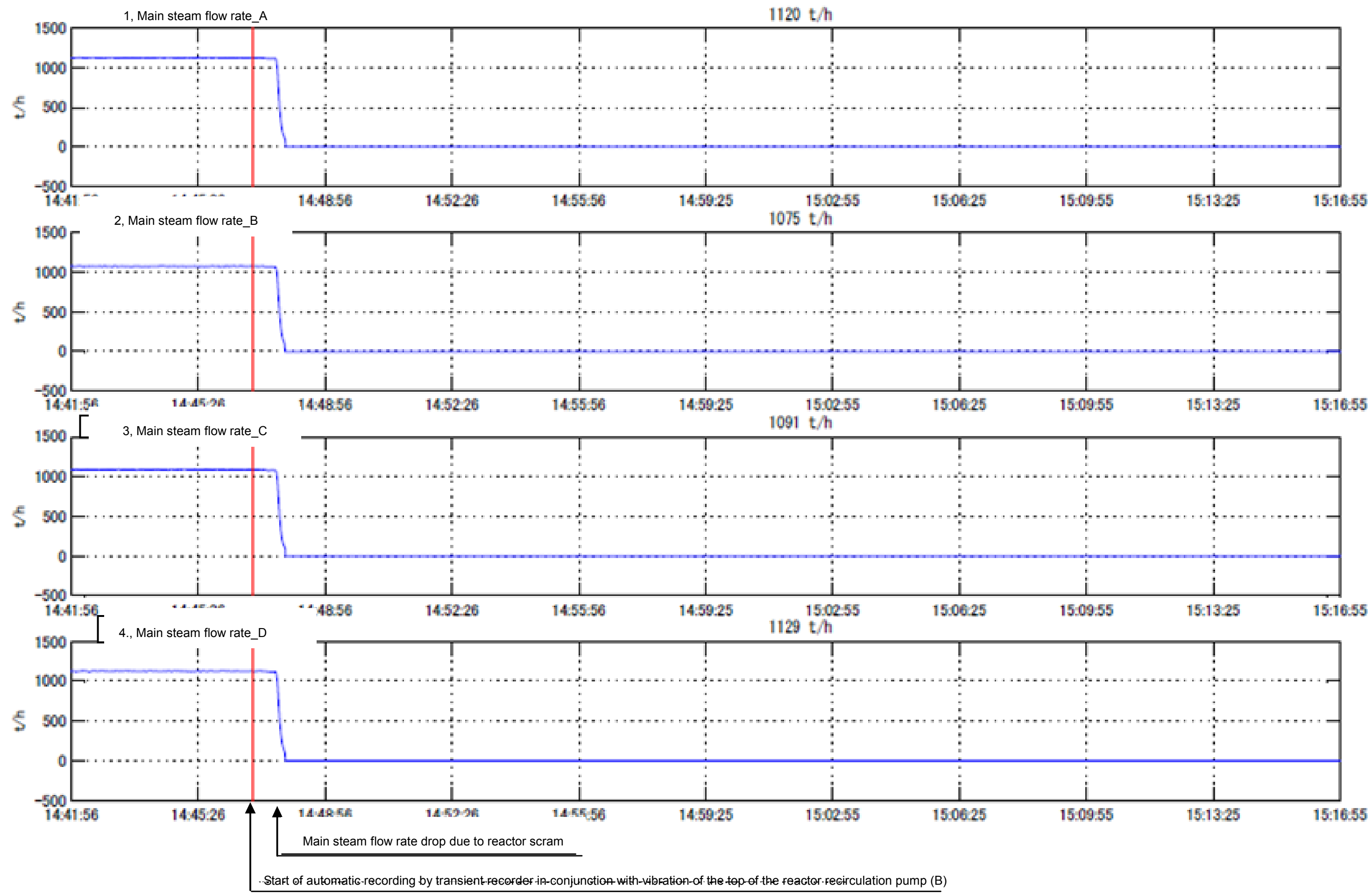
File name 1F2_Cy26_EVF_DET_2011_03_11_14_46_56_400.dat
Time of event: 14:46:56 on March 11, 2011 400 millisec.

Data period 0.01sec.



Fukushima Daiichi Unit 2 Transient Recorder Trends

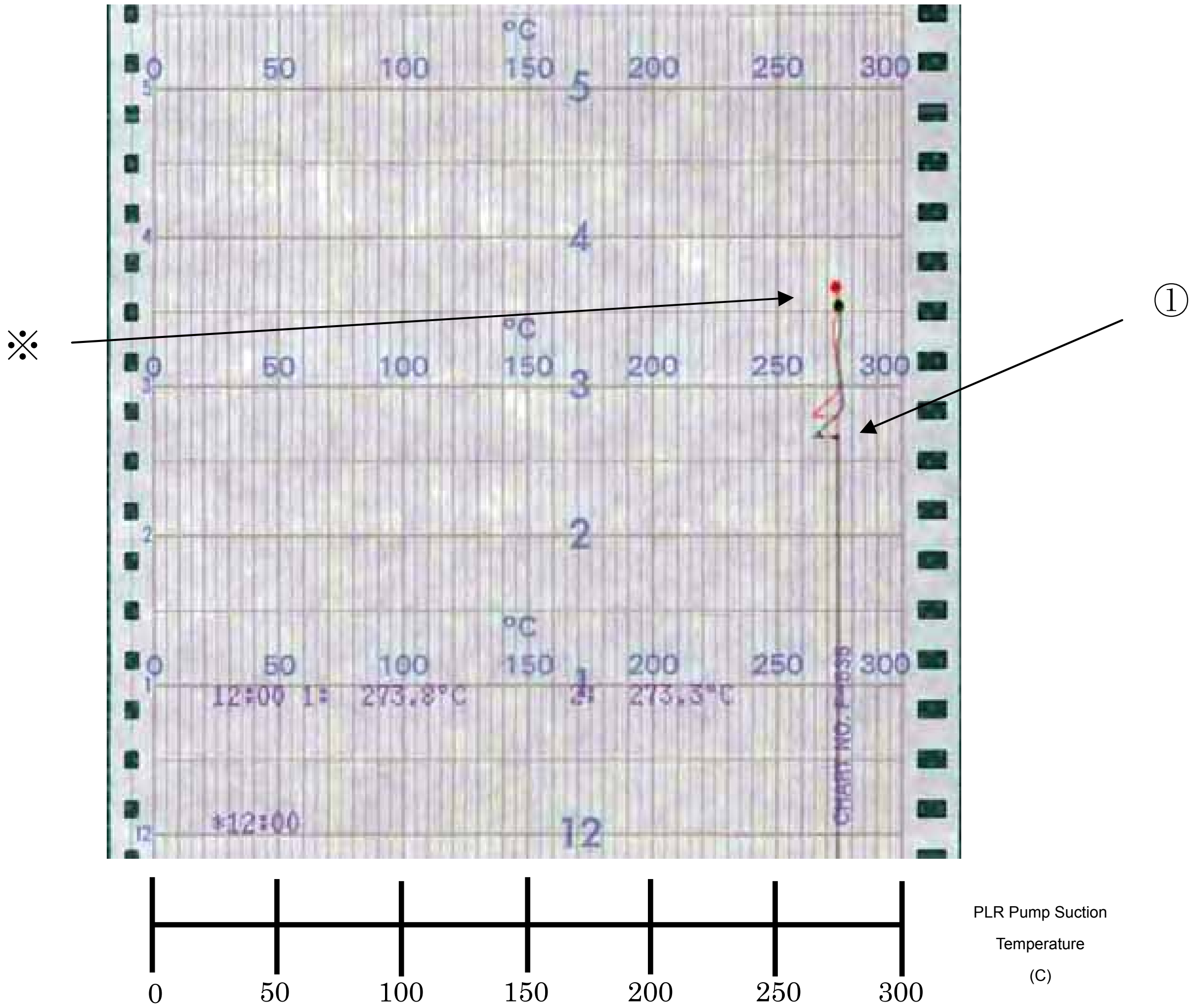
Attachment 6-2 (7) (2/2)

Parameter	Notes
	The main steam flow rate drops in conjunction with reactor scram.

Fukushima Daiichi Unit 2 Transient Recorder Trends

Attachment 6-2 (8)

[Primary Loop Recirculation (PLR) Pump Suction Temperature]



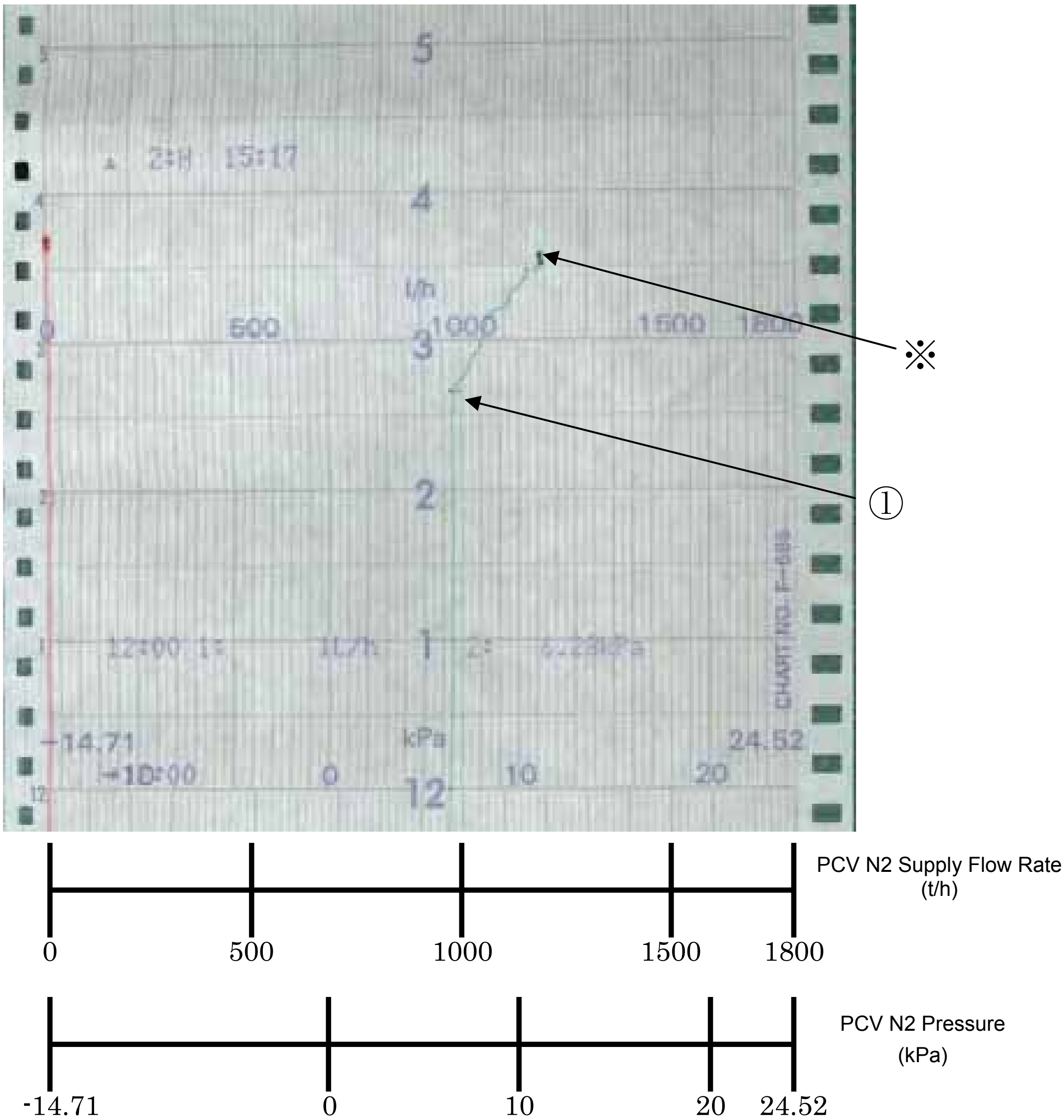
TR-2-165

Red	PLR PUMP A SUCTION TEMP
Green	PLR PUMP B SUCTION TEMP

①Scram triggered by earthquake at 14:47

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

[Primary Containment Vessel Nitrogen Pressure /
Primary Containment Vessel Nitrogen (N2) Supply Flow Rate]



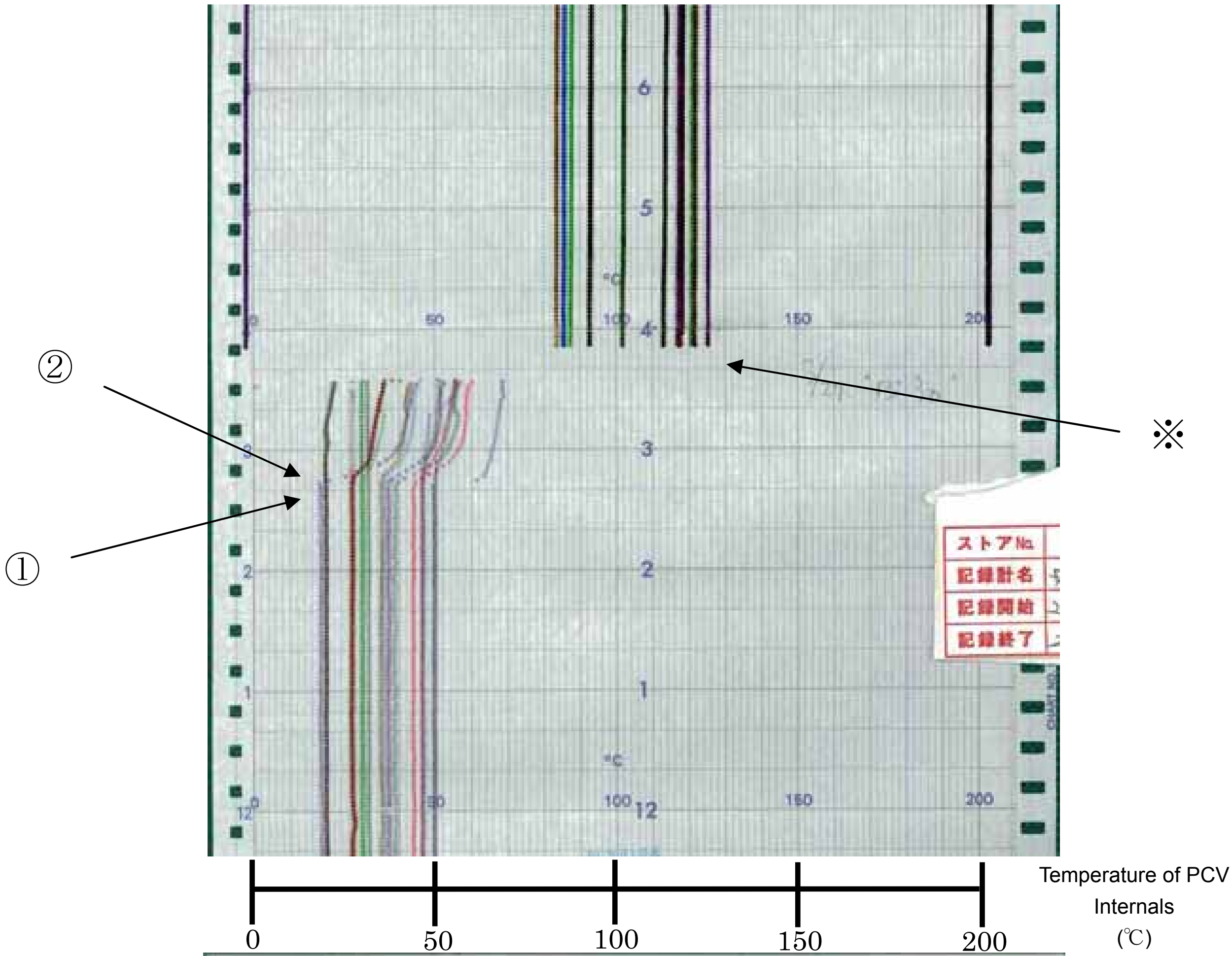
(Red) PCV N2 Supply Flow Rate
(Green) PCV N2 Pressure

① Scram triggered by earthquake at 14:47

* It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the chart no longer gives an accurate reading due to the impact of the tsunami.

Fukushima Daiichi Unit 2 Chart

[Temperature of Primary Containment Vessel (PCV) Internals]



TRS-16-115

No.	測定個所 Object of Measurement	設定値 set point
1	Return air/drywell cooler HVH-16A	66.0℃
2	Return air/drywell cooler HVH-16B	66.0℃
3	Return air/drywell cooler HVH-16C	66.0℃
4	Return air/drywell cooler HVH-16D	66.0℃
5	Return air/drywell cooler HVH-16E	66.0℃
6	Supply air/drywell cooler HVH-16A	66.0℃
7	Supply air/drywell cooler HVH-16B	66.0℃
8	Supply air/drywell cooler HVH-16C	66.0℃
9	Supply air/drywell cooler HVH-16D	66.0℃
10	Supply air/drywell cooler HVH-16E	66.0℃
11	RPV Beraud seal area	66.0℃
12	RPV Beraud seal area	66.0℃
13	RPV Beraud seal area	66.0℃
14	RPV Beraud seal area	66.0℃
15	RPV Beraud seal area	66.0℃
16	S/C gas temperature	65.5°C
17	S/C gas temperature	65.5°C
18	S/C gas temperature	65.5°C
19	S/C gas temperature	65.5°C
20	Backup	—
21	Electricity penetration temperature	—
22	Electricity penetration temperature	—
23	Electricity penetration temperature	—
24	Electricity penetration temperature	—

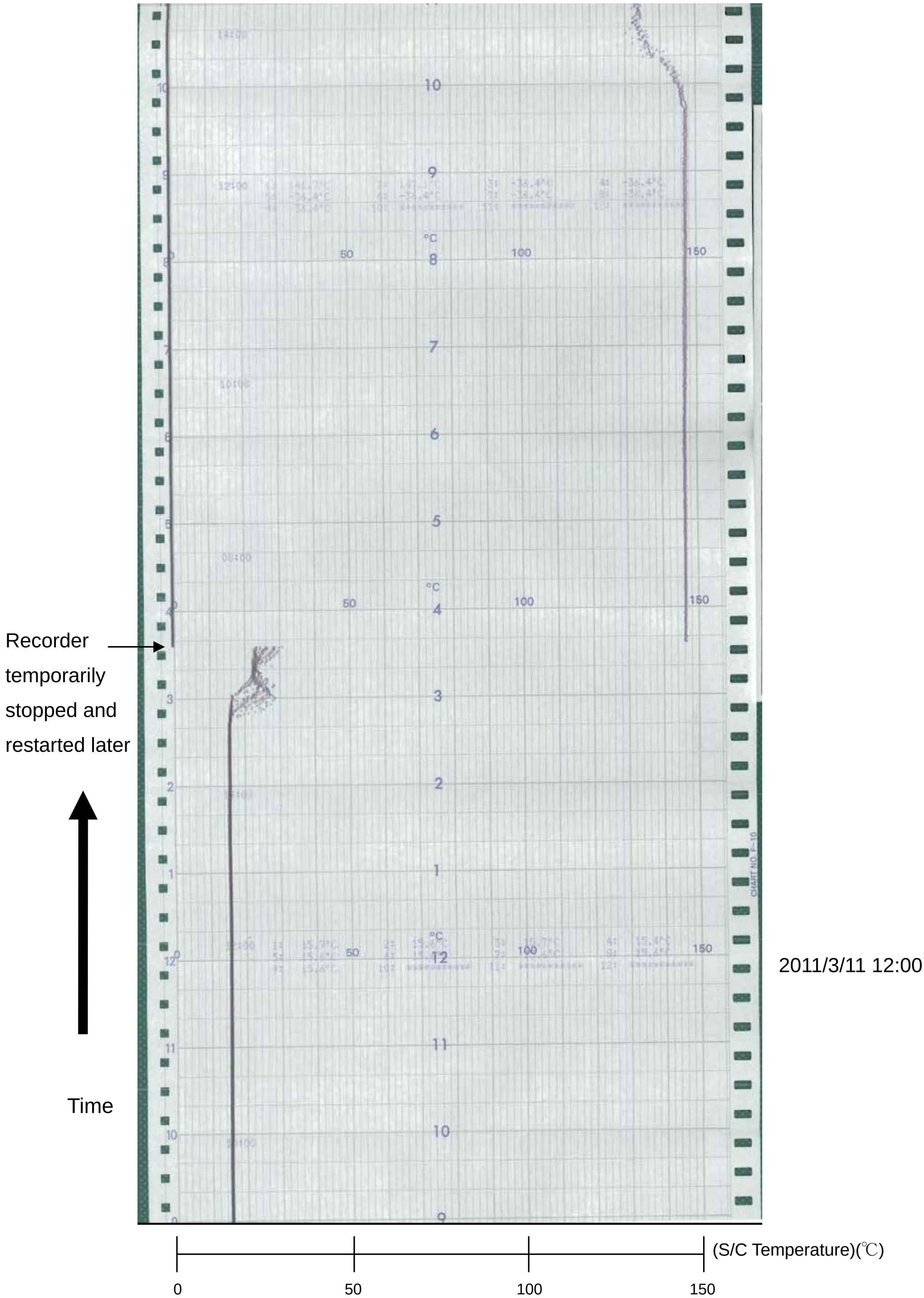
① Scram triggered due to Earthquake at 14:47

② Rise in PCV Temperature following shutdown of PCV air conditioning due to loss of power (Unable to confirm significant rise in pressure due to piping ruptures)

* It is supposed that the tsunami arrived shortly after 15:30. Recorders temporarily halted due to the impact of tsunami. Later, recorders restarted after connecting to temporary power. It is assumed that correct measurements are not indicated.

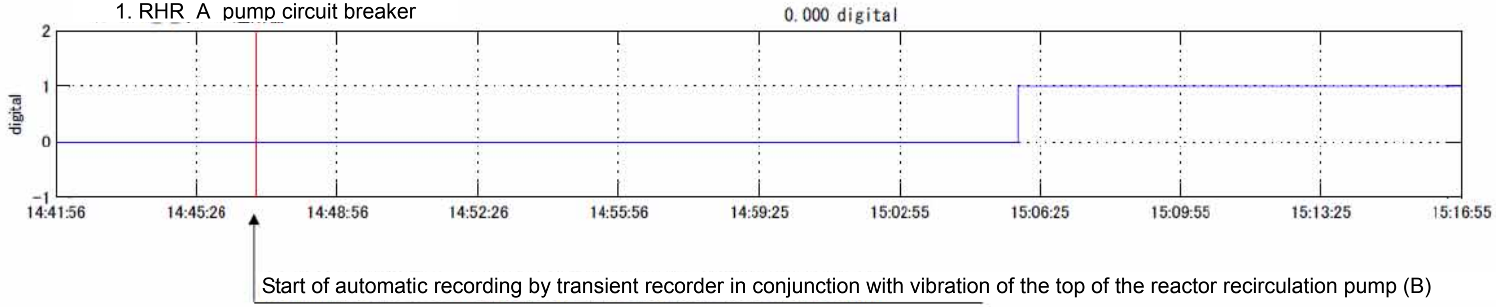
Fukushima Daiichi Unit 2 Chart

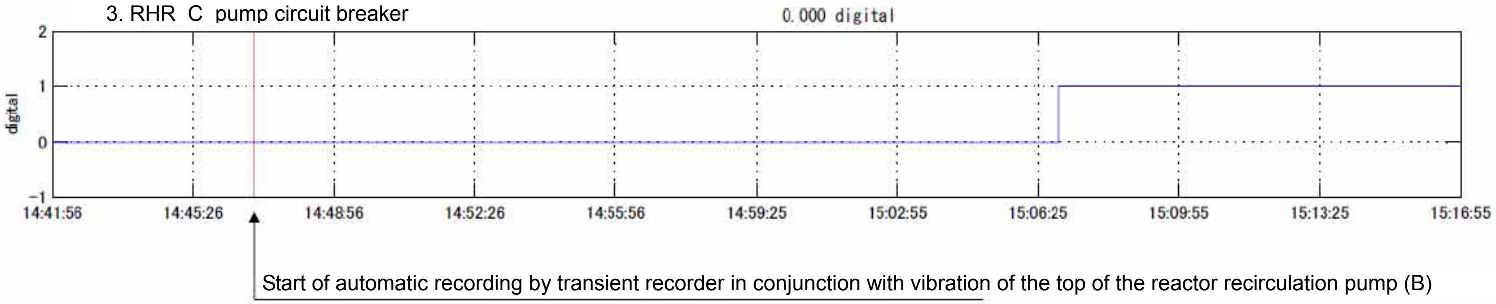
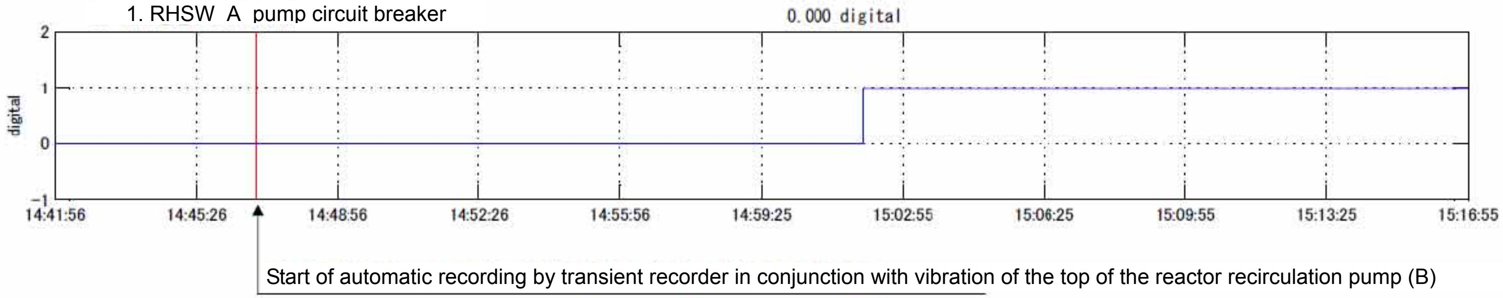
[Suppression Pool Water Temperature]



TRS-16-720A

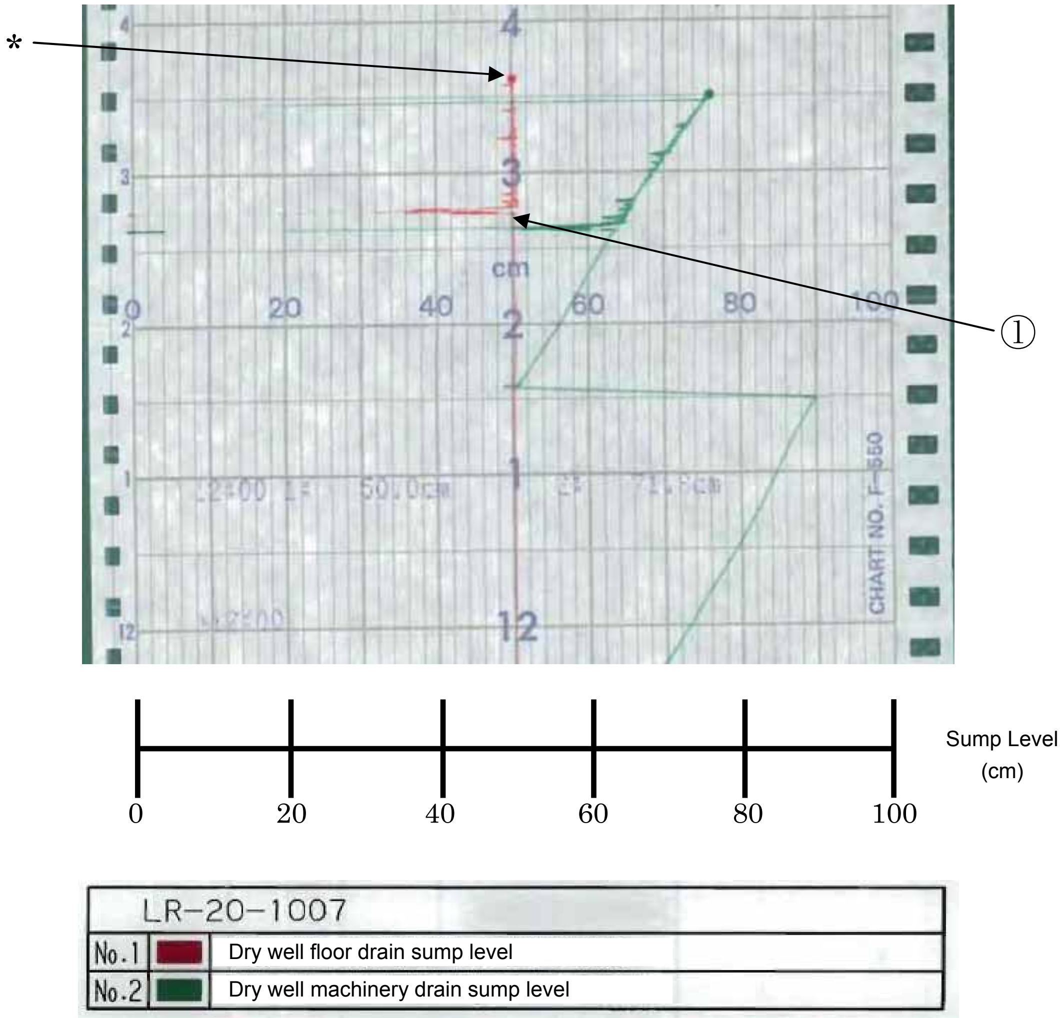
No	色 (Color)	打点 (Mark)	測定名称 (Object of measurement)	No	色 (Color)	打点 (Mark)	測定名称 (Object of measurement)
1	■	●	MV/I-16-708A Suppression pool water temperature (31°)	7	■	○	MV/I-16-714A Suppression pool water temperature (301°)
2	■	●	MV/I-16-709A Suppression pool water temperature (76°)	8	■	○	MV/I-16-715A Suppression pool water temperature (346°)
3	■	●	MV/I-16-710A Suppression pool water temperature (121°)	9	■	○	TΣ-16-718A Suppression pool water temperature (average)
4	■	●	MV/I-16-711A Suppression pool water temperature (166°)	10	■	○	
5	■	●	MV/I-16-712A Suppression pool water temperature (211°)	11	■	○	
6	■	●	MV/I-16-713A Suppression pool water temperature (256°)	12	■	○	

<table>
<tr><th>Parameters</th><th>Notes</th></tr>
<tr><td>1. RHR A pump circuit breaker

</td><td>It is assumed that at around 15:04 the residual heat removal (RHR) pump A started up in order to cool the suppression chamber pool water.*

*In the journal of shift workers, it states “15:07 RHR(A)S/C cooling”</td></tr>
<tr><td>3. RHR C pump circuit breaker

</td><td>It is assumed that at around 15:07 the residual heat removal (RHR) pump C started up in order to cool the suppression chamber pool water.*</td></tr>
<tr><td>1. RHSW A pump circuit breaker

</td><td>It is assumed that at around 15:00 the residual heat removal seawater pump A started up in order to cool the suppression chamber pool water.*</td></tr>
</table>

Fukushima Daiichi Unit 2 Transient Recorder Trends

[Dry Well (D/W) Floor Drain Sump Water Level]



① Scram triggered by earthquake at 14:47.

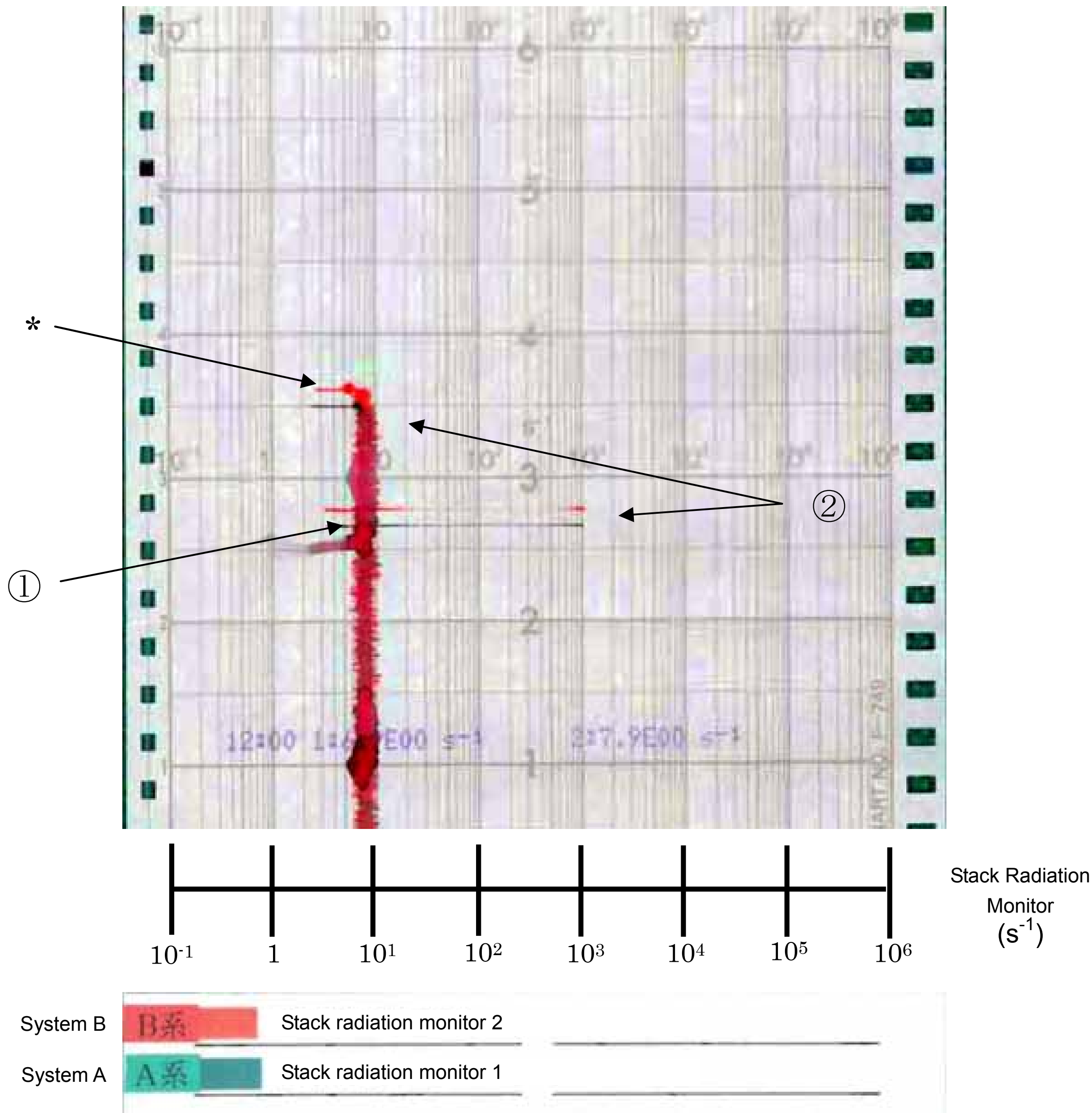
*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

[Standby Gas Treatment System (SGTS) Operation]

* 2011/3/11 14:47	D520	原子炉　水位　A	Reactor water level A	=	低域	Low range
* 2011/3/11 14:47	D521	原子炉　水位　B	Reactor water level B	=	低域	Low range
* 2011/3/11 14:47	D522	原子炉　水位　C	Reactor water level C	=	低域	Low range
* 2011/3/11 14:47	D523	原子炉　水位　D	Reactor water level D	=	低域	Low range
2011/3/11 14:47	D708	SGTS　A　起動信号	SGTS A startup signal	=	ON	
2011/3/11 14:47	Z558	TIPパージ隔離弁　開	TIP purge isolation valve open	=	OFF	
2011/3/11 14:47	Z559	TIPパージ隔離弁　閉	TIP purge isolation valve closed	=	ON	
2011/3/11 14:47	Z593	TIP制御盤　正常	TIP control panel normal	=	OFF	

Standby Gas Treatment System (A) startup

[Stack Radiation Monitor]
(Stack Radiation Monitor is shared by Units 1 & 2)

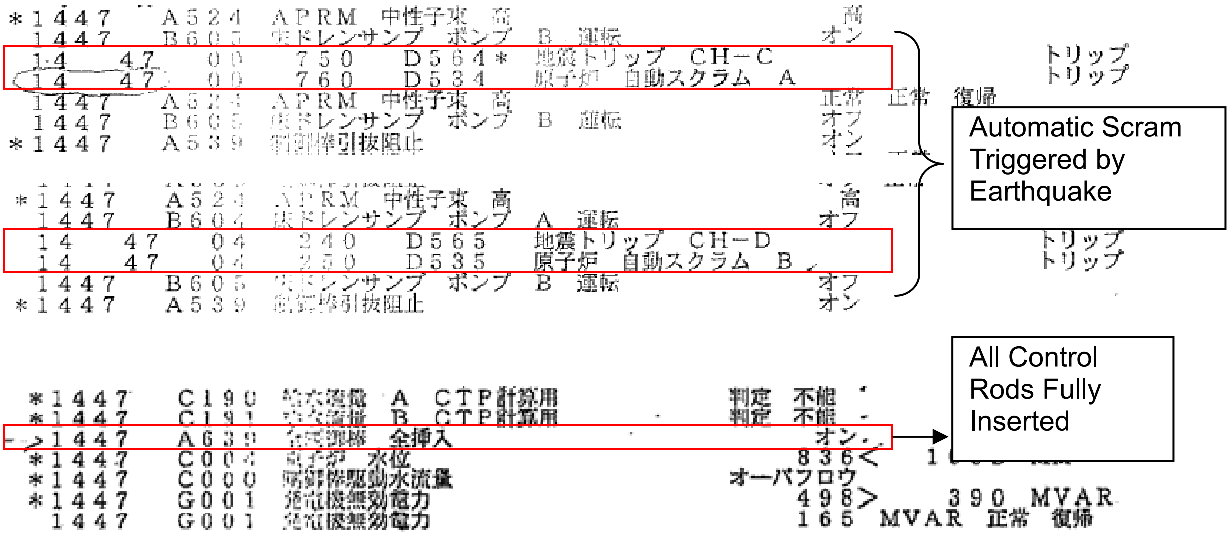


① Scram triggered by earthquake at 14:46
② Signal thought to be noise
*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

Fukushima Daiichi Unit 2 Chart

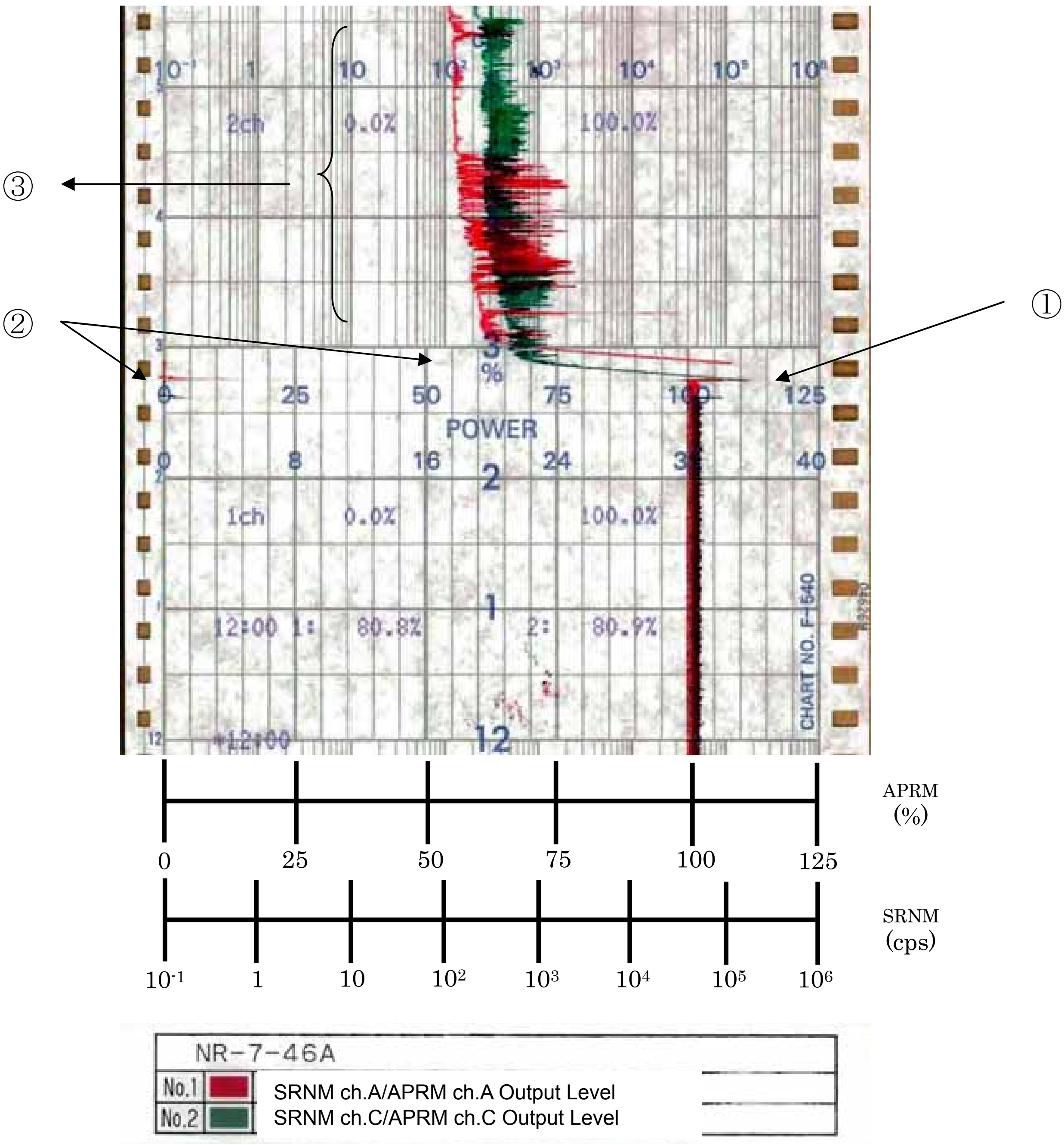
Fukushima Daiichi Unit 3 Plant Data

[Scram / All Control Rods Fully Inserted]


＊1447　A524　APRM　中性子束　高　高
1447　B605　床ドレンサンプ　ポンプ　B　運転　オン
14　47　00　750　D564＊　地震トリップ　CH－C　トリップ
14　47　00　760　D534　原子炉　自動スクラム　A　トリップ
1447　A524　APRM　中性子束　高　正常　正常　復帰
1447　B605　床ドレンサンプ　ポンプ　B　運転　オフ
＊1447　A539　制御棒引抜阻止　オン
＊1447　A524　APRM　中性子束　高　高
1447　B604　床ドレンサンプ　ポンプ　A　運転　オフ
14　47　04　240　D565　地震トリップ　CH－D　トリップ
14　47　04　250　D535　原子炉　自動スクラム　B　トリップ
1447　B605　床ドレンサンプ　ポンプ　B　運転　オフ
＊1447　A539　制御棒引抜阻止　オン
＊1447　C190　給水流量　A　CTP計算用　判定　不能
＊1447　C191　給水流量　B　CTP計算用　判定　不能
－＞1447　A639　全制御棒　全挿入　オン
＊1447　C004　原子炉　水位　836＜　1
＊1447　C000　再循環駆動水流量　オーバフロウ
＊1447　G001　発電機無効電力　498＞　390　MVAR
1447　G001　発電機無効電力　165　MVAR　正常　復帰

Fukushima Daiichi Unit 3 Alarm Data Logger

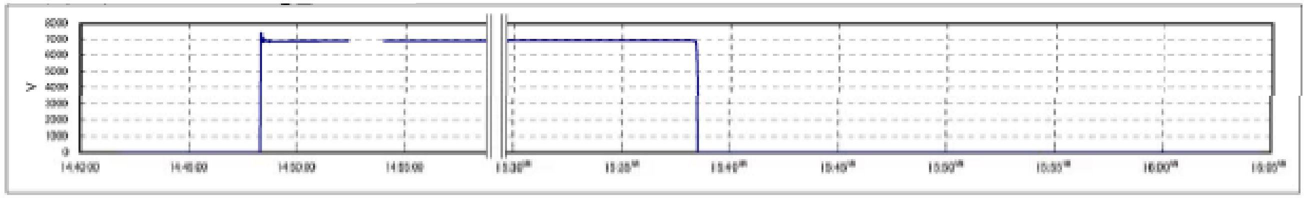
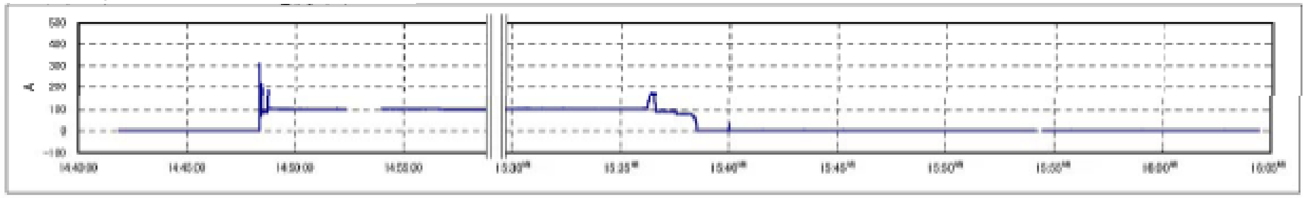
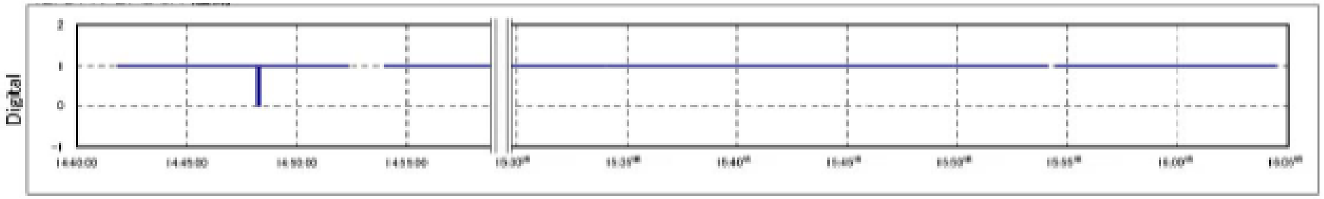
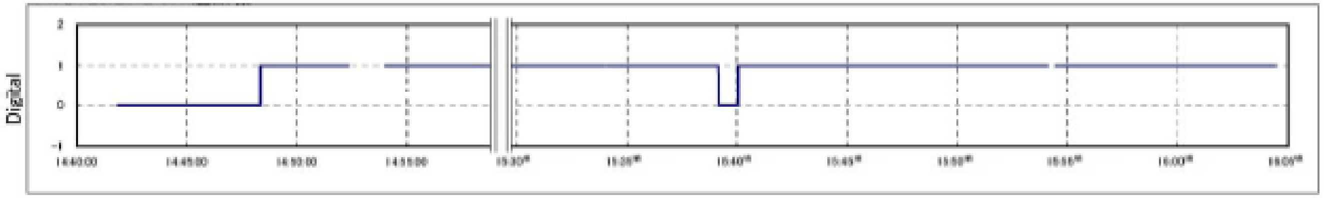
[Start-Up Range Neutron Monitor (SRNM), Average Power Range Monitor (APRM)]



① Scram triggered by earthquake at 14:47 and drop in output due to scram

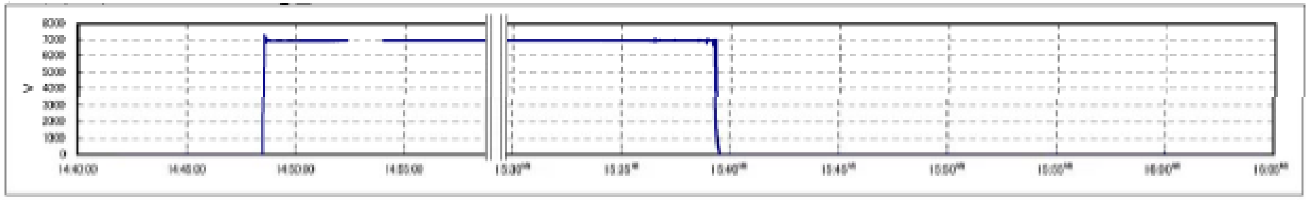
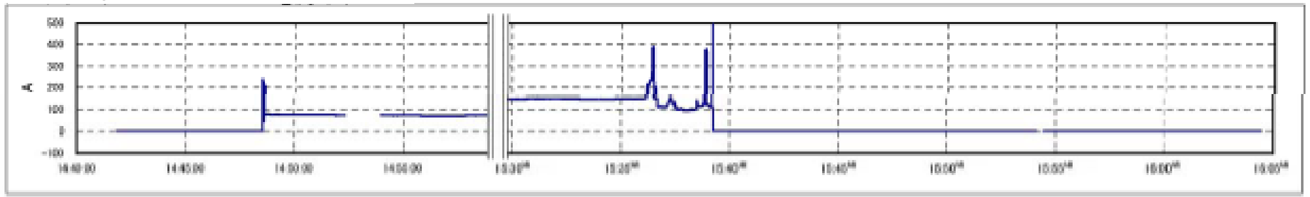
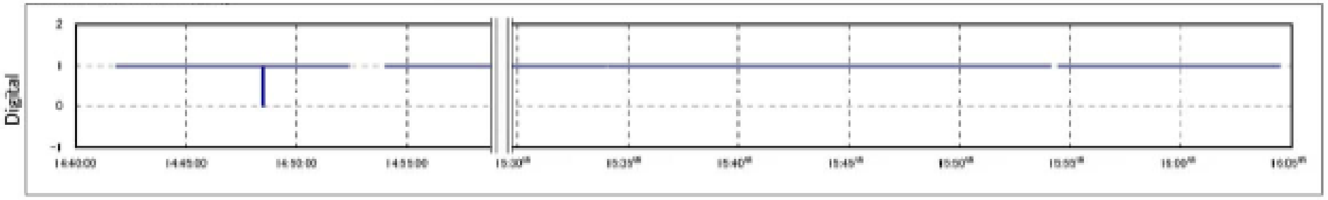
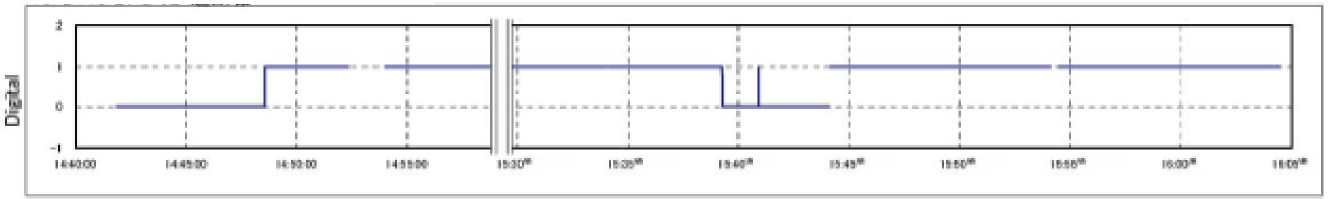
② Below the range of Average Power Range Monitor (APRM) and switch to the Start-Up Range Neutron Monitor (SRNM)

③ Change in indication due to noise.

Parameters	Notes
21. Analog PIDA 754 D/G 3A voltage R-T  23. Analog PIDA 757 D/G 3A current (R)  12. D717 D/G 3A startup  14. D720 D/G 3A circuit breaker 	It is assumed that the diesel generator (3A) stopped working between 15:35-15:40 supposedly due to the impact of the tsunami.

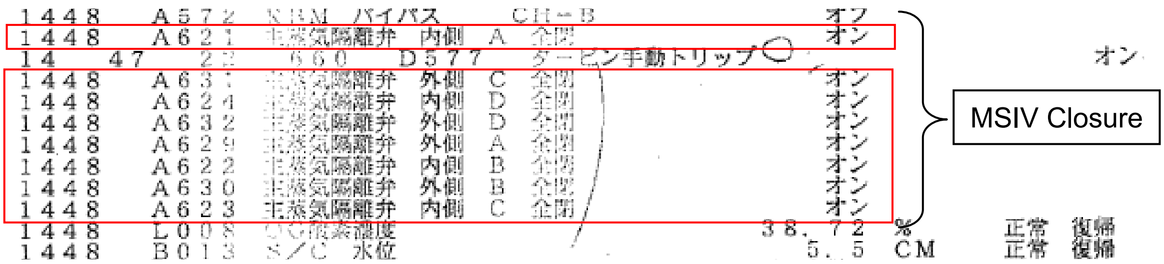
Fukushima Daiichi Unit 3 Transient Recorder Trends

Attachment 6-3 (3) (1/2)

Parameters	Notes
22. Analog PIDA 755 D/G 3B voltage R-T  24. Analog PIDA 758 D/G 3B current (R)  13. D716 D/G 3B startup  15. D719 D/G 3B circuit breaker 	It is assumed that the diesel generator (3B) stopped working between 15:35~15:40 supposedly due to the impact of the tsunami.

Fukushima Daiichi Unit 3 Transient Recorder Trends

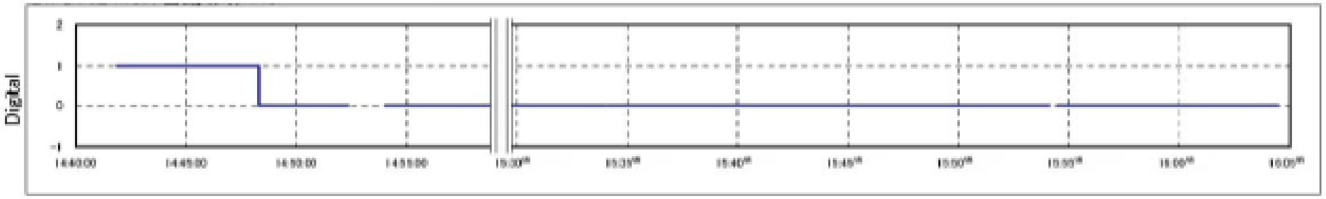
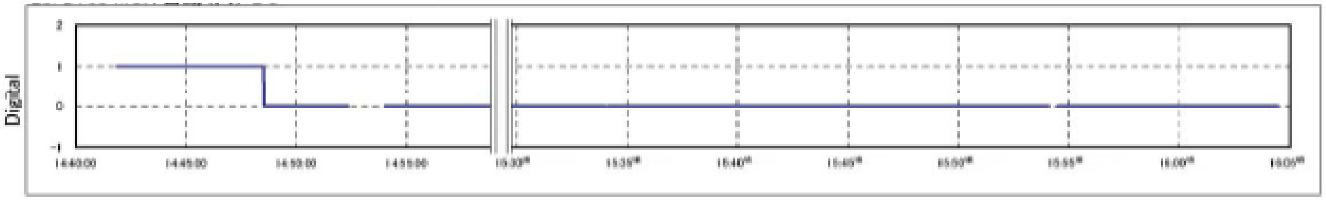
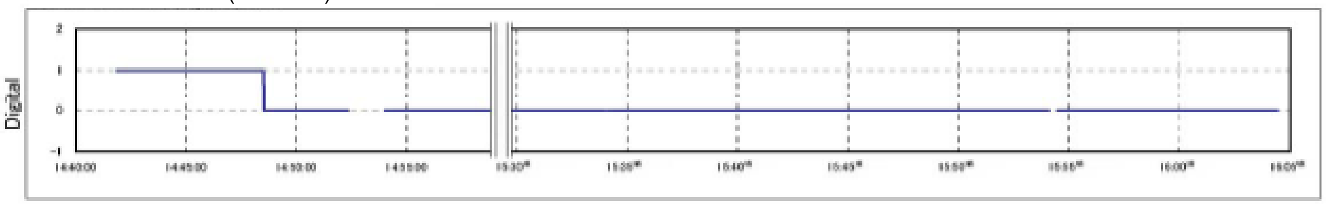
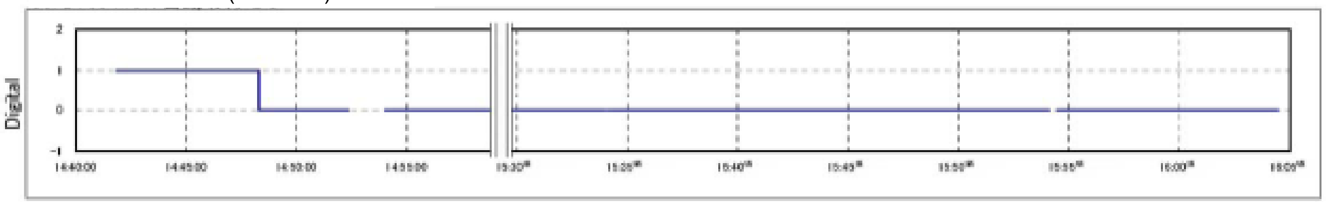
[Main Steam Isolation Valve (MSIV) Closure]



1448	A572	SRM バイパス			CH－B	オフ	
1448	A621	主蒸気隔離弁	内側	A	全閉	オン	
14 47	22	660	D577	タービン手動トリップ			オン
1448	A631	主蒸気隔離弁	外側	C	全閉	オン	
1448	A624	主蒸気隔離弁	内側	D	全閉	オン	
1448	A632	主蒸気隔離弁	外側	D	全閉	オン	
1448	A629	主蒸気隔離弁	外側	A	全閉	オン	
1448	A622	主蒸気隔離弁	内側	B	全閉	オン	
1448	A630	主蒸気隔離弁	外側	B	全閉	オン	
1448	A623	主蒸気隔離弁	内側	C	全閉	オン	
1448	L008	OG酸素濃度			38.72	%	正常 復帰
1448	B013	S/C 水位			5.5	CM	正常 復帰

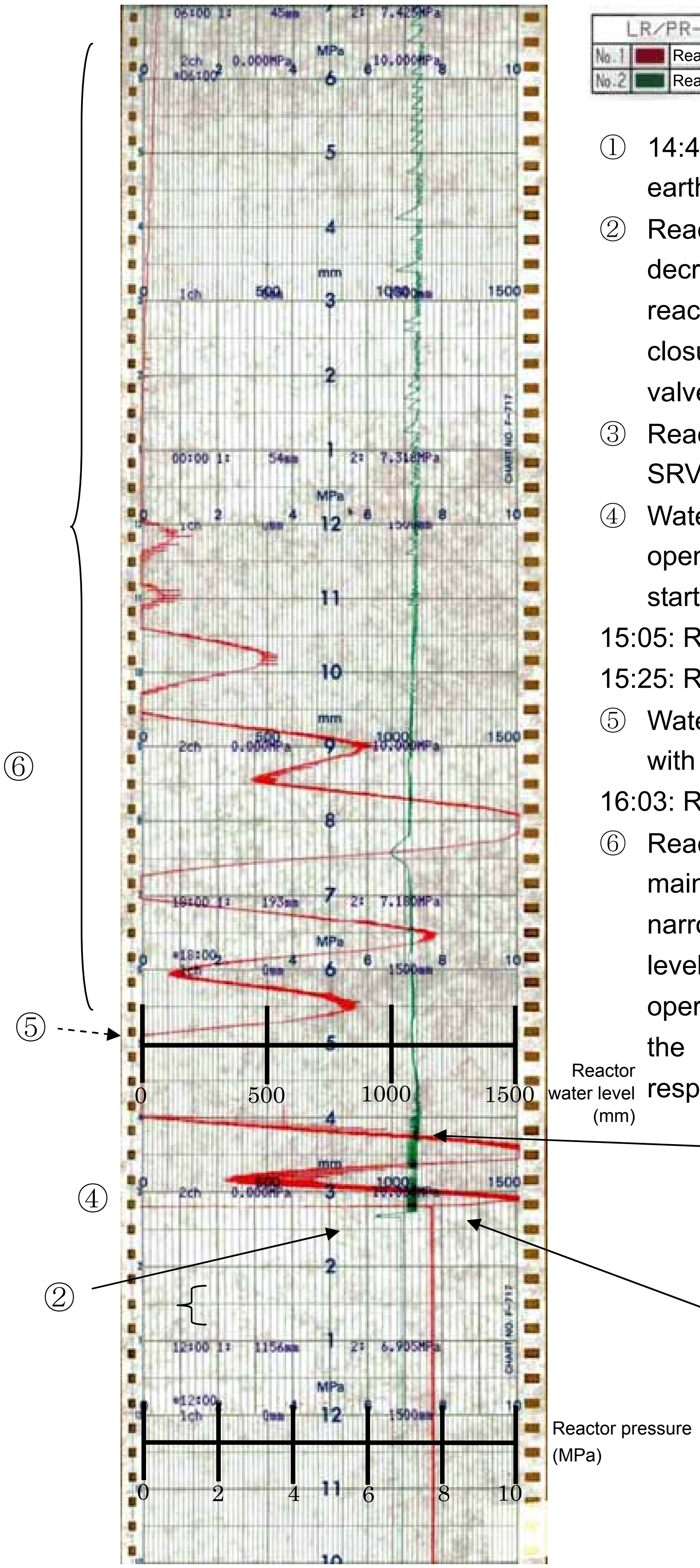
Bypass		ON	
Inboard MSIV A fully closed	ON		
Turbine manual trip		ON	
Outboard MSIV C fully closed	ON		
Inboard MSIV D fully closed	ON		
Outboard MSIV D fully closed	ON		
Outboard MSIV A fully closed	ON		
Inboard MSIV B fully closed	ON		
Outboard MSIV B fully closed	ON		
Inboard MSIV C fully closed	ON		
OG oxygen concentration			Normal recovery
S/C water level			Normal recovery

(Note) Before and after MSIV closure, abnormal signals such as rupture detection have been recorded, but it is observed that these abnormal signals were sent as a fail safe measure following the loss of power for the instruments due to the loss of off-site power as a result of the earthquake. Signs of abnormalities, such as the increase in steam flow rates, are not seen in the process of closing the MSIV.

Parameters	Notes
27. D762 MSIV auto (Inboard) AC  	Close signals were sent for the inboard and outboard main steam isolation valves.
28. D763 MSIV auto (Inboard) DC  	
29. D764 MSIV auto (Outboard) AC  	
30. D765 MSIV auto (Outboard) DC  	

Fukushima Daiichi Unit 3 Transient Recorder Trends

[Reactor water level, Reactor pressure (1/3)]



LR/PR-6-97		
No.1		Reactor water level
No.2		Reactor pressure

① 14:47 Scram triggered by earthquake

② Reactor pressure decrease due to decrease in output, followed by reactor pressure increase due to closure of the main steam isolation valve (MSIV)

③ Reactor pressure controlled using SRV

④ Water level fluctuations caused by opening/closing of SRV and RCIC startup/shut down

15:05: RCIC startup

15:25: RCIC trip (high water level)

⑤ Water level fluctuation in conjunction with RCIC startup

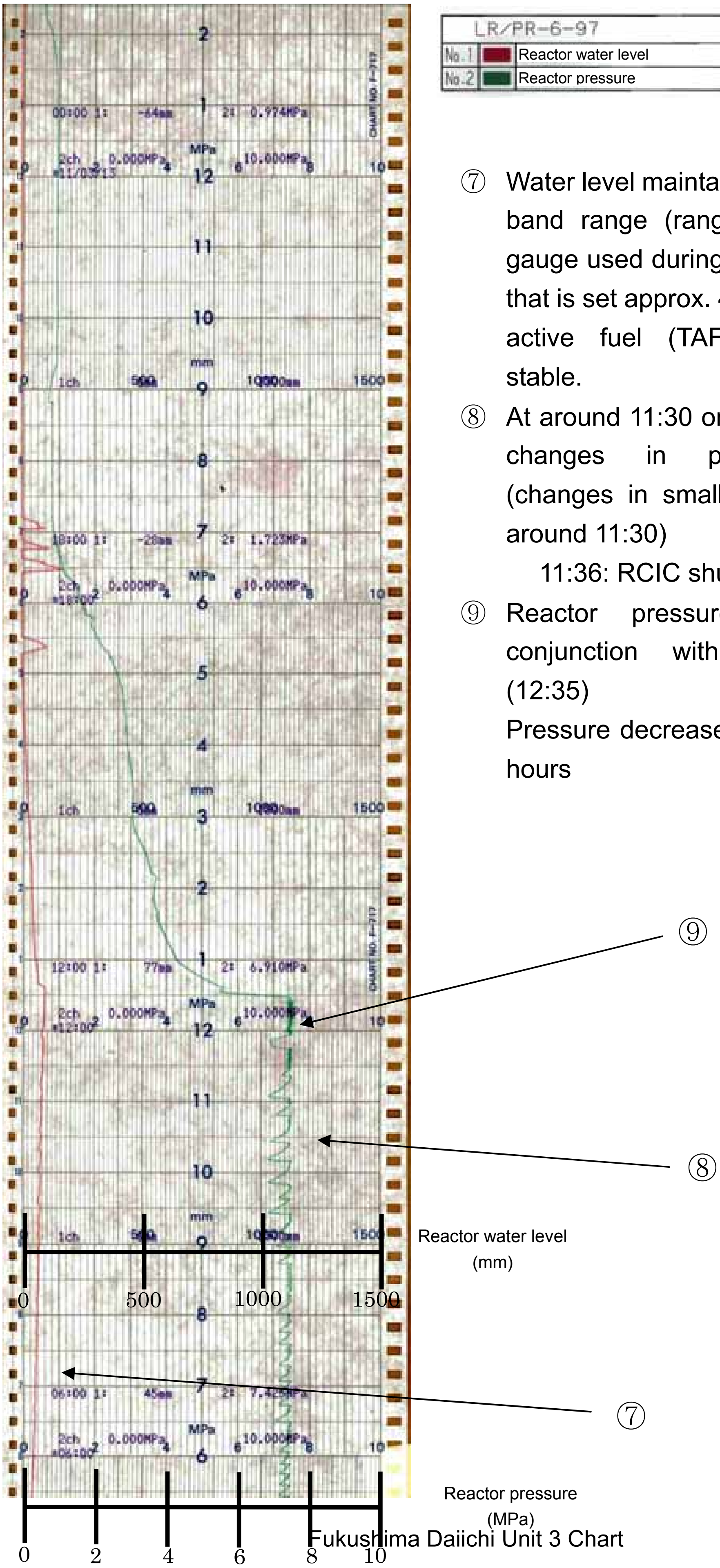
16:03: RCIC startup

⑥ Reactor pressure and water level maintained at 7MPa and within narrow band range (range of water level gauge used during normal operation that is set approx. 4m from the top of active fuel (TAF)), respectively, and remains stable.

Fukushima Daiichi Unit 3 Chart

[Reactor water level, Reactor pressure (2/3)]

LR/PR-6-97	
No.1	Reactor water level
No.2	Reactor pressure



⑦ Water level maintained within narrow band range (range of water level gauge used during normal operation that is set approx. 4m from the top of active fuel (TAF)) and remains stable.

⑧ At around 11:30 on March 12 phase changes in pressure control (changes in small motions starting around 11:30)

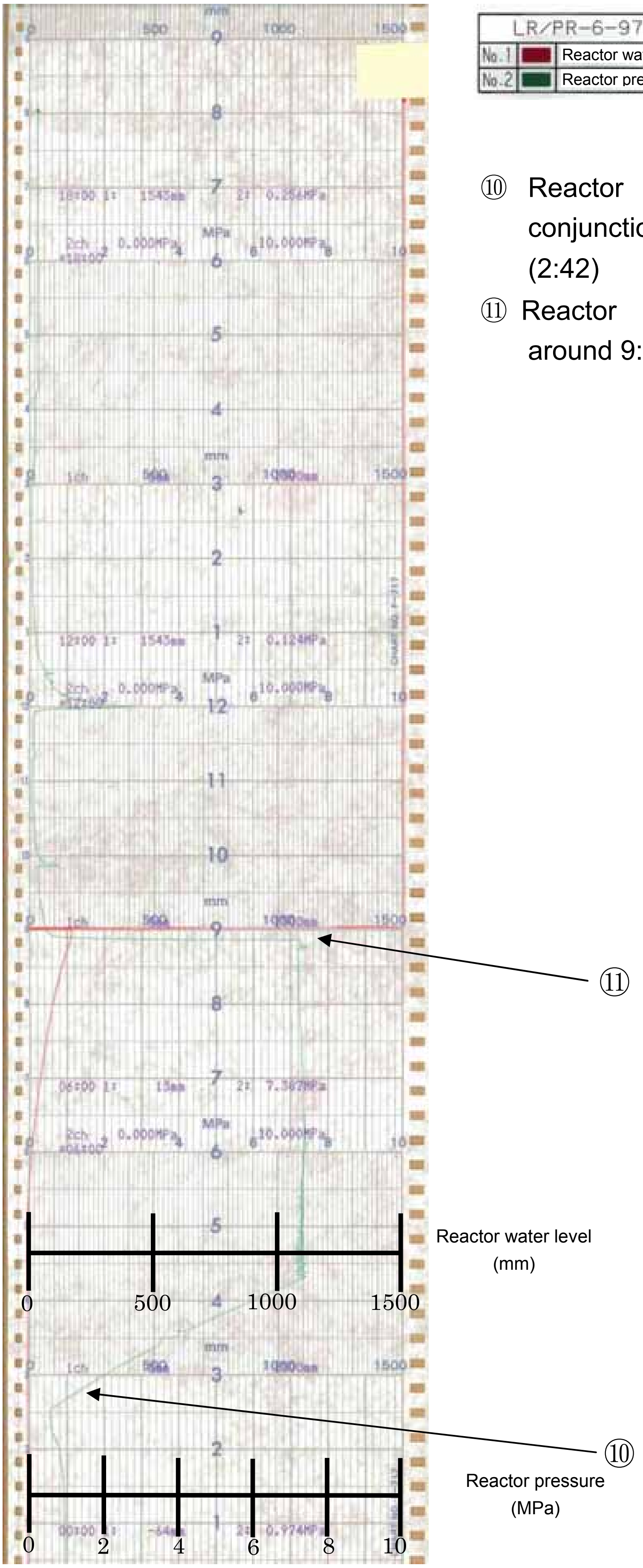
11:36: RCIC shutdown

⑨ Reactor pressure decrease in conjunction with HPCI startup (12:35)

Pressure decreases over the next 6 hours

Fukushima Daiichi Unit 3 Chart

[Reactor water level, Reactor pressure (3/3)]

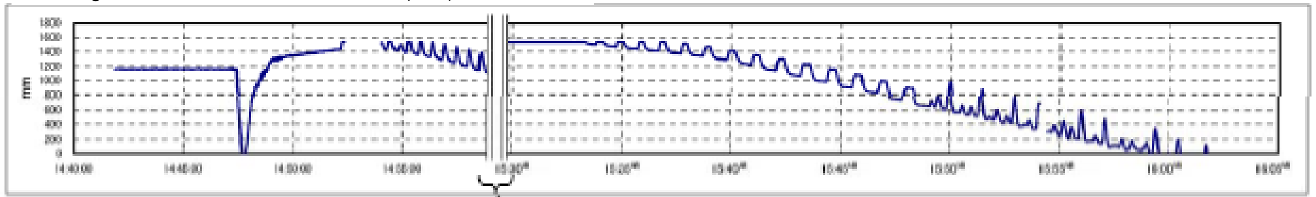
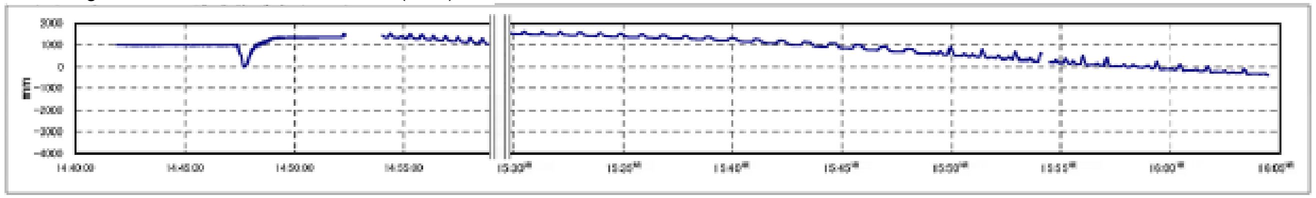
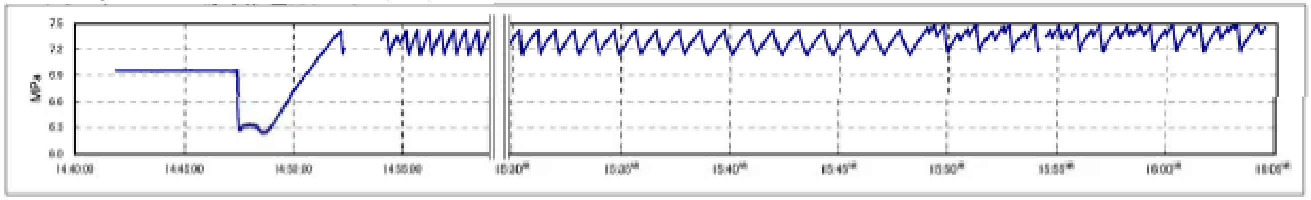
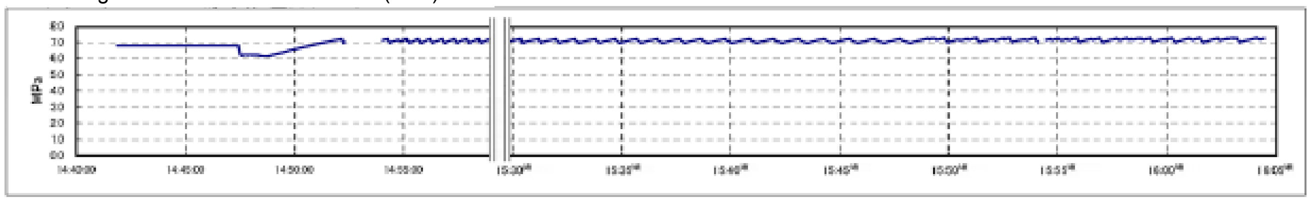


LR/PR-6-97	
No.1	Reactor water level
No.2	Reactor pressure

⑩ Reactor pressure increases in conjunction with HPCI shutdown (2:42)

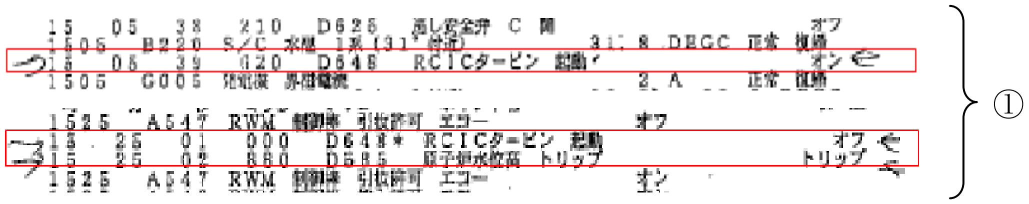
⑪ Reactor depressurization from around 9:00 on March 13

Fukushima Daiichi Unit 3 Chart

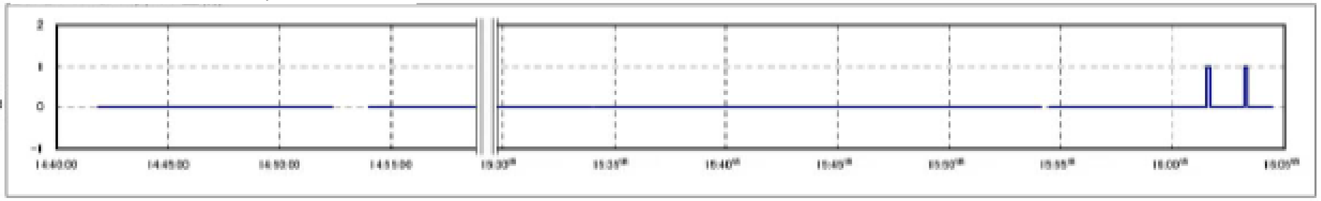
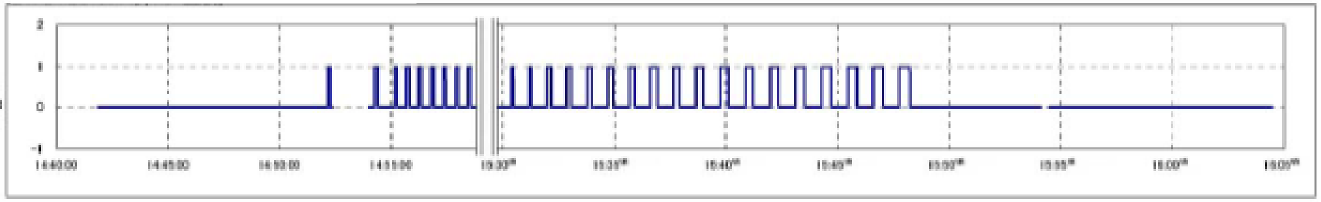
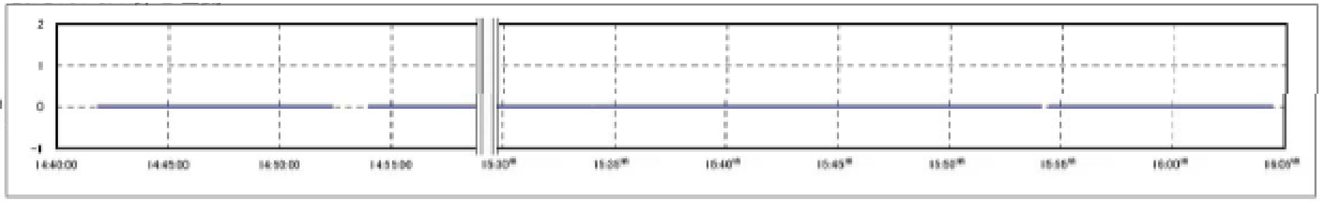
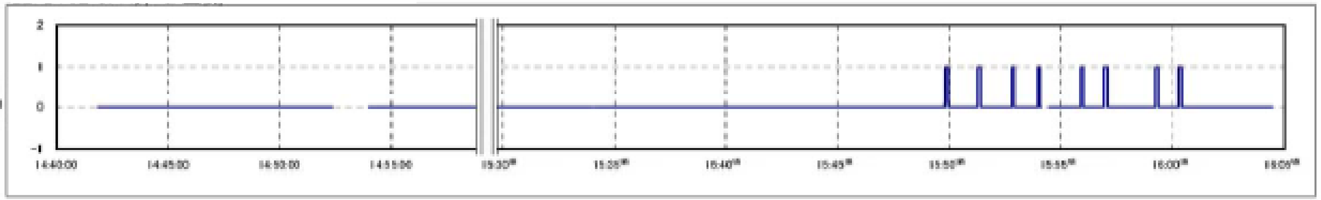
Parameters	Notes
7. Analog PIDA 300 Reactor Water Level (N/R)A  About 30 min. of missing data (the same shall apply hereinafter in this page) 8. Analog PIDA 303 Reactor Water Level (W/R)A 	Reactor water level fluctuates due to the collapse of voids (bubbles) immediately after the scram but recovers to normal levels thereafter. From around 14:55 reactor water level cyclically fluctuates in conjunction with the opening and closing of the main steam safety relief valve. Water level also gradually decreases.
25. Analog PIDA 600 Reactor Pressure (N/R)  26. Analog PIDA 601 Reactor Pressure (W/R)A 	Reactor pressure decreases immediately after the scram. However, whereas pressure increases thereafter due to closing of the main steam isolation valve and decay heat, this pressure cyclically fluctuates due to opening and closing of the main steam safety relief valve.

Fukushima Daiichi Unit 3 Transient Recorder Trends

[Reactor Core Isolation Cooling System (RCIC) Operation Status]

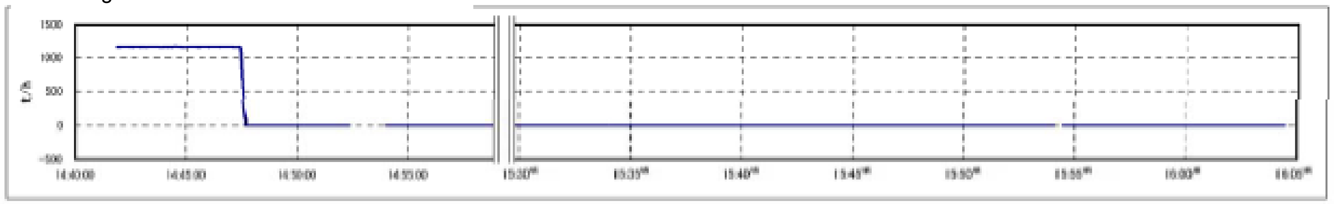
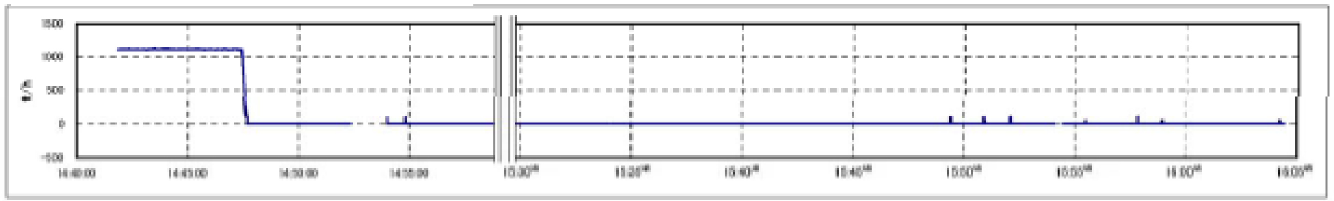
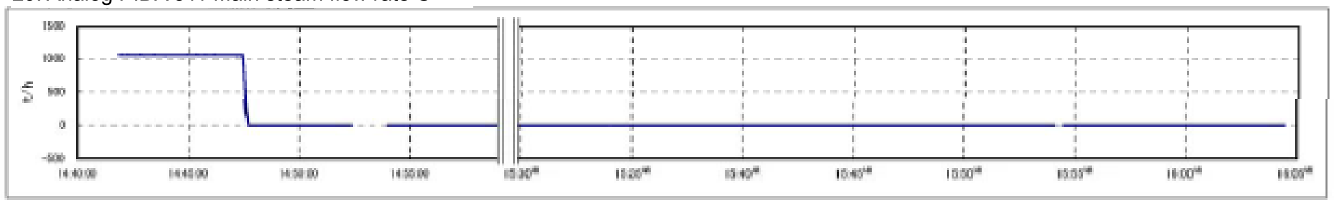
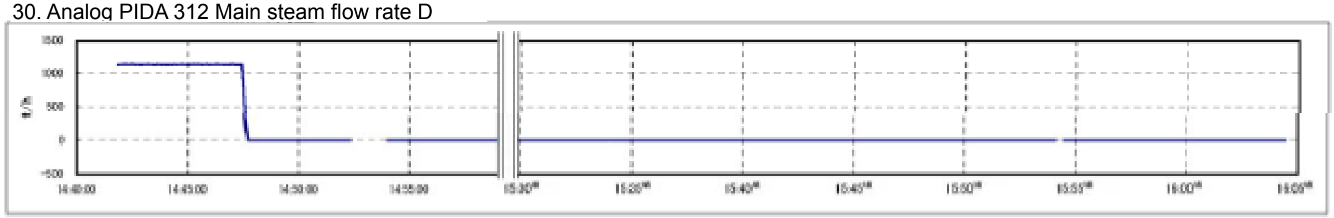


① RCIC manually activated at 15:05, afterwards, shut down at 15:25 due to high reactor water levels.

Parameters	Notes
26. D747 S/R valve A full open  21. D728 S/R valve C full open  23. D731 S/R valve E full open  22. D732 S/R valve G full open 	The main steam safety relief valve (SRV) was working cyclically from before around 14:55. It is presumed that firstly main steam safety relief valve C was activated but frequent activation and subsequent loss of operation pressure caused the switch over to valve G, after which the same phenomenon led to the switch over to valve A.

Fukushima Daiichi Unit 3 Transient Recorder Trends

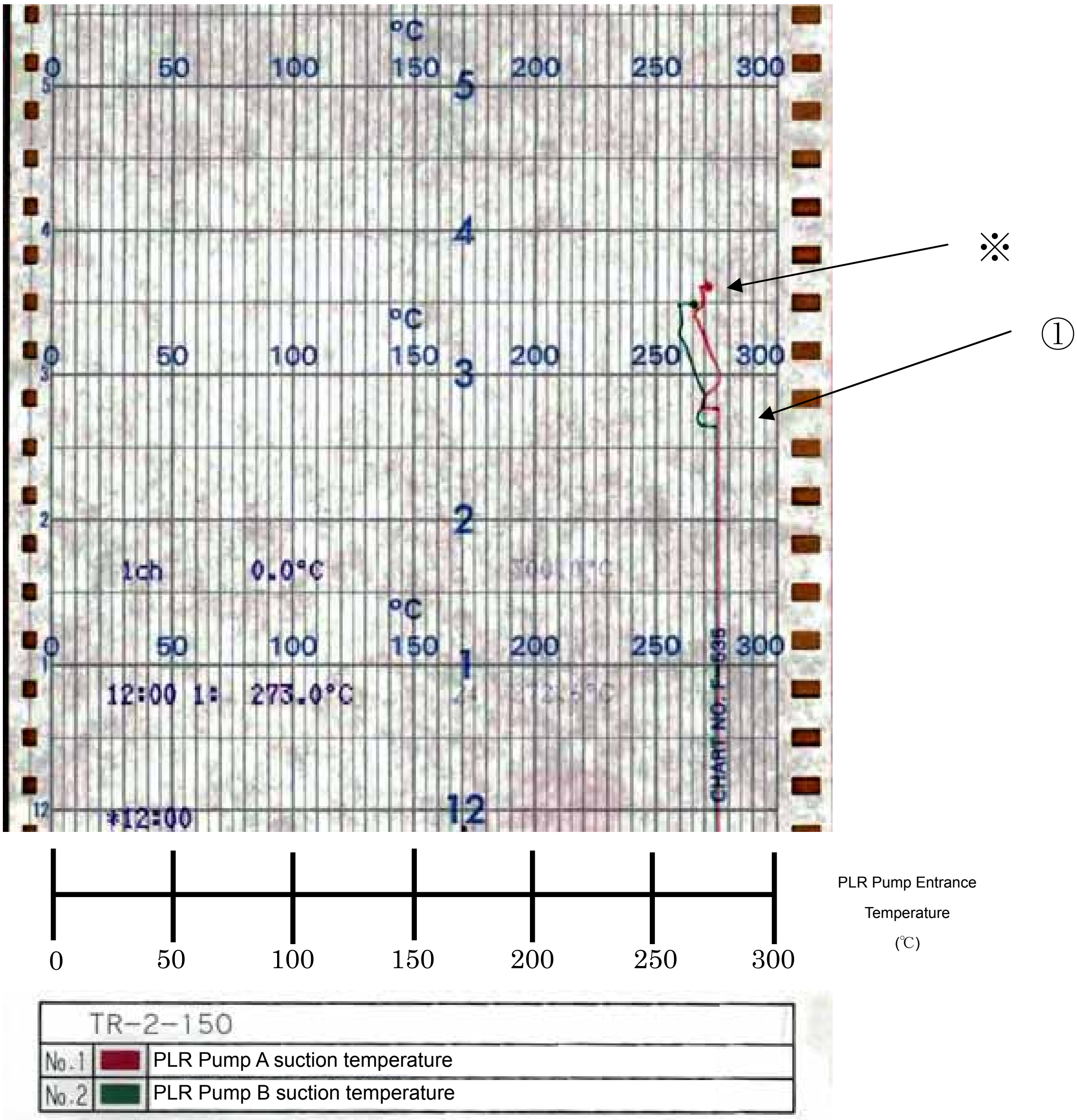
Attachment 6-3 (7)

<table>
<tr><th>Parameters</th><th>Notes</th></tr>
<tr><td>
27. Analog PIDA 309 Main steam flow rate A

28. Analog PIDA 310 Main steam flow rate B

29. Analog PIDA 311 Main steam flow rate C

30. Analog PIDA 312 Main steam flow rate D

</td><td>Main steam flow rate decreases in conjunction with the scram.</td></tr>
</table>

Attachment 6-3 (8)

Fukushima Daiichi Unit 3 Transient Recorder Trends

[Primary Loop Recirculating (PLR) Pump Suction Temperature]

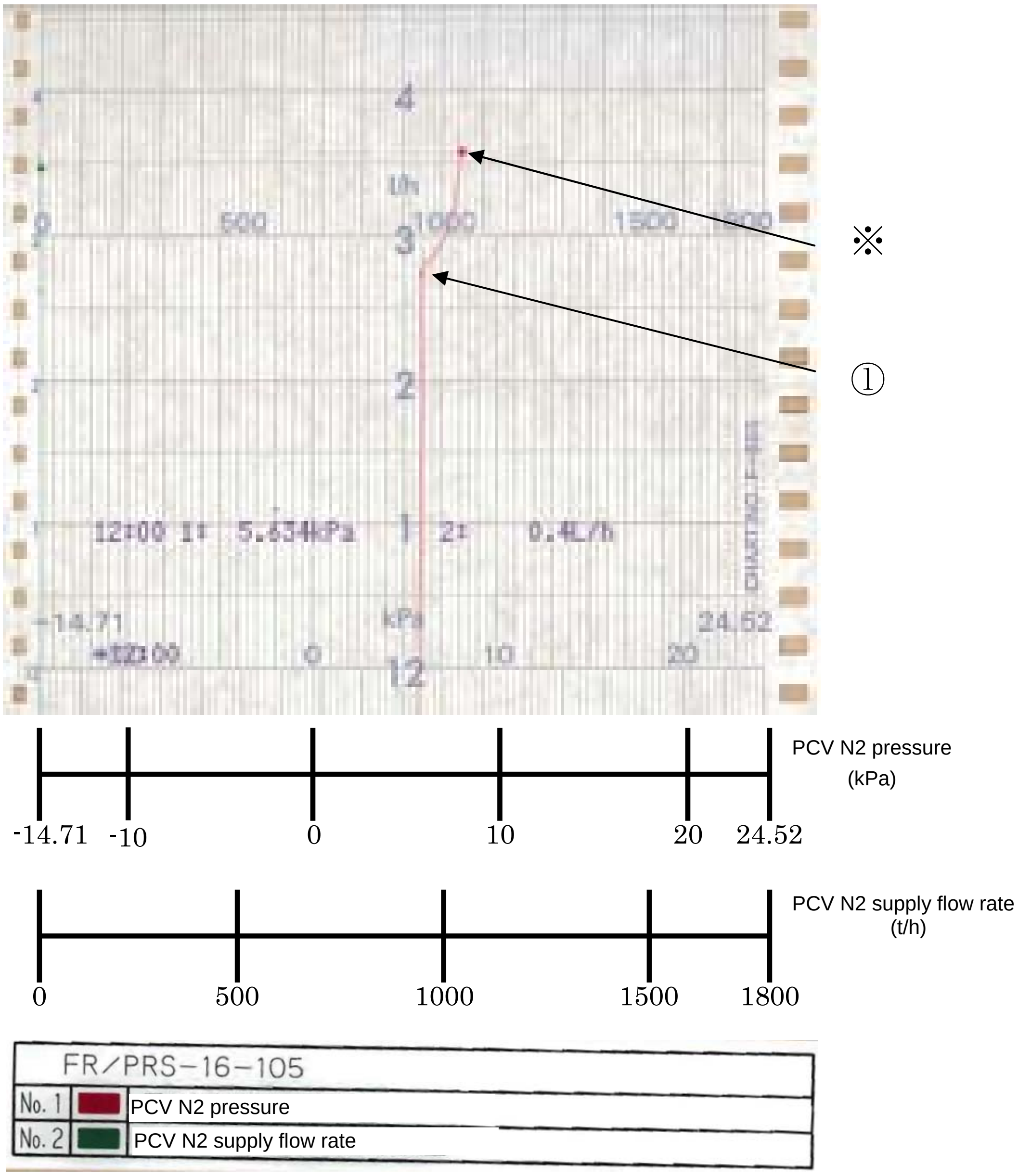


①Scram triggered by earthquake at 14:47

*It is supposed that the tsunami arrived shortly after 15:30.

It is assumed that the record stopped due to the impact of the tsunami.

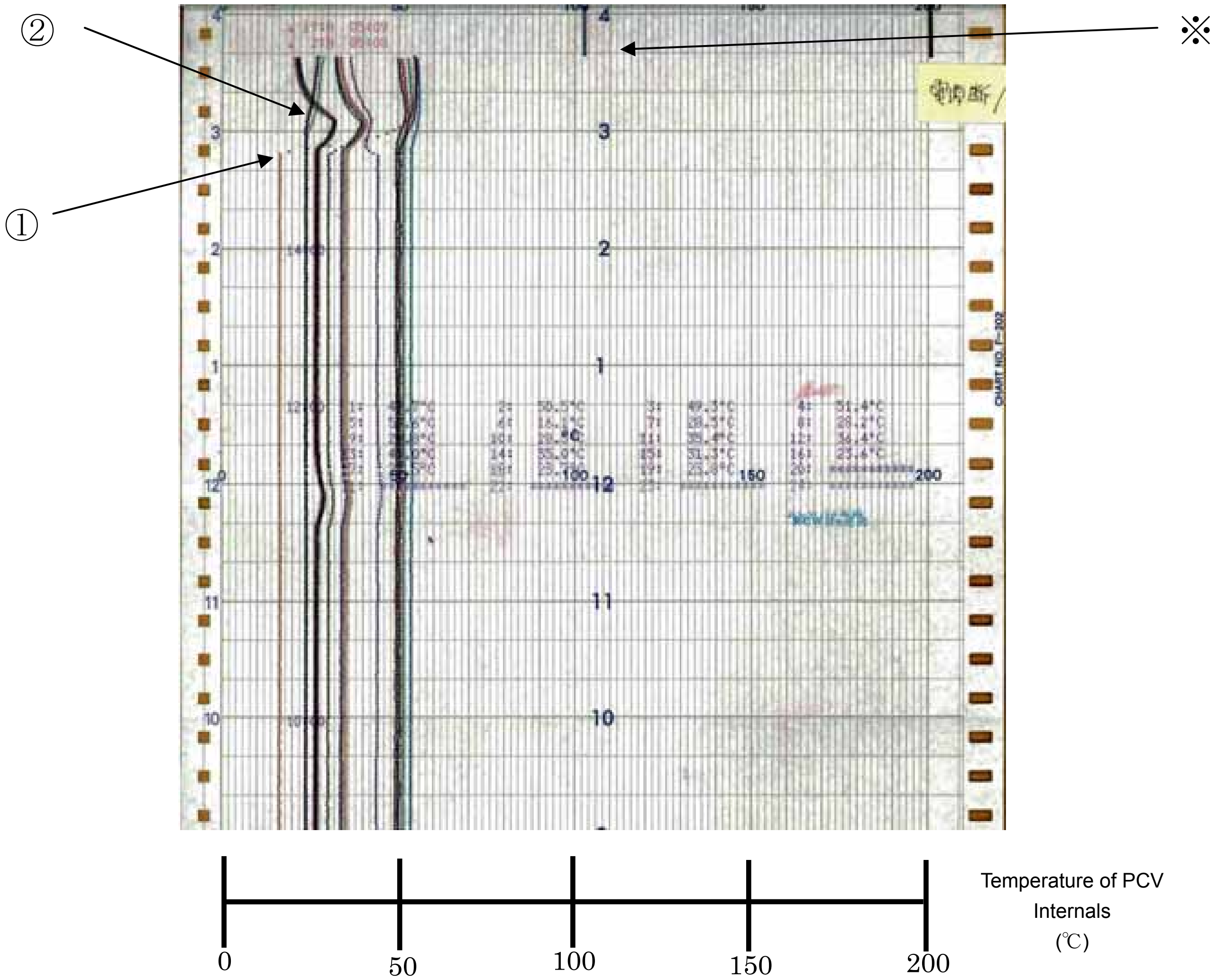
[Primary Containment Vessel (PCV) Nitrogen Pressure /
Primary Containment Vessel (PCV) Nitrogen (N2) Supply Flow Rate]



① Scram triggered by earthquake at 14:47

* It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the chart no longer gives an accurate reading due to the impact of the tsunami.

[Temperature of Primary Containment Vessel (PCV) Internals]



TRS-16-115

Store No.	Unit 3-19

Input No.	Color	Mark	Input measurement no.	Point of measurement	Switch set point	Input No.	Color	Mark	Input measurement no.	Point of measurement	Switch set point
1		●	TE-16-114A	PCV air conditioning return air temperature	65.6℃	13		+	TE-16-114N	Reactor Beraud seal part temperature	65.6℃
2		●	TE-16-114B	PCV air conditioning return air temperature	65.6℃	14		+	TE-16-114P	Reactor Beraud seal part temperature	65.6℃
3		●	TE-16-114C	PCV air conditioning return air temperature	65.6℃	15		+	TE-16-114R	Reactor Beraud seal part temperature	65.6℃
4		●	TE-16-114D	PCV air conditioning return air temperature	65.6℃	16		+	TE-16-114T	S/C gas temperature	65.6℃
5		●	TE-16-114E	PCV air conditioning return air temperature	65.6℃	17		+	TE-16-114U	S/C gas temperature	65.6℃
6		●	TE-16-114F	PCV air conditioning supply air temperature	65.6℃	18		+	TE-16-114V	S/C gas temperature	65.6℃
7		○	TE-16-114G	PCV air conditioning supply air temperature	65.6℃	19		Y	TE-16-114W	S/C gas temperature	65.6℃
8		○	TE-16-114H	PCV air conditioning supply air temperature	65.6℃	20		Y			
9		○	TE-16-114J	PCV air conditioning supply air temperature	65.6℃	21		Y			
10		○	TE-16-114K	PCV air conditioning supply air temperature	65.6℃	22		Y			
11		○	TE-16-114L	Reactor Beraud seal part temperature	65.6℃	23		Y			
12		○	TE-16-114M	Reactor Beraud seal part temperature	65.6℃	24		Y			

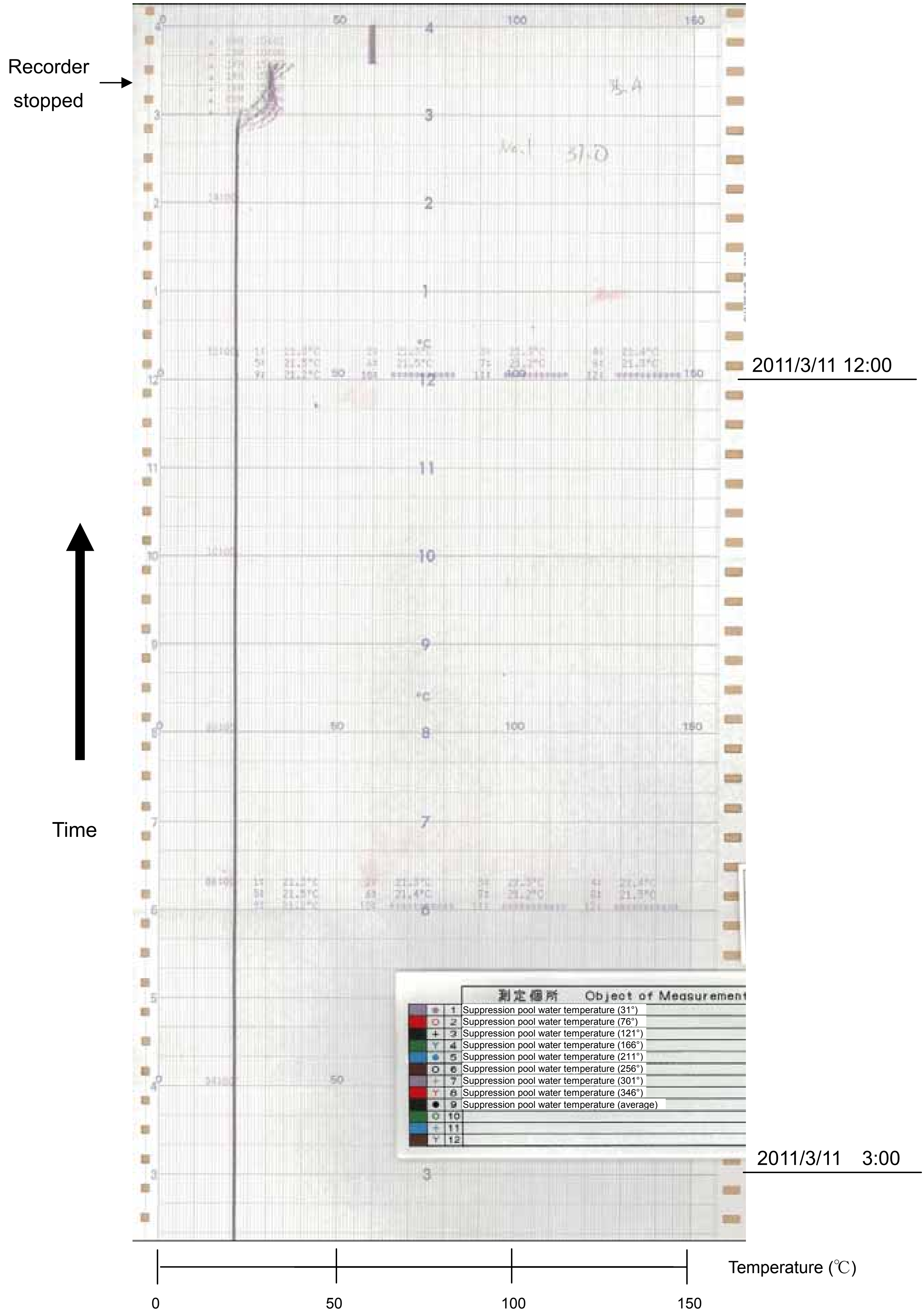
① Scram triggered due to Earthquake at 14:47

② Shutdown of PCV air conditioning due to loss of power, change in PCV temperature followed by drop in output triggered by scram (Unable to confirm rise in temperature due to piping ruptures)

*It is assumed that recorders temporarily halted due to loss of power caused by the tsunami that arrived shortly after 15:30.

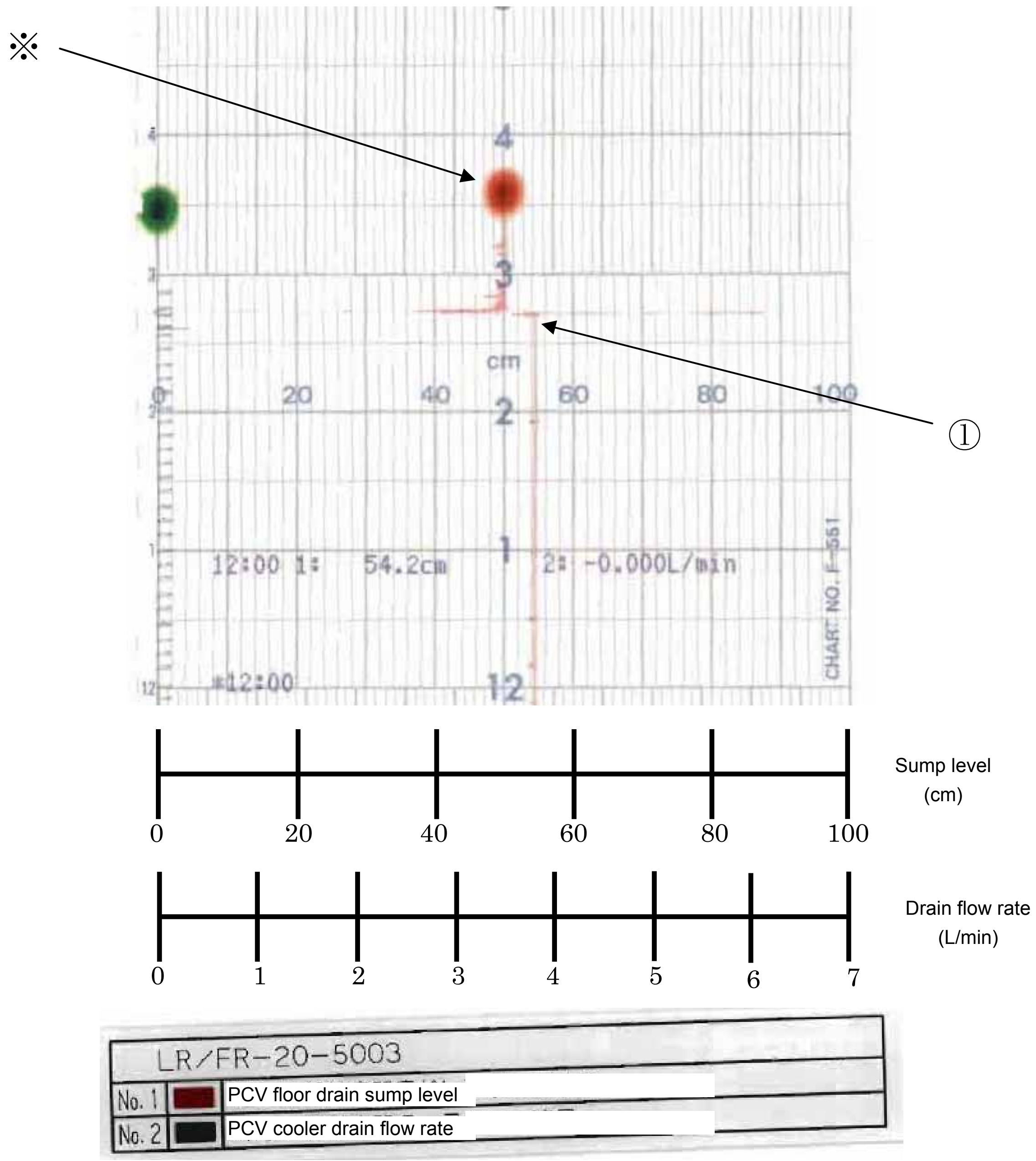
Fukushima Daiichi Unit 3 Chart

[Suppression Pool Water Temperature]



Fukushima Daiichi Unit 3 Chart

[Dry Well (D/W) Floor Drain Sump Level]



① Scram triggered by earthquake at 14:47

*It is supposed that the tsunami arrived shortly after 15:30. It is assumed that the record stopped due to the impact of the tsunami.

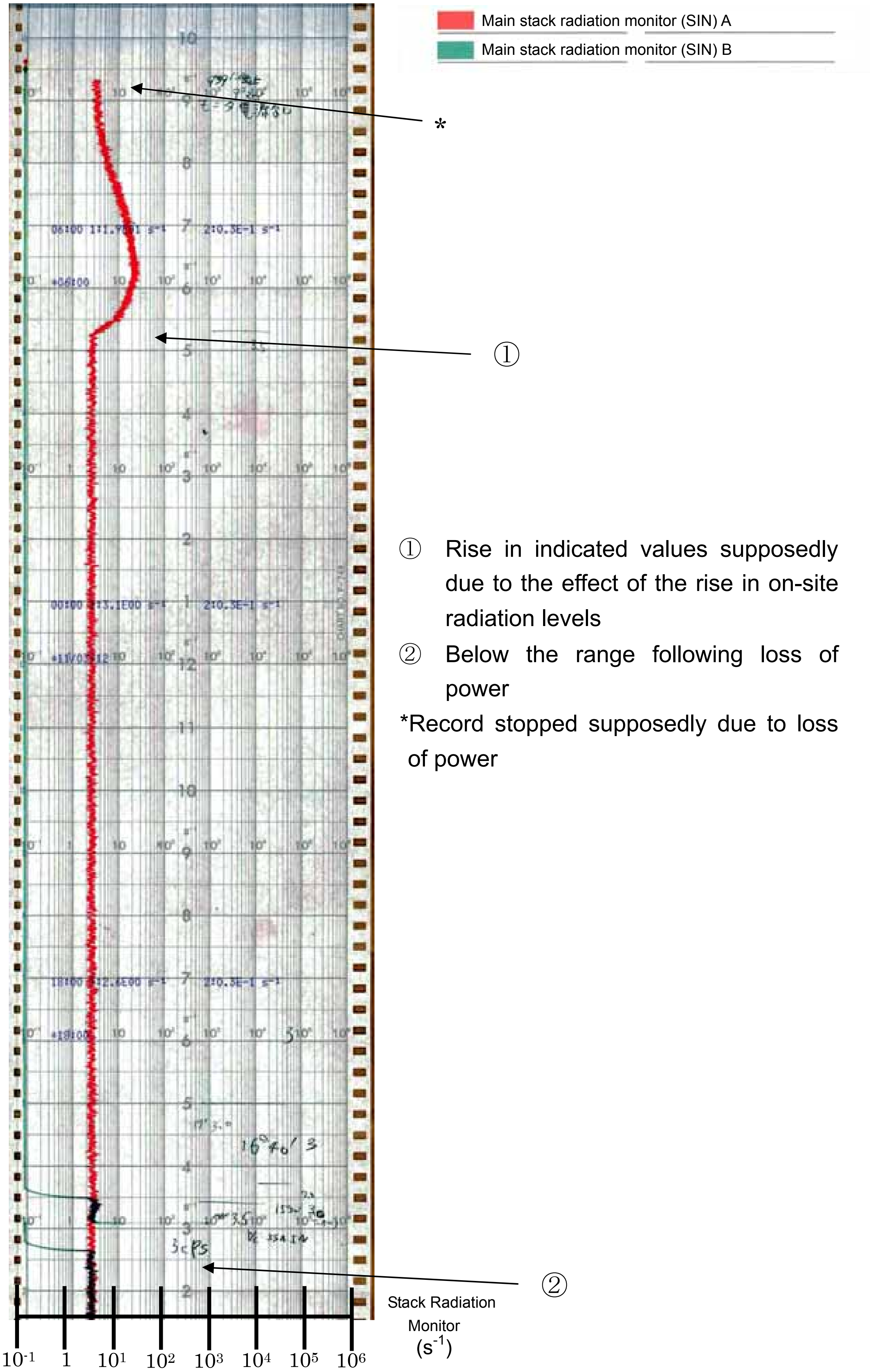
[Standby Gas Treatment System (SGTS) Operation]

```
*1447   C183  原子炉 給水流量 (TOTAL)          判定 不能
 1447   A549  熱負荷 警報点                         以下
 1447   B013  S/C 水位                              4.5 CM      正常 復帰
 1447   A600  PCIS隔離信号 内側 トリップ            オン
 14  47   12   620   D570   高圧復水ポンプ A 運転                  オン
 1447   L600  SGTS A 運転                           オン
*1447   S646  TIP盤 正常                            オフ
 14  47   12   630   D567   モーター駆動給水ポンプ B 運転           オン
 1447   A601  PCIS隔離信号 外側 トリップ            オン
```

Standby Gas Treatment

Reactor feed water flow rate (TOTAL) Unidentifiable
Heat load alarm point Below
S/C water level Normal recovery
PCIS isolation signal inboard trip ON
High pressure condensate pump A Operation ON
SGTS A operation ON
TIP panel normal OFF
Motor-driven feed water pump B operation ON
PCIS isolation signal outboard trip ON

[Main Stack Radiation Monitor]



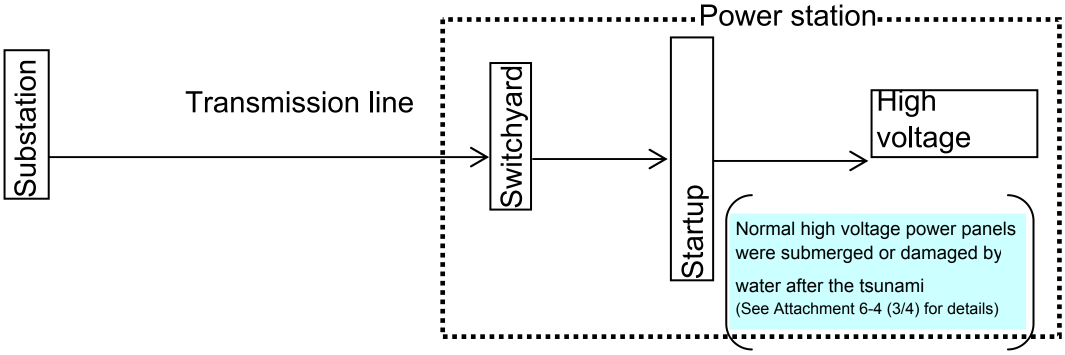
① Rise in indicated values supposedly due to the effect of the rise in on-site radiation levels

② Below the range following loss of power

*Record stopped supposedly due to loss of power

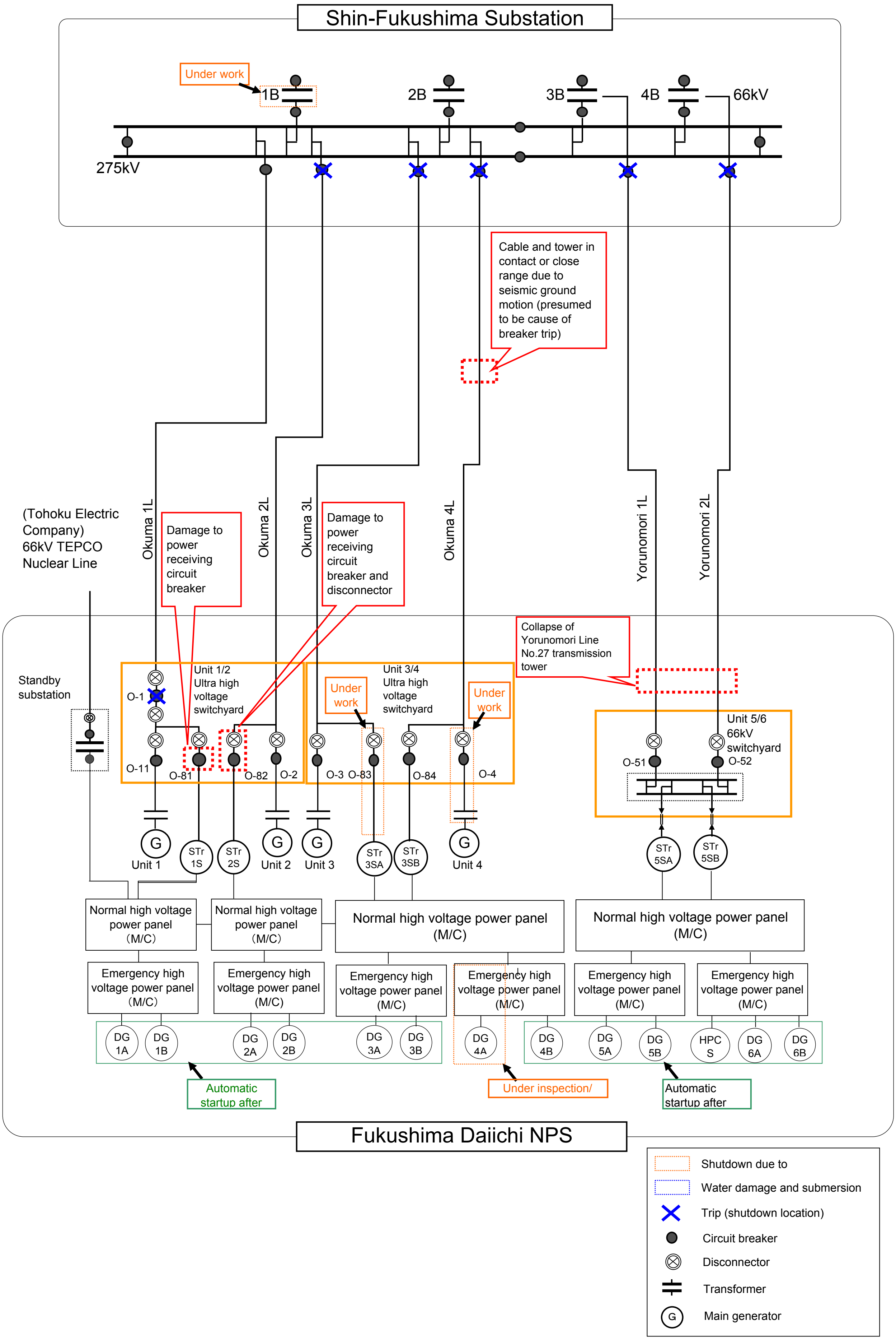
Fukushima Daiichi Nuclear Power Station Offsite power receiving status list

	Transmission line name	Power receipt from transmission line to switchyard: Before earthquake	After earthquake - before tsunami arrival	After tsunami	Onsite power reception status (Check results after tsunami arrival)		Comments
Offsite power	Okuma 1L	○ (receiving power)	Power not received due to damage to power receiving circuit breaker		Power not received due to water damage and submersion of site-side power receiving Unit 1 normal high voltage power panel		
Offsite power	Okuma 2L	○ (receiving power)	Power not received due to damage to power receiving circuit breaker		Power not received due to water damage and submersion of site-side power receiving Unit 2 normal high voltage power panel		
Offsite power	Okuma 3L	Power not received due to facility update work on power receiving circuit breakers					Connected Yorunomori 1L to Okuma 3L on same tower. 3/22: received power at Unit 3/4 low voltage power panel
Offsite power	Okuma 4L	○ (receiving power)	Power reception stopped. (Presumed to be breaker trip due to contact or close range between cable and tower due to ground motion. Found watermarks on switchyard facilities)		Power not received due to water damage and submersion of site-side power receiving Unit 3, 4 normal high voltage power panel		
Offsite power	Yorunomori 1L	○ (receiving power)	Power not received due to collapsed tower.		Power not received due to water damage and submersion of site-side power receiving Unit 5, 6 normal high voltage power panel		3/22: received power at Unit 3, 4 low voltage power panel via Okuma 3L
Offsite power	Yorunomori 2L	○ (receiving power)	Power not received due to collapsed tower.		Power not received due to water damage and submersion of site-side power receiving Unit 5, 6 normal high voltage power panel		3/21: pass through new route via Futaba Line transmission tower and received power at Unit 5, 6 existing power panel
(Standby)	TEPCO Nuclear Line	Charging up to disconnector on receiving side (disconnector "open")	Shut down		Found cable defect from receiving end to Unit 1 normal high voltage power panel	Power not received due to water damage and submersion of site-side power receiving Unit 1 normal high voltage power panel	3/20: received power on Unit 1,2 low voltage power panel after laying cable
(Ref) transmission facility	Futaba 1L	–	–	–	–	–	*Futaba Line is not offsite power (transmission only)
(Ref) transmission facility	Futaba 2L	–	–	–	–	–	

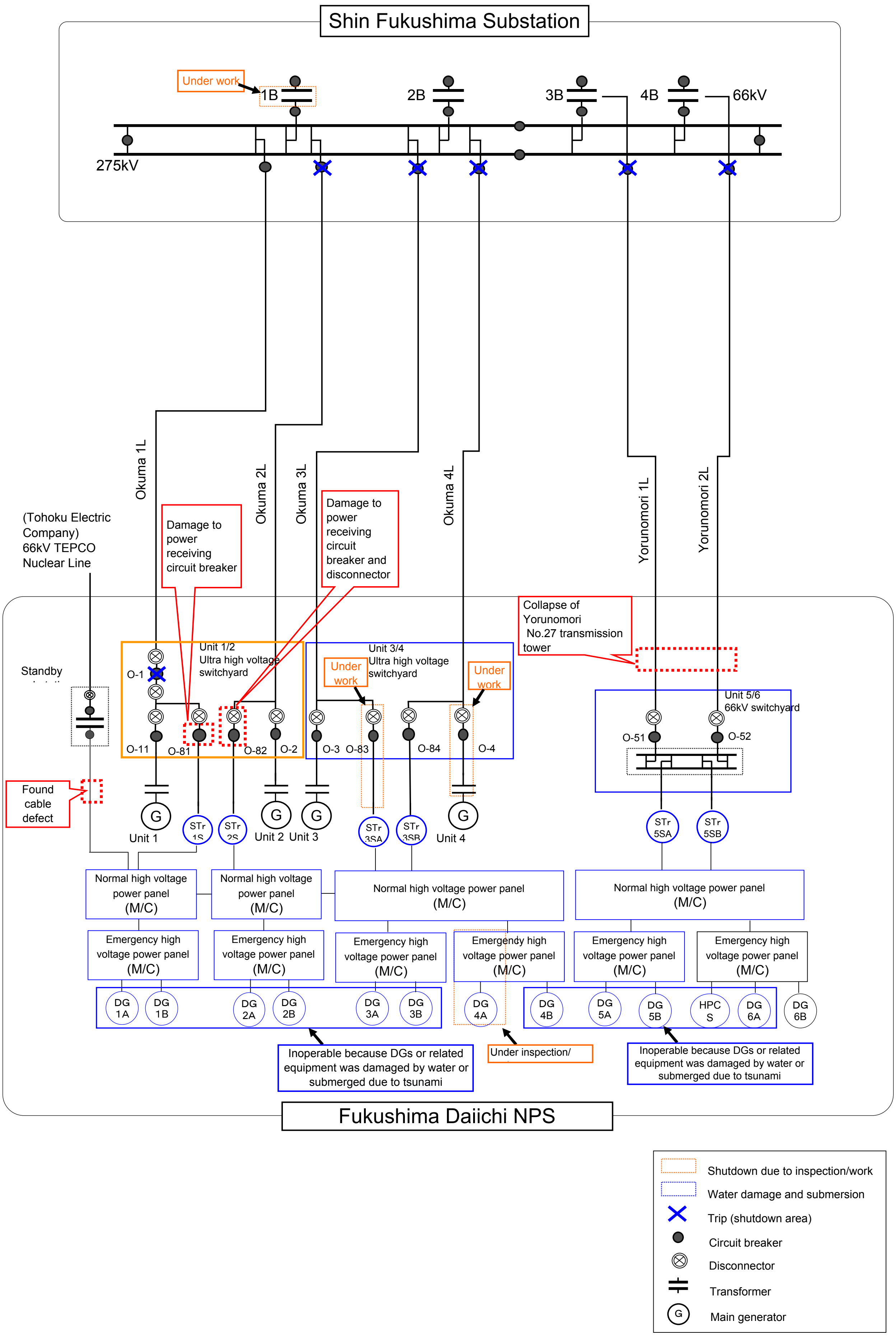


Flow of power reception from offiste power (substation)

Fukushima Daiichi Nuclear Power Station Offsite power system drawing (conditions after earthquake, before tsunami)



Fukushima Daiichi Nuclear Power Station Offsite power system drawing (conditions after tsunami)



Damages to offsite power facilities

Figure 1. Fukushima Daiichi Nuclear Power Station
Okuma 1L circuit breaker

Figure 2. Yorunomori Line No. 27 transmission tower

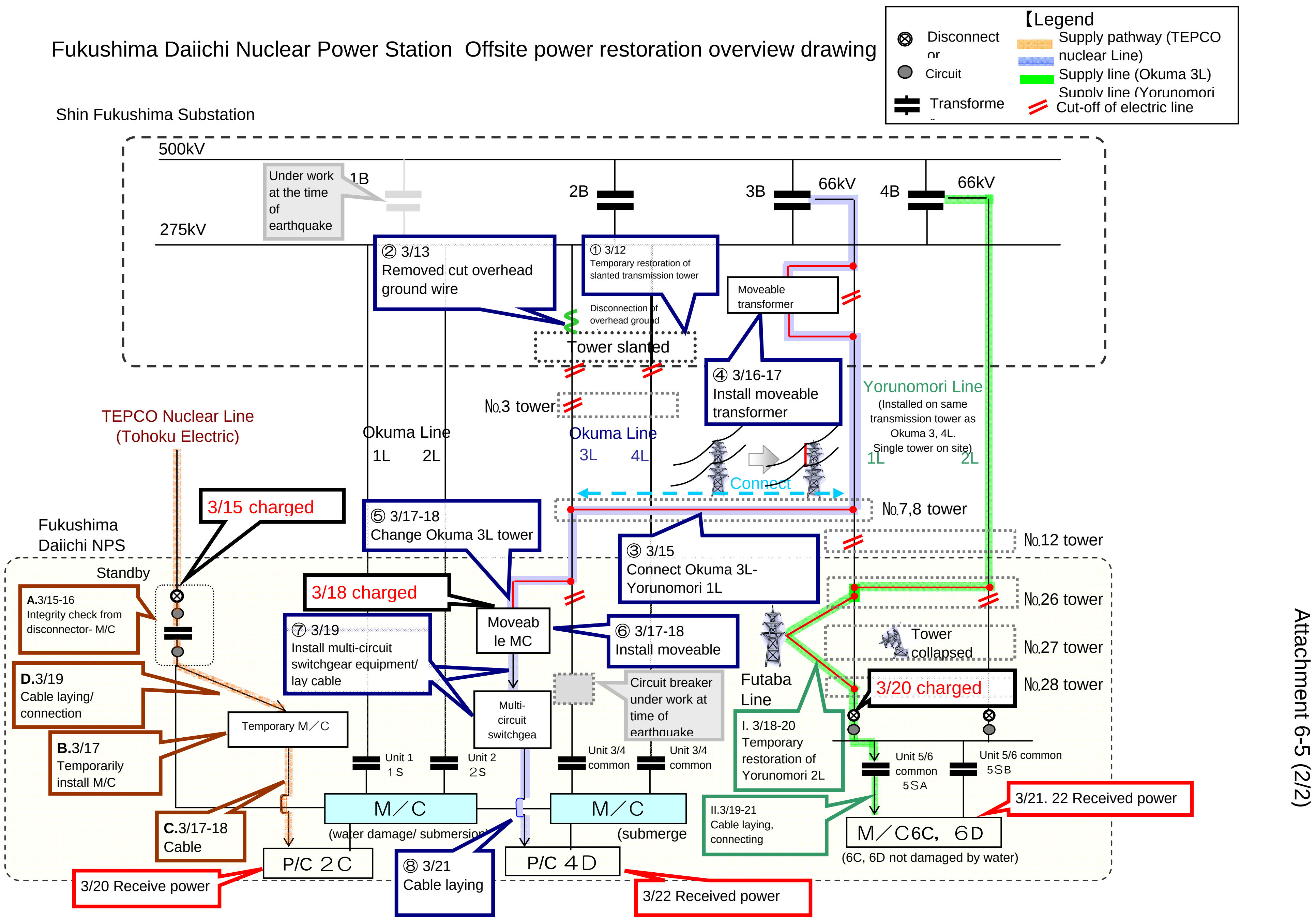
Fukushima Daiichi Nuclear Power Statiom Chronology of Offsite Power Restoration

The chronology of events for restoration of power supply to Fukushima Daiichi NPS from offsite power is as follows (chronology up to March 22 when all units started receiving power)

Supplied to	Date and main work content
Unit 1 & 2	3/15: Charged up to power receiving circuit breaker via Tohoku Electric Power Company's TEPCO Nuclear Line 3/15, 16: Integrity check of TEPCO Nuclear Line between power receiving circuit breaker and M/C (Work A*) 3/17: Install Unit 1/2 temporary metal clad switchgear (M/C)* (Work B) 3/17-18: Laid cable between Unit 1/2 M/C and Unit 2 power center (P/C) 2C (Work C) 3/19: Laid cable and connected between standby substation M/C and Unit 1/2 temporary M/C (Work D) 3/20: Start supply to Unit 1/2 (P/C 2C receiving power)
Unit 3 & 4	3/12: Temporary restoration of Shin Fukushima Substation Okuma 3L, 4L transmission tower slanting (Work ①*) 3/13: Remove Okuma 3L cut-off elevated cables for Shin Fukushima Substation (Work ②) 3/15: Connected Okuma 3L and Yorunomori 1L on Okuma 3, 4L No.7 and No. 8 transmission tower (Work ③) 3/16-17: Install moveable transformer (66kV/6kV) at Shin Fukushima Substation (Work ④) 3/17-18: Change Fukushima Daiichi NPS Okuma 3L lead-in (Work ⑤) 3/17-18: Install moveable mini-metal clad switch gear (MC)* onsite of Fukushima Daiichi NPS (Work ⑥) 3/18: Charged up to (Yorunomori 1L-) Okuma 3L moveable MC 3/19: Laid cable between moveable MC and multi-circuit switchgear (Work ⑦) 3/21: Laid cable between multi-circuit switchgear* - Unit 4 P/C 4D (Work ⑧) 3/22: Start supply to Units 3/4 (received power at P/C4D)
Units 5 & 6	3/18-19: Temporary restoration of Yorunomori Line No.27 transmission tower 2L (cut trees) (Work I*) 3/19-20: Temporary restoration of Yorunomori Line No. 27 transmission tower 2L (overhead line) (Work I) 3/19-21: Laid temporary cable and connected between Unit 5/6 common startup transformer 5SA and Unit 6 M/C6C, 6D (Work II) 3/20: Charged between Yorunomori 2L - 1L disconnector 3/21: Start supply to Units 5/6 (received power at M/C6C. 3/22: received power at M/C6D)

*) Work number and symbol corresponds with numbers/symbols in the figure (next page)

*) Temporary metal clad switchgear (M/C), moveable mini metal clad switchgear (MC), multi-circuit switchgear
Each department of the restoration team (nuclear, transmission, distribution) procured power panels and other equipment, respectively.

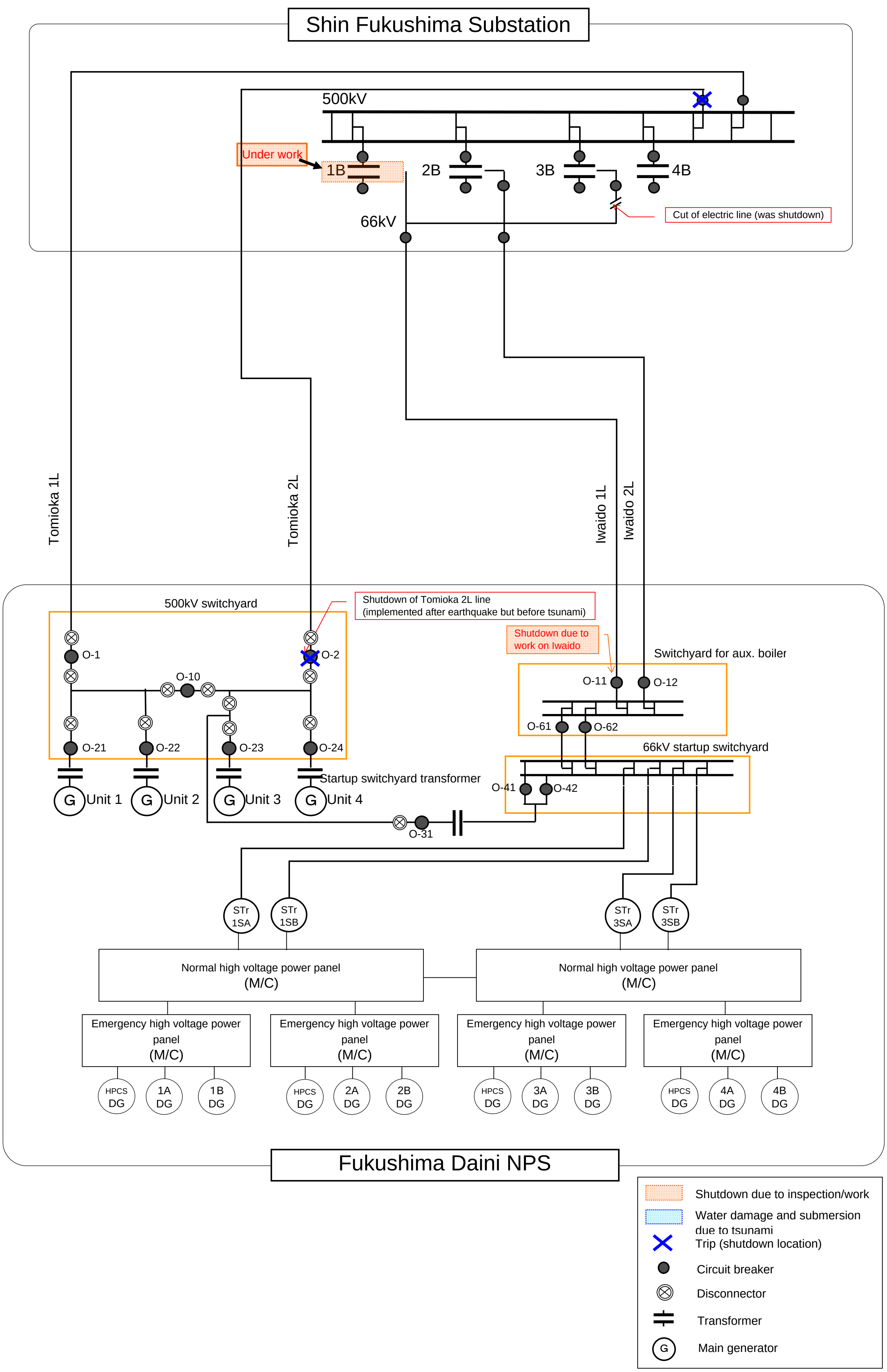


Fukushima Daiichi Nuclear Power Station Offsite power restoration overview drawing
【Legend
Disconnect or
Circuit
Transforme
Supply pathway (TEPCO nuclear Line)
Supply line (Okuma 3L)
Supply line (Yorunomori
Cut-off of electric line
Shin Fukushima Substation
500kV
275kV
Under work at the time of earthquake
1B
2B
3B
66kV
4B
66kV
② 3/13 Removed cut overhead ground wire
① 3/12 Temporary restoration of slanted transmission tower
Disconnection of overhead ground
Tower slanted
Moveable transformer
④ 3/16-17 Install moveable transformer
No.3 tower
TEPCO Nuclear Line (Tohoku Electric)
Okuma Line
1L 2L
Okuma Line
3L 4L
Yorunomori Line
(Installed on same transmission tower as Okuma 3, 4L. Single tower on site)
1L 2L
Connect
No.7,8 tower
No.12 tower
3/15 charged
⑤ 3/17-18 Change Okuma 3L tower
③ 3/15 Connect Okuma 3L-Yorunomori 1L
Fukushima Daiichi NPS
Standby
3/18 charged
No.26 tower
A.3/15-16 Integrity check from disconnector- M/C
Moveable MC
⑥ 3/17-18 Install moveable
⑦ 3/19 Install multi-circuit switchgear equipment/ lay cable
Tower collapsed
No.27 tower
D.3/19 Cable laying/ connection
Multi-circuit switchgea
Circuit breaker under work at time of earthquake
Futaba Line
3/20 charged
No.28 tower
Temporary M／C
I. 3/18-20 Temporary restoration of Yorunomori 2L
B.3/17 Temporarily install M/C
Unit 1 1S
Unit 2 2S
Unit 3/4 common
Unit 3/4 common
Unit 5/6 common 5SA
Unit 5/6 common 5SB
M／C
M／C
II.3/19-21 Cable laying, connecting
3/21. 22 Received power
C.3/17-18 Cable
(water damage/ submersion)
(submerge
M／C6C, 6D
(6C, 6D not damaged by water)
P/C 2C
⑧ 3/21 Cable laying
P/C 4D
3/20 Receive power
3/22 Received power
Attachment 6-5 (2/2)

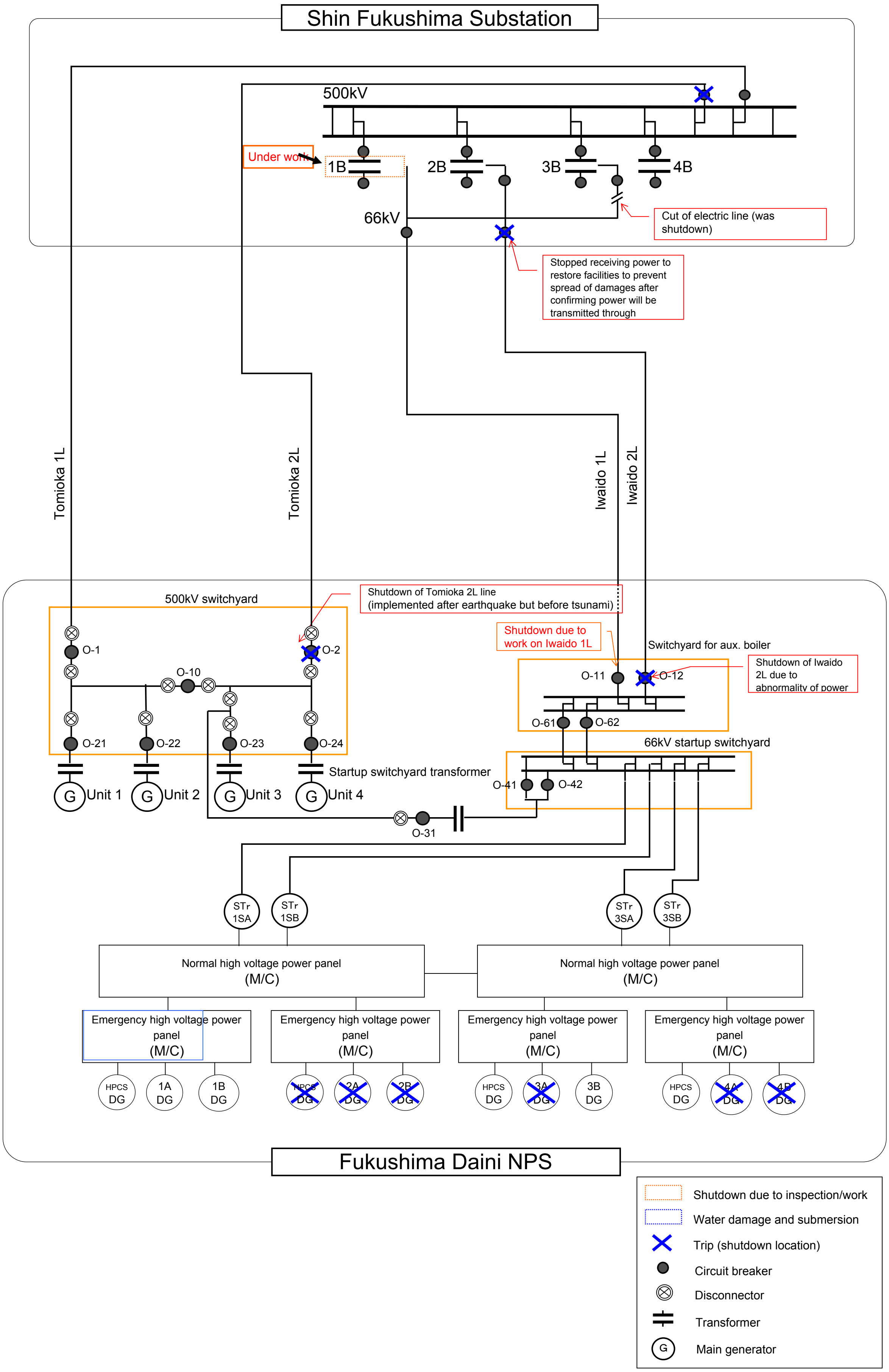
Fukushima Daini NPS　Offsite power receiving status list

	Transmission line name	Power receipt from transmission line to switchyard			Comments
		Before earthquake	After earthquake - before tsunami arrival	After tsunami	
Offsite power	Tomioka 1L	○ (receiving power)			
	Tomioka 2L	○ (receiving power)	Stopped receiving power due to damage to disconnector insulator at Shin Fukushima Substation		4/15: received power
(Standby)	Iwaido 1L	Shutdown due to inspection			3/13: received power
	Iwaido 2L	○ (charging)	○ (charging) Continued receiving power despite damage to lightning arrestor at Shin Fukushima Substation	Temporarily stopped receiving power to prevent spread of damage after checking that power suply will be continued with Tomioka 1L	3/12: received power

Fukushima Daini Nuclear Power Station Offsite power system drawing (conditions after earthquake, before tsunami)



Fukushima Daini Nuclear Power Station Offsite power system drawing (conditions after tsunami)



Fukushima Daiichi Nuclear Power Station Unit 1 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 1.The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on July 28, 2011.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 1 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.14×10^{-3} (N-S direction, first floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure 2, 3).

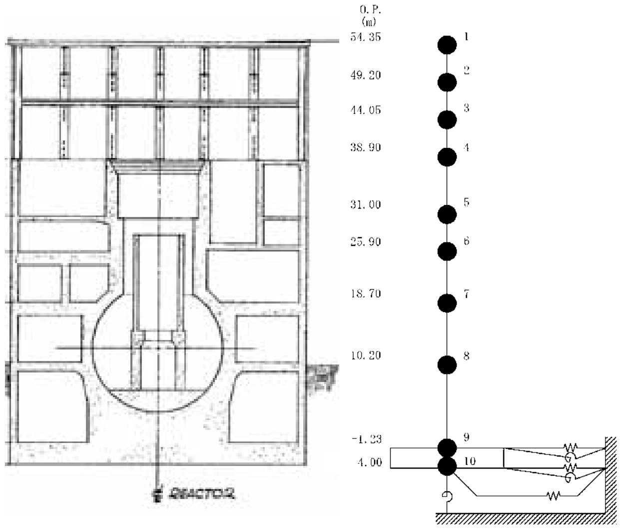


Figure 1. Unit 1 R/B (model drawing)

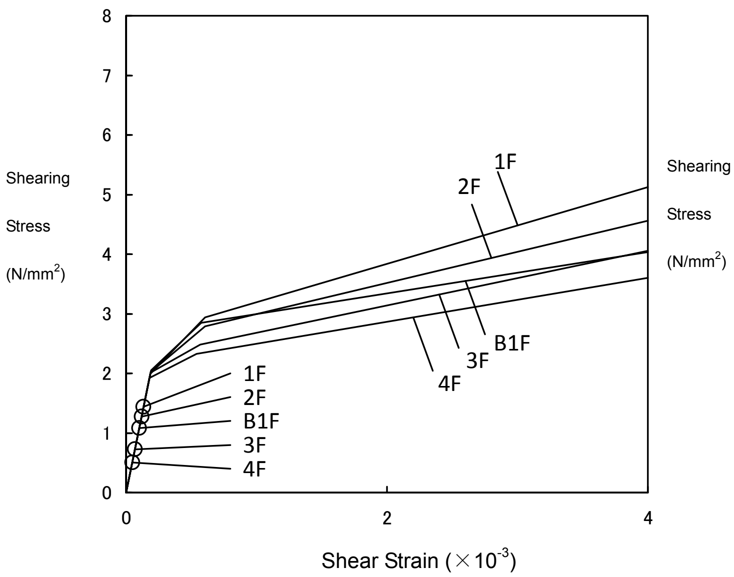


Figure 2. Shear strain of seismic wall (N-S)

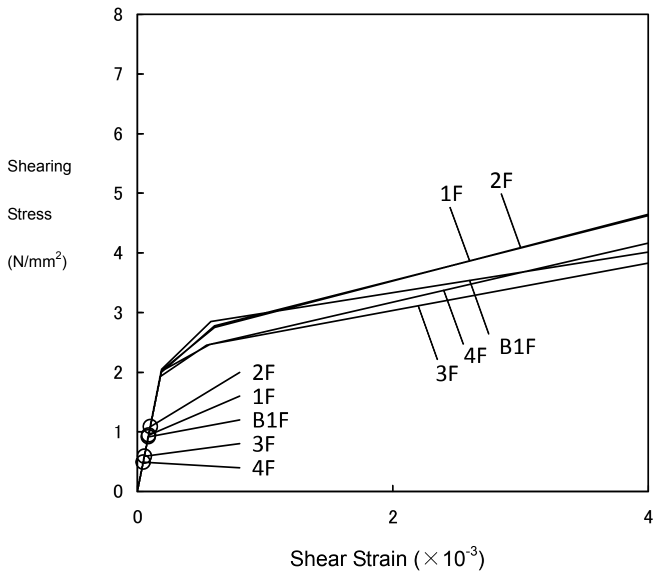


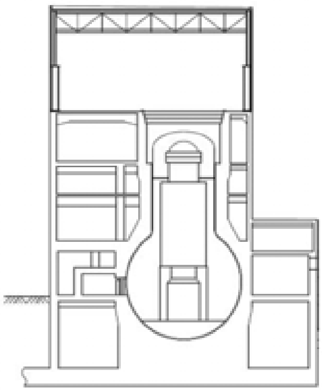
Figure 3. Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 1, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake partially exceeded some of such figures from the seismic safety analysis. However, the seismic performance of major facilities with safety-critical functions such as “shutting down” and “cooling down” the reactor, as well as “confining inside” radioactive material was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table 1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

Figure 4. Example of large equipment coupled seismic response analysis model



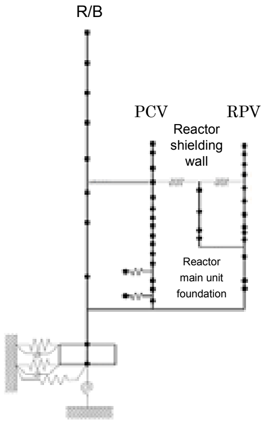
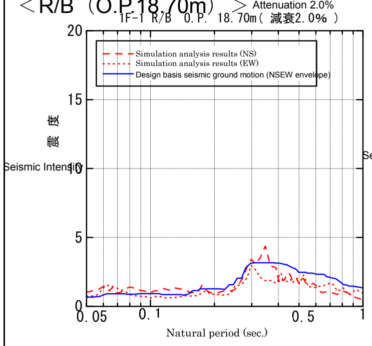
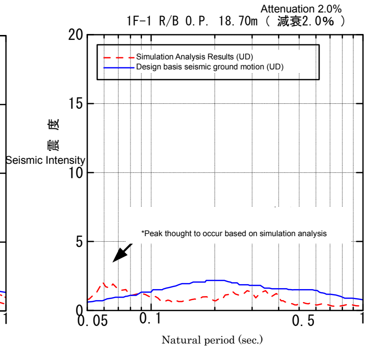
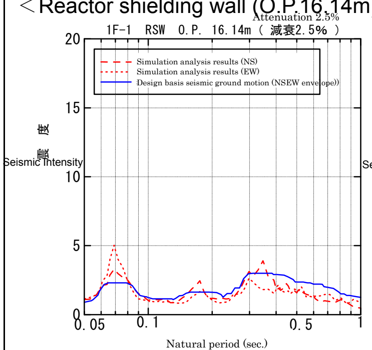
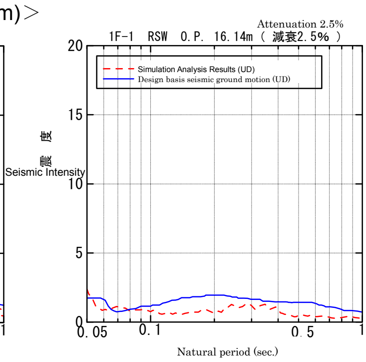
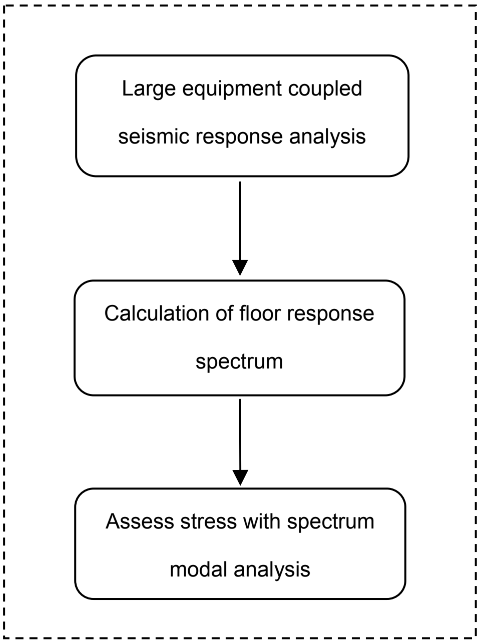


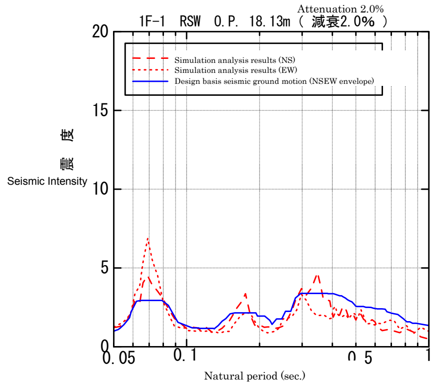
Table 1. Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 1)

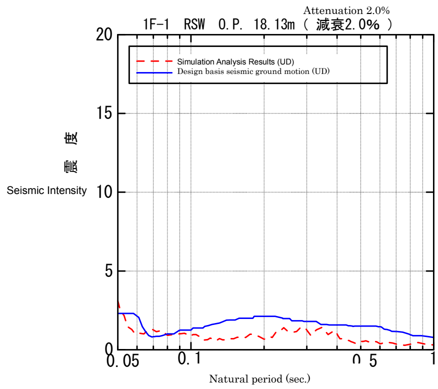
	Facility	Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	4730	6110	RPV (foundation bolt) Calculated value: 93MPa Assessment standard value: 222MPa
		Moment	(kN・m)	45900	62200	
		Axial force	(kN)	5250	3890	
	PCV foundation	Shear force	(kN)	4270	5080	PCV (drywell) Calculated value:98MPa Assessment standard value: 411MPa
		Moment	(kN・m)	55900	64200	
		Axial force	(kN)	2070	1560	
	Core shroud foundation	Shear force	(kN)	3060	3370	Core support structure (shroud support) Calculated value:103MPa Assessment standard value:196MPa
		Moment	(kN・m)	15300	16600	
		Axial force	(kN)	1020	792	
	Fuel assembly	Relative displacement	(mm)	21.2	26.4	Control rods (insertability) Assessment standard value:40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.96	1.29	Reactor shutdown cooling pump (foundation bolt) Calculated value: 8MPa Assessment standard value: 127MPa
		Seismic intensity (vertical)	(G)	0.58	0.54	
	Base mat	Seismic intensity (horizontal)	(G)	0.60	0.57	
		Seismic intensity (vertical)	(G)	0.51	0.32	
Floor response spectrum (R/B)	＜R/B（O.P.18.70m）＞  (horizontal)	 (vertical)				Main steam piping Calculated value: 269MPa Assessment standard value: 374MPa Reactor shutdown cooling piping Calculated value: 228MPa Assessment standard value: 414MPa
Floor response spectrum (R/B shielding wall)	＜Reactor shielding wall (O.P.16.14m)＞  (horizontal)	 (vertical)				

(Reference 1) Overview of seismic performance assessment (Example of main steam piping)

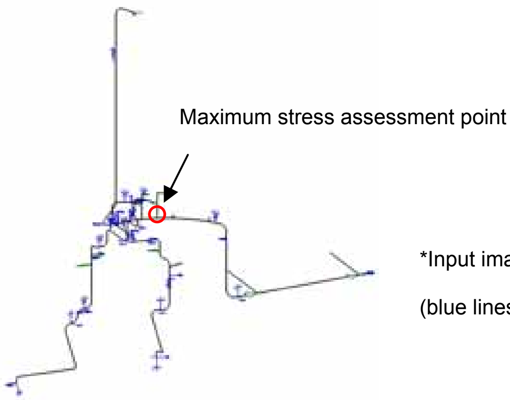


Assessment flow





Floor response spectrum



*Input image of anchor and supports (blue lines in the figure)

Main steam piping model

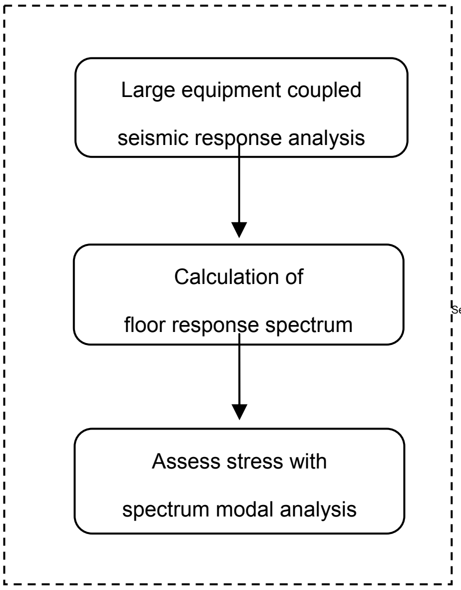
Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	287*	374	Detailed	Primary	269*	374	Detailed

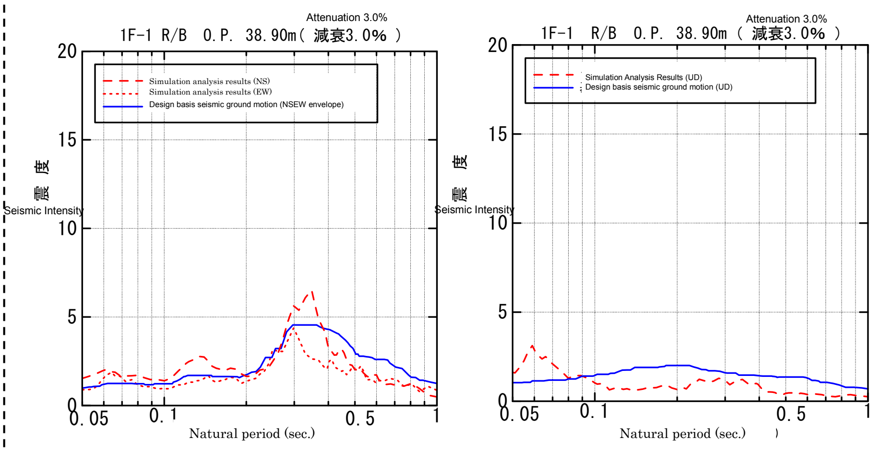
*: Though the horizontal floor response spectrum for the earthquake exceeded the design basis seismic ground motion in some periodic bands, the vertical floor response spectrum for the earthquake was mostly below the floor response spectrum for the design basis seismic ground motion, Ss. Therefore, it is believed that the calculated value for this earthquake is below the calculated value for the design basis seismic ground motion.

(Reference 2) Fukushima Daiichi Unit 1
Seismic performance assessment of isolation condenser (IC) piping

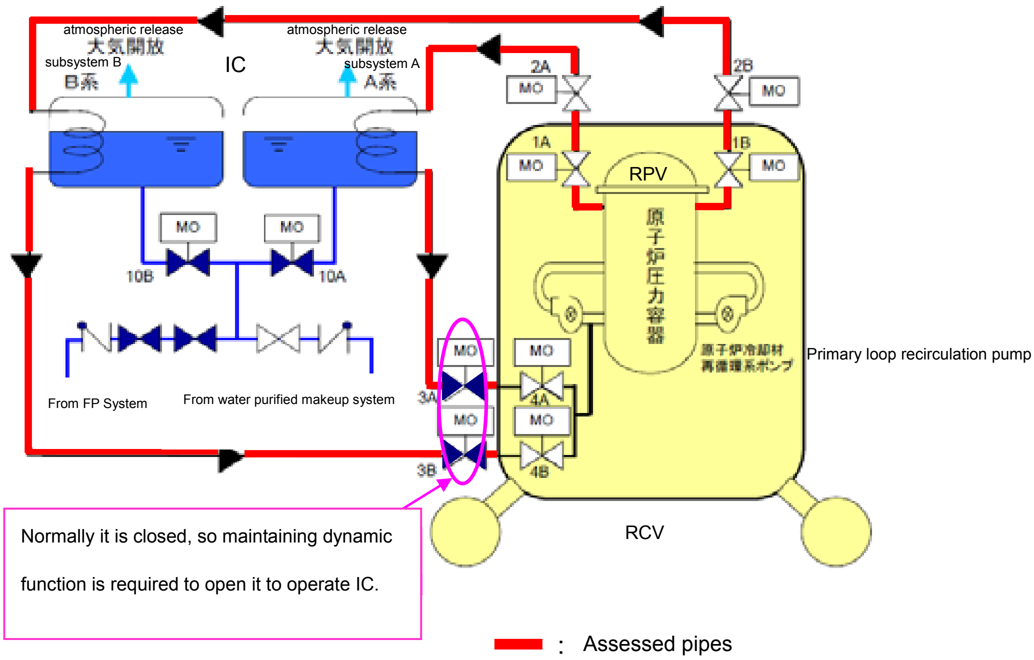
Seismic performance was assessed for Unit 1 IC piping (steam pipes) using the floor response spectrum defined based on the R/B simulation analysis at this time.
The results verified that the calculated values were sufficiently below the assessment standard value for this earthquake.



Assessment flow



Floor response spectrum



Note: Normal value positions are indicated.

Schematic system drawing of the IC system

Structural strength assessment results

Analysis model	Calculated value (MPa)	Assessment standard value *1 (MPa)	Margin
IC-PD-1	106	414	3.90
IC-PD-2	106	414	3.90
IC-R-1	94	414	4.40
IC-R-2	85	414	4.87
IC-R-3	105	310	2.95
IC-R-4	86	310	3.60
IC-R-5	75	351	4.68
IC-R-6	82	351	4.28

Dynamic function maintenance assessment results

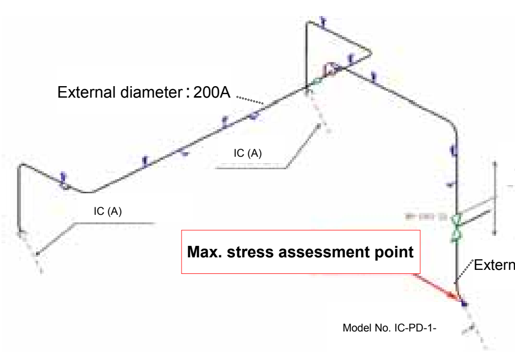
Name of valve	Horizontal (G*2)		Vertical (G*2)		Judgment
	Calculated value	Assessment standard value*3	Calculated value	Assessment standard value*3	
MO-1301-3A	0.9	6.0	2.0	6.0	○
MO-1301-3B	0.9	6.0	1.9	6.0	○

*1: Allowable values for service condition D as provided under “Codes for nuclear power generation facilities : rules on design and construction for nuclear power plants JSME S NC1-2005”

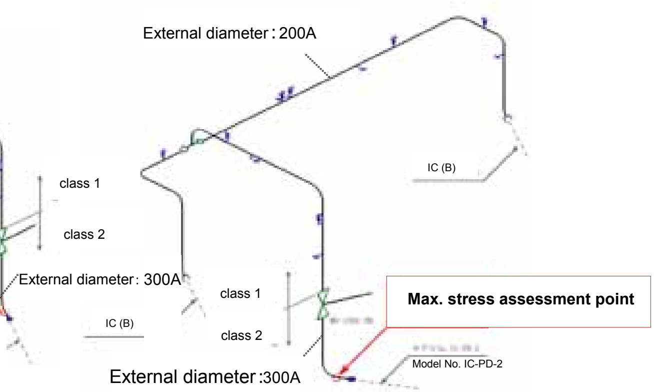
(Equivalent to allowable stress condition IV AS as indicated in “Technical Guidelines for Aseismic Design of Nuclear Power Plants JEAG4601 Supplement 1984”)

*2: G=9.80665(m/s^2)

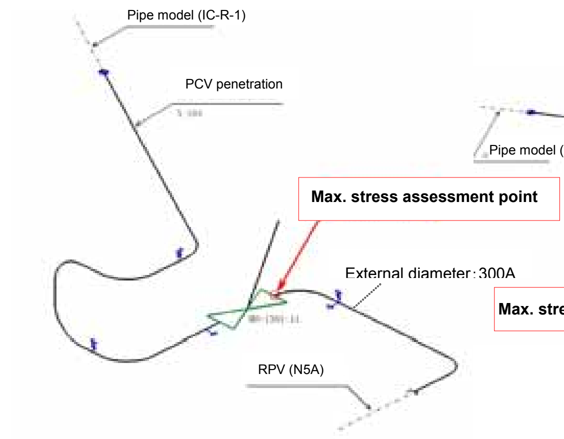
*3: Acceleration with function verified indicated in “Technical Guidelines for Aseismic Design of Nuclear Power Plants JEAG4601-1991 Supplemental Volume”



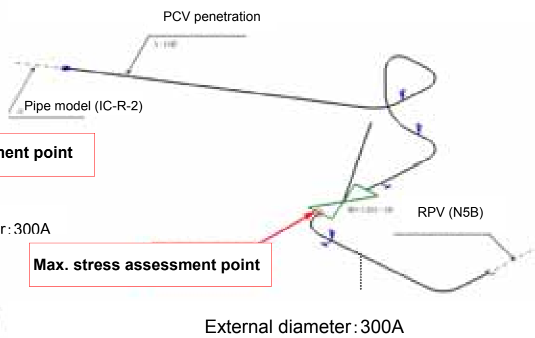
Pipe model (IC-R-1)



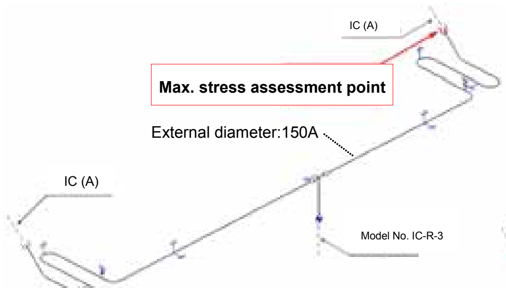
Pipe model (IC-R-2)



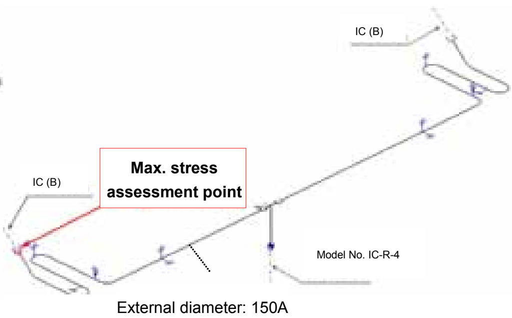
Pipe model (IC-PD-1)



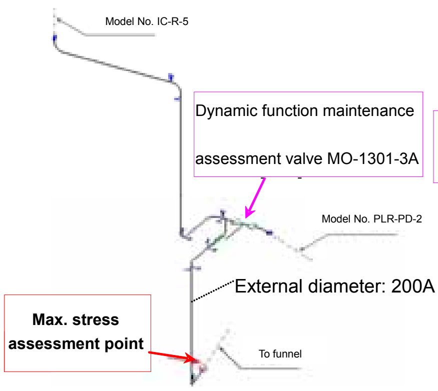
Pipe model (IC-PD-2)



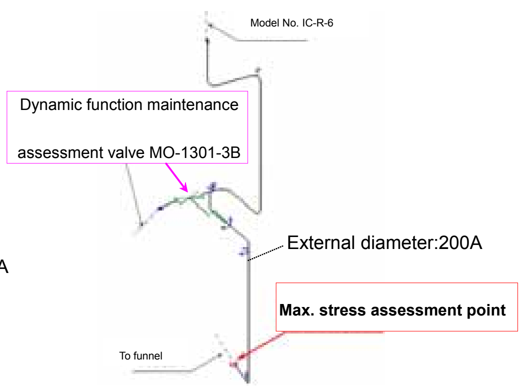
Pipe Model (IC-R-5)



Pipe Model (IC-R-6)



Pipe Model (IC-R-3)



Pipe Model (IC-R-4)

Fukushima Daiichi Nuclear Power Station Unit 2 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 2.The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on June 17, 2011.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 2 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.43×10^{-3} (E-W direction, fifth floor) and that the stress and deformation conditions for all seismic walls, excluding those in the E-W direction on the fifth floor, were at or below the first flexion point on the skeleton curve (Figure 2, 3).

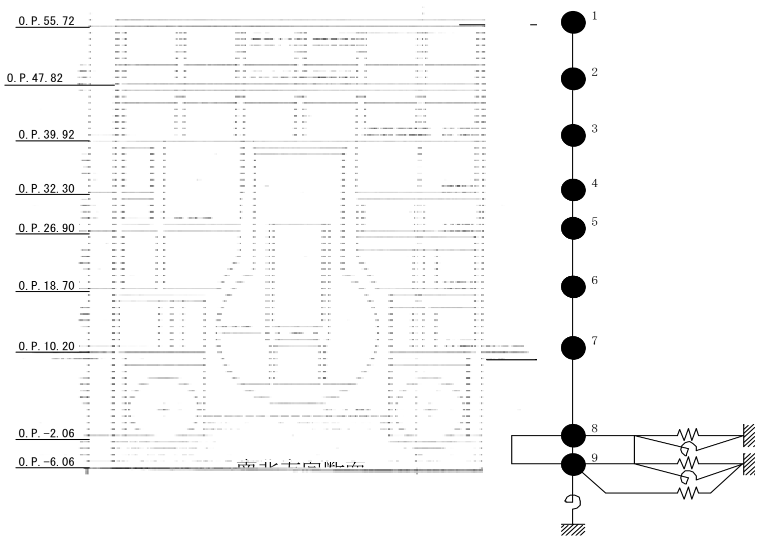


Figure 1. Unit 2 R/B (model drawing)

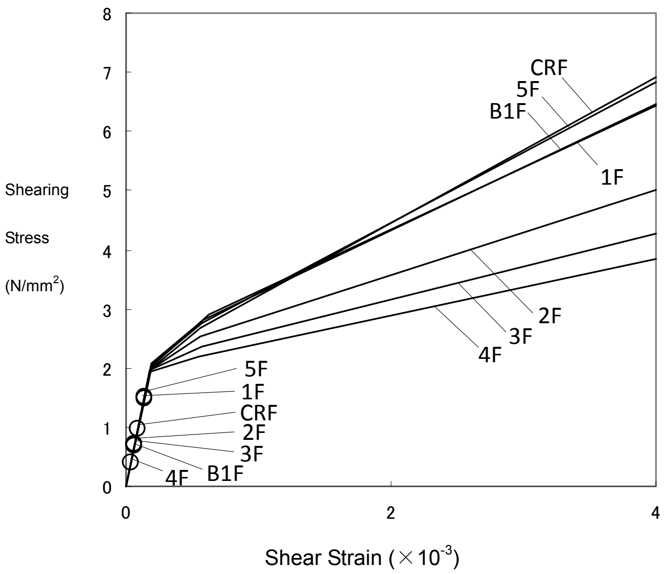


Figure 2. Shear strain of seismic wall (N-S)

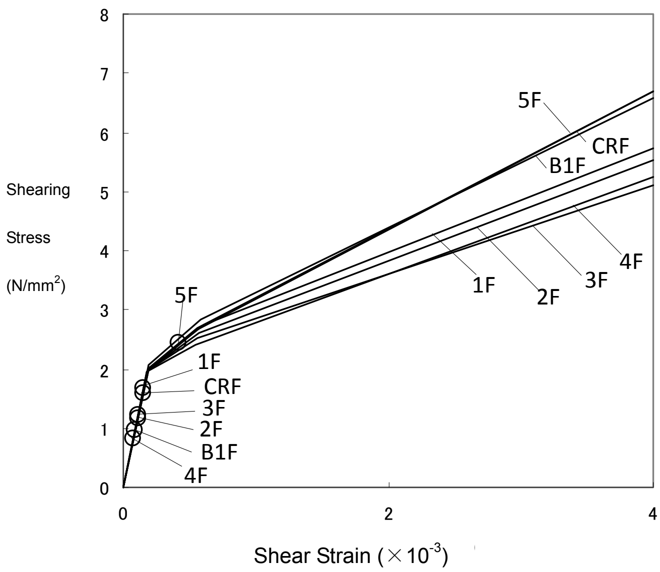


Figure 3. Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 2, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake partially exceeded some of such figures from the seismic safety analysis. However, the seismic performance of major facilities with safety-critical functions such as “shutting down” and “cooling down” the reactor, as well as “confining inside” radioactive material was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table 1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

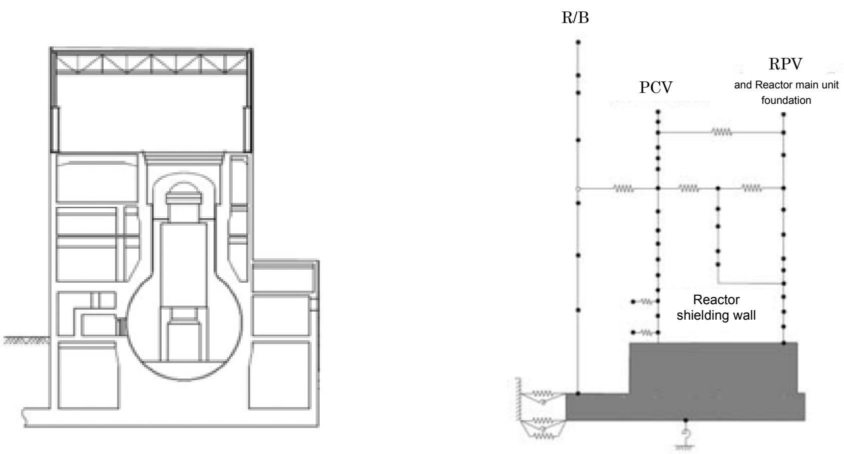
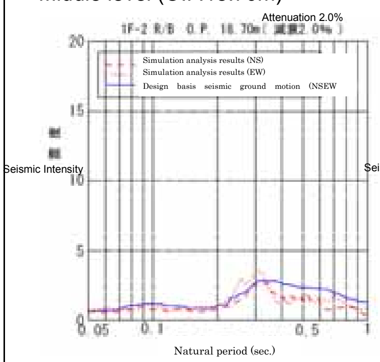
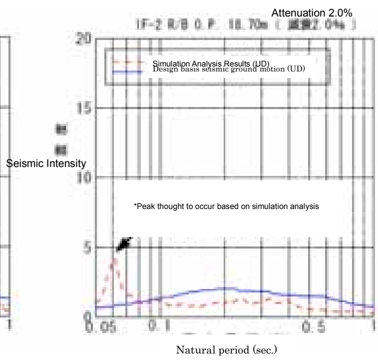
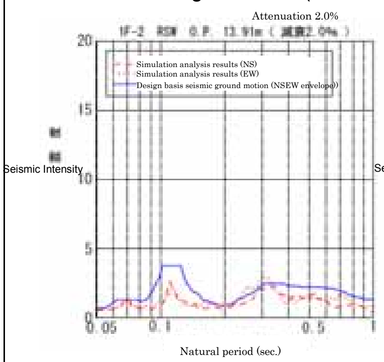
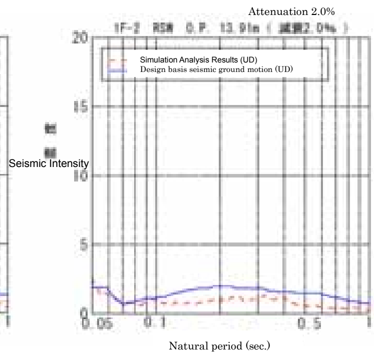
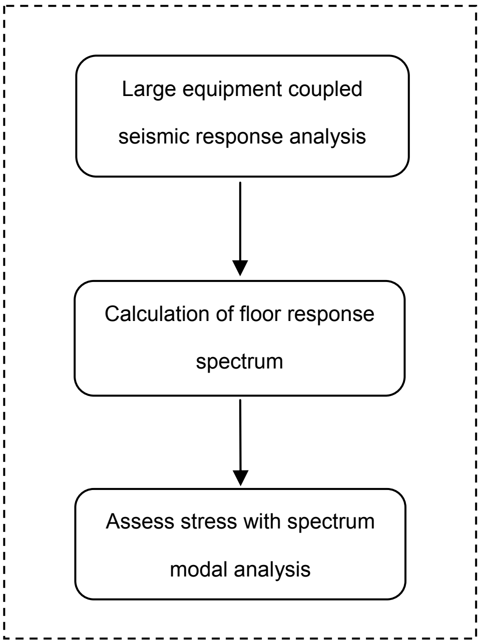


Figure 4. Example of large equipment coupled seismic response analysis model

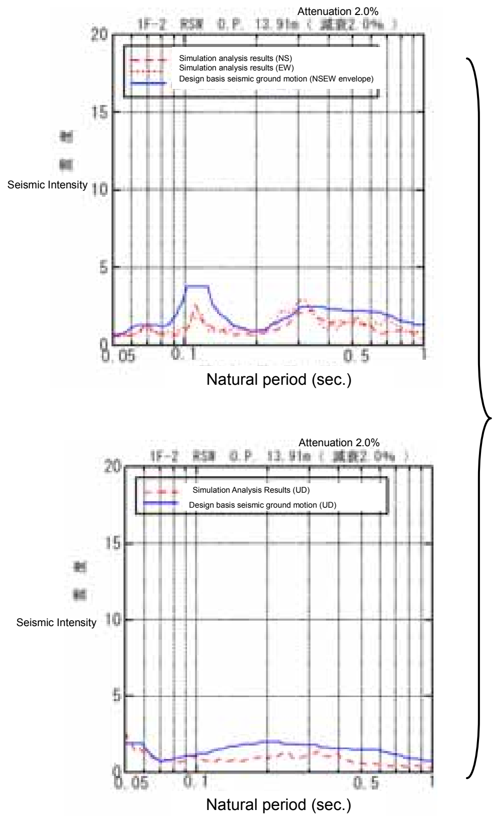
Table 1. Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 2)

Facility		Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	4960	5110	RPV (foundation bolt) Calculated value: 29MPa Assessment standard value: 222MPa
		Moment	(kN・m)	22500	25600	
		Axial force	(kN)	5710	4110	
	PCV foundation	Shear force	(kN)	7270	8290	PCV (drywell) Calculated value: 87MPa Assessment standard value: 278MPa
		Moment	(kN・m)	124000	153000	
		Axial force	(kN)	3110	2350	
	Core shroud foundation	Shear force	(kN)	2590	3950	Core support structure (shroud support) Calculated value:122MPa Assessment standard value:300MPa
		Moment	(kN・m)	13800	21100	
		Axial force	(kN)	760	579	
	Fuel assembly	Relative displacement	(mm)	16.5	33.2	Control rods (insertability) Assessment standard value:40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.97	1.21	RHR cooling system pump (motor bolt) Calculated value: 45MPa Assessment standard value: 185MPa
		Seismic intensity (vertical)	(G)	0.56	0.70	
	Base mat	Seismic intensity (horizontal)	(G)	0.54	0.68	
		Seismic intensity (vertical)	(G)	0.52	0.37	
Floor response spectrum (R/B)	＜Middle level (O.P.18.70m)＞  (horizontal)  (vertical)						Main steam piping Calculated value: 208MPa Assessment standard value: 360MPa RHR piping Calculated value: 87MPa Assessment standard value: 315MPa
Floor response spectrum (R/B shielding wall)	＜Reactor shielding wall base (O.P.13.91 m)＞  (horizontal)  (vertical)						

(Reference) Overview of seismic performance assessment
(Example of main steam piping)



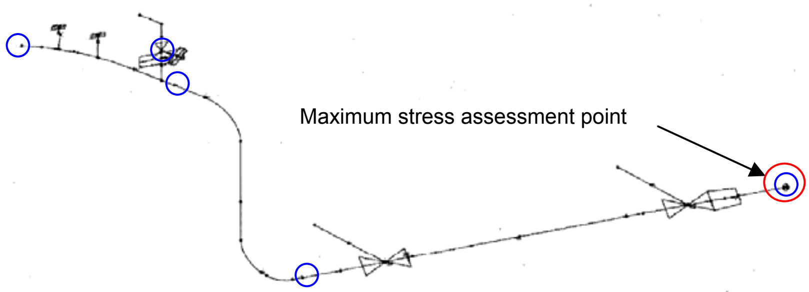
Assessment flow



Floor response spectrum

The values for the earthquake was mostly below the values for the design basis seismic ground motion Ss, and only some values for the earthquake exceeded design basis seismic ground motion Ss values.

*Input image of anchor and supports (blue lines in the figure)



Main steam piping model (portion)

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	288	360	Detailed	Primary	208	360	Detailed

Fukushima Daiichi Nuclear Power Station Unit 3 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the Reactor Building (R/B) base mat. Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 3.The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on July 28, 2011.

*Written order
"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 3 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.17×10^{-3} (E-W direction, fifth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure 2, 3).

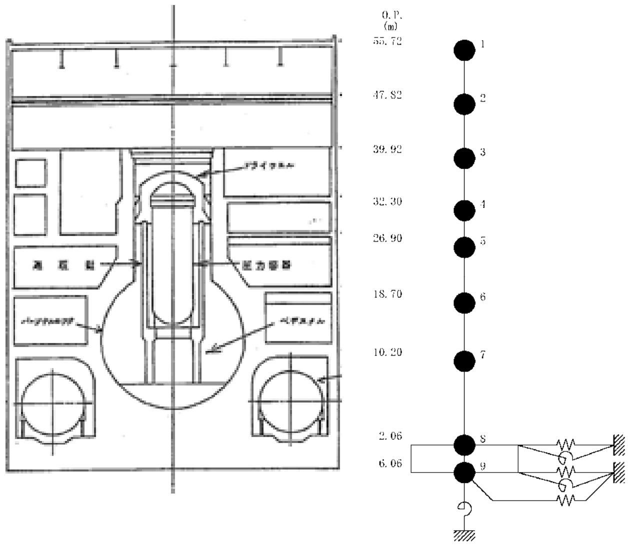


Figure 1. Unit 3 R/B (model drawing)

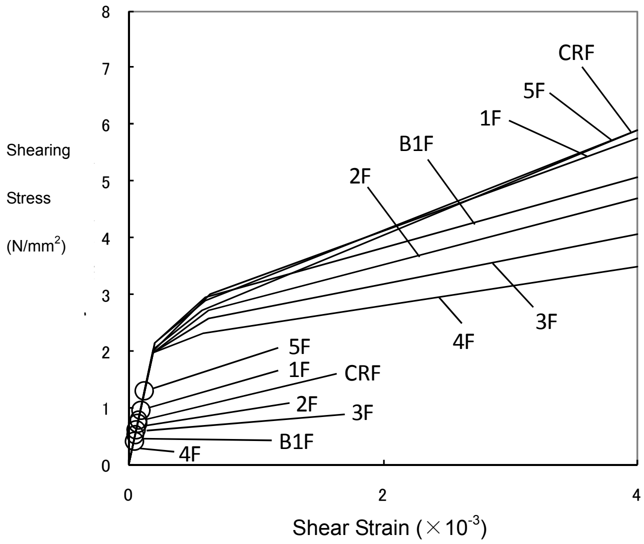


Figure 2. Shear strain of seismic wall (N-S)

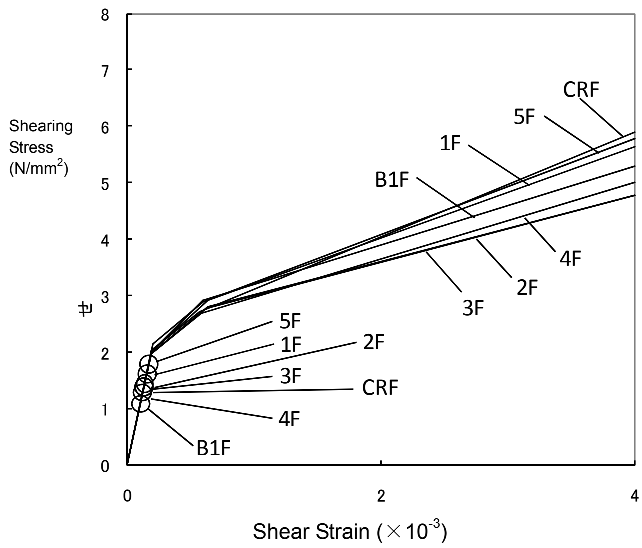
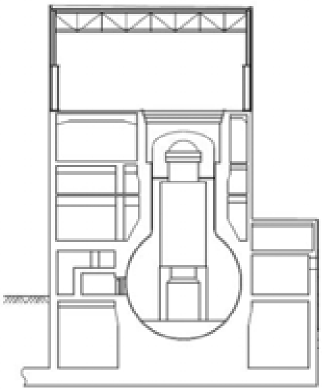


Figure 3. Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 3, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake partially exceeded some of such figures from the seismic safety analysis. However, the seismic performance of major facilities with safety-critical functions such as “shutting down” and “cooling down" the reactor, as well as "confining inside" radioactive material was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table 1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.



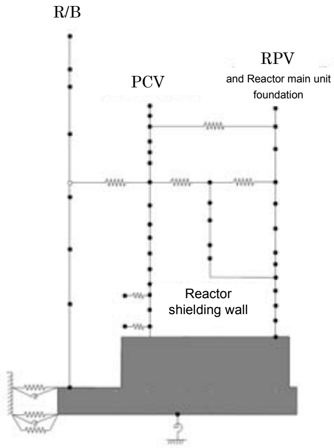
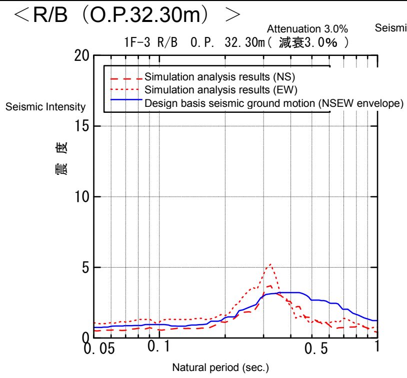
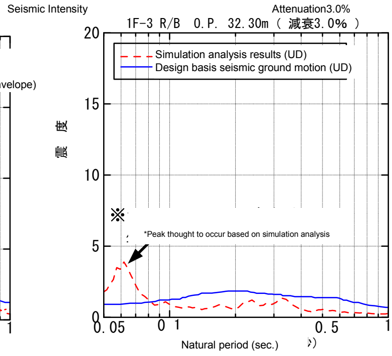
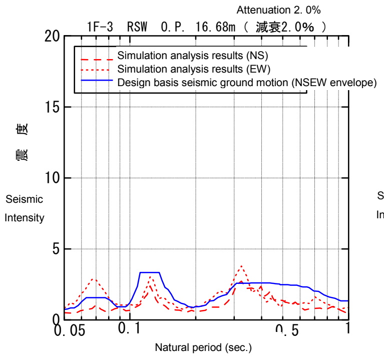
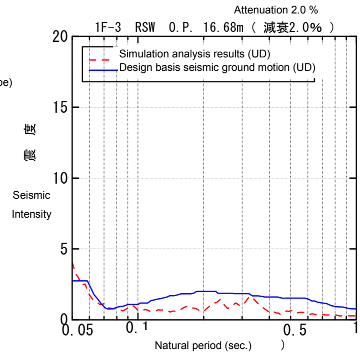


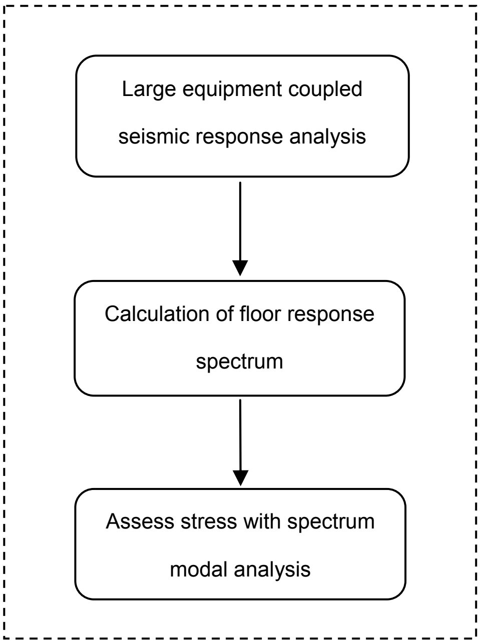
Figure 4. Example of large equipment coupled seismic response analysis model

Table 1. Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 3)

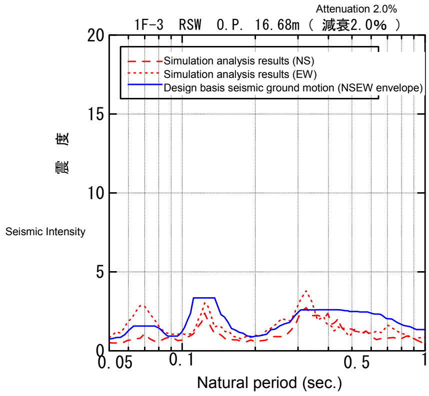
<table>
<tr><th colspan="2">Facility</th><th>Seismic response load</th><th>Design basis seismic ground motion Ss</th><th>Simulation calculated result</th><th>Seismic performance assessment result</th></tr>
<tr><td rowspan="10">Seismic load and others</td><td rowspan="3">RPV foundation</td><td>Shear force (kN)</td><td>4970</td><td>5750</td><td rowspan="3">RPV
(foundation bolt)
Calculated value: 50MPa
Assessment standard value: 222MPa</td></tr>
<tr><td>Moment (kN・m)</td><td>30400</td><td>41700</td></tr>
<tr><td>Axial force (kN)</td><td>5780</td><td>4900</td></tr>
<tr><td rowspan="3">PCV foundation</td><td>Shear force (kN)</td><td>7070</td><td>8150</td><td rowspan="3">PCV
(drywell)
Calculated value: 158MPa
Assessment standard value: 278MPa</td></tr>
<tr><td>Moment (kN・m)</td><td>123000</td><td>153000</td></tr>
<tr><td>Axial force (kN)</td><td>2930</td><td>2080</td></tr>
<tr><td rowspan="3">Core shroud foundation</td><td>Shear force (kN)</td><td>2440</td><td>3010</td><td rowspan="3">Core support structure
(shroud support)
Calculated value:100MPa
Assessment standard value:300MPa</td></tr>
<tr><td>Moment (kN・m)</td><td>13600</td><td>16600</td></tr>
<tr><td>Axial force (kN)</td><td>783</td><td>681</td></tr>
<tr><td>Fuel assembly</td><td>Relative displacement (mm)</td><td>14.8</td><td>24.1</td><td>Control rods (insertability)
Assessment standard value:40.0mm</td></tr>
<tr><td rowspan="4">Seismic intensity for assessment</td><td rowspan="2">Refueling floor</td><td>Seismic intensity (horizontal) (G)</td><td>0.95</td><td>1.34</td><td rowspan="4">RHR cooling system pump
(motor bolt)
Calculated value: 42MPa
Assessment standard value: 185MPa</td></tr>
<tr><td>Seismic intensity (vertical) (G)</td><td>0.57</td><td>0.81</td></tr>
<tr><td rowspan="2">Base mat</td><td>Seismic intensity (horizontal) (G)</td><td>0.55</td><td>0.61</td></tr>
<tr><td>Seismic intensity (vertical) (G)</td><td>0.53</td><td>0.29</td></tr>
<tr><td>Floor response spectrum (R/B)</td><td colspan="4"><R/B（O.P.32.30m）>

(horizontal)

(vertical)</td><td rowspan="2">Main steam piping
Calculated value: 151MPa
Assessment standard value: 378MPa

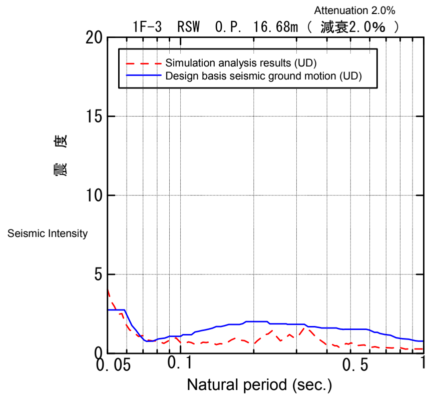
RHR piping
Calculated value: 269MPa
Assessment standard value: 363MPa</td></tr>
<tr><td>Floor response spectrum (R/B shielding wall)</td><td colspan="4"><Reactor shielding wall (O.P.16.68 m)>

(horizontal)

(vertical)</td></tr>
</table>

(Reference 1) Overview of seismic performance assessment
(Example of main steam piping)

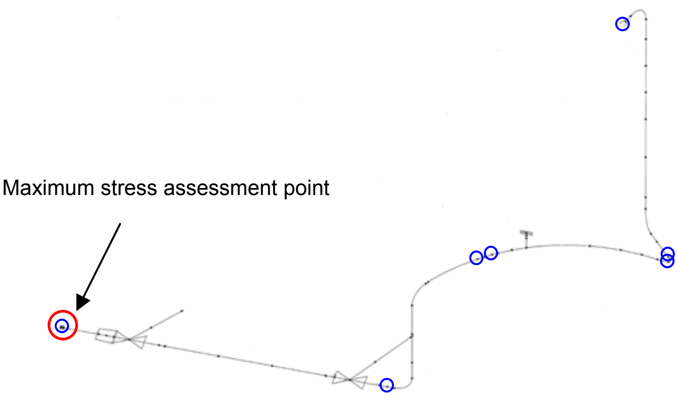


Assessment flow





Floor response spectrum



※Input image of anchor and supports (blue lines in the figure)

Main steam piping model (portion)

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	183	417※	Detailed	Primary	151	378※	Detailed

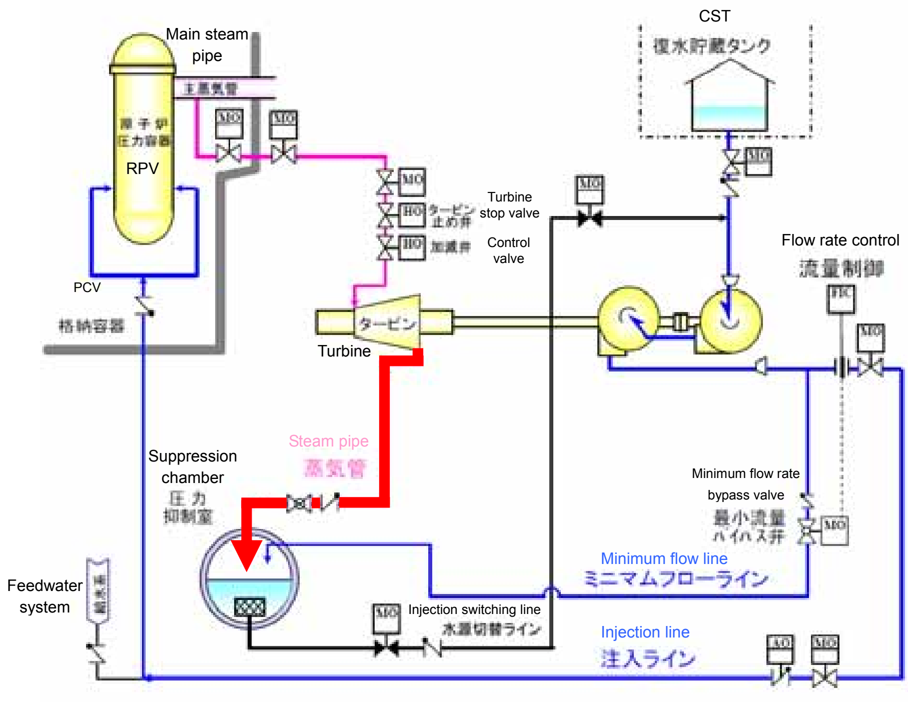
※ : Since the material of piping at the maximum stress assessment point (point with minimum margin) is different for the assessment of design basis seismic ground motion Ss and the recent March 11 earthquake, the assessment standard value is different

(Reference 2) Seismic performance assessment of high-pressure coolant injection piping

Seismic performance was assessed for Unit 3 high-pressure coolant injection (HPCI) piping (steam pipes) using the floor response spectrum defined based on the R/B simulation analysis at this time.
The results verified that the calculated values were sufficiently below the assessment standard value for this earthquake.

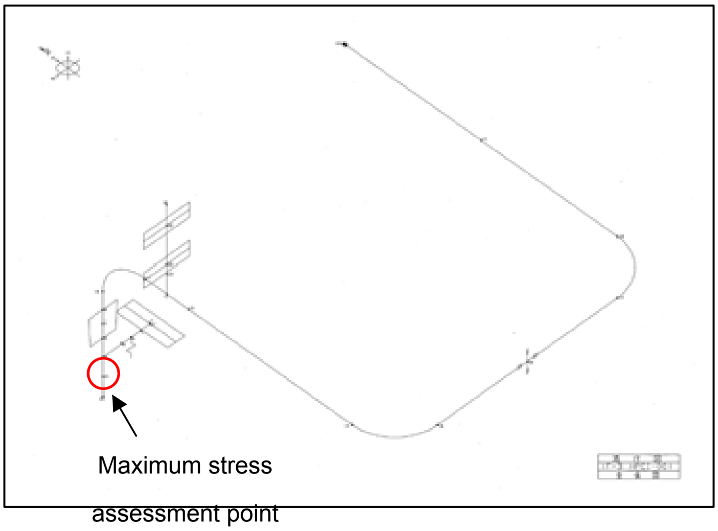
Results of seismic performance assessment for HPCI piping

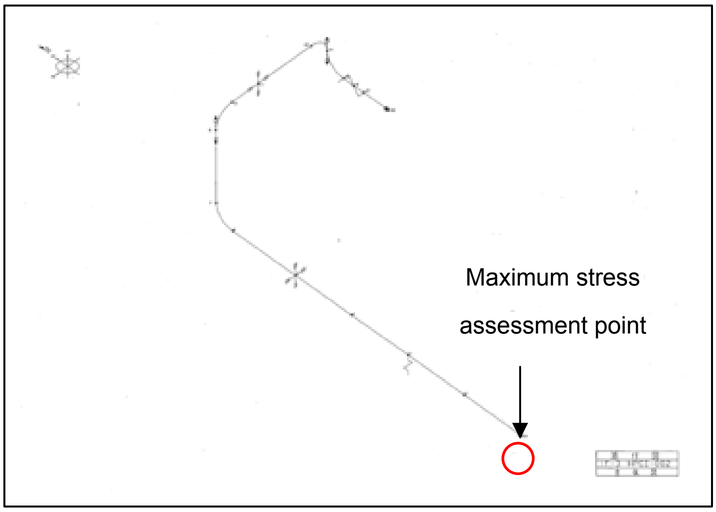
Analysis model	Calculated value (MPa)	Assessment standard value (MPa)	Stress ratio (Calculated value/ Assessment standard value)
HPCI-001	113	335	0.34
HPCI-002	52	335	0.16
HPCI-003	75	335	0.22

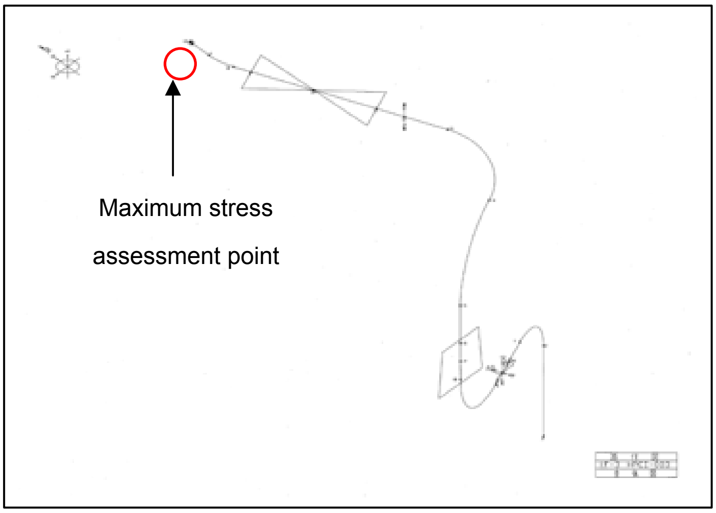


▬ : Assessed pipes

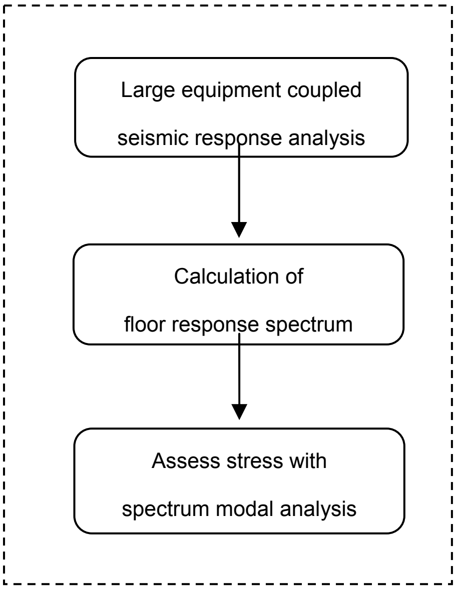
Schematic system drawing of the HPCI system



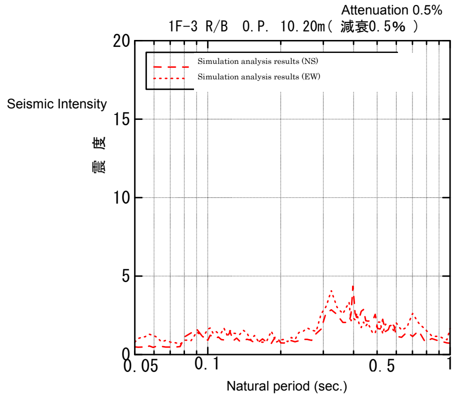




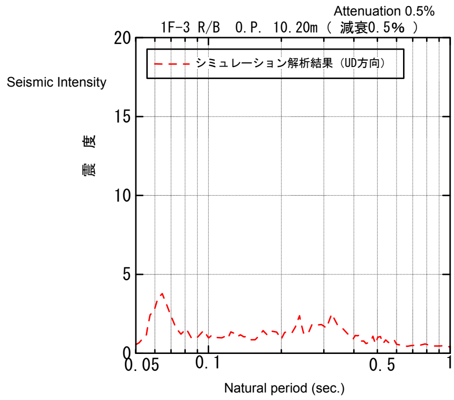
HPCI piping analysis model
(From top: HPCI-001, HPCI-002, HPCI-003)



Assessment flow



Simulation Analysis Results (UD)



Overview of seismic performance assessment for HPCI piping

Fukushima Daiichi Nuclear Power Station Unit 4 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the Reactor Building (R/B) base mat. Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 4. The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on June 17, 2011.

*Written order

" Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 4 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.15×10^{-3} (E-W direction, fifth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point (Figure 2, 3).

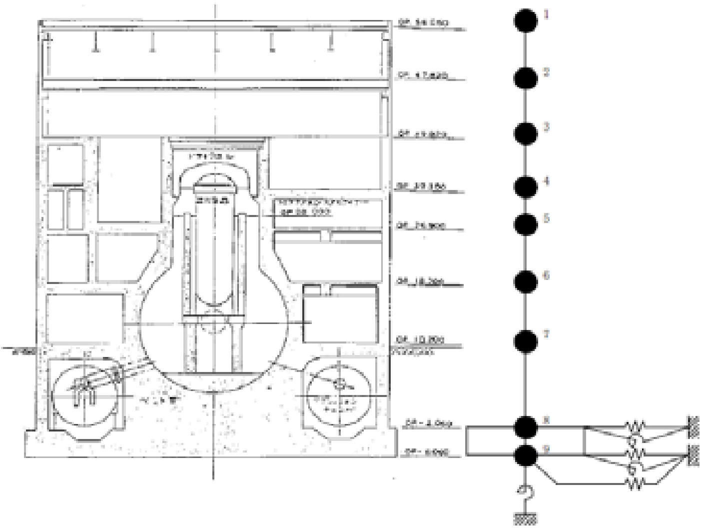


Figure 1. Unit 4 R/B (model drawing)

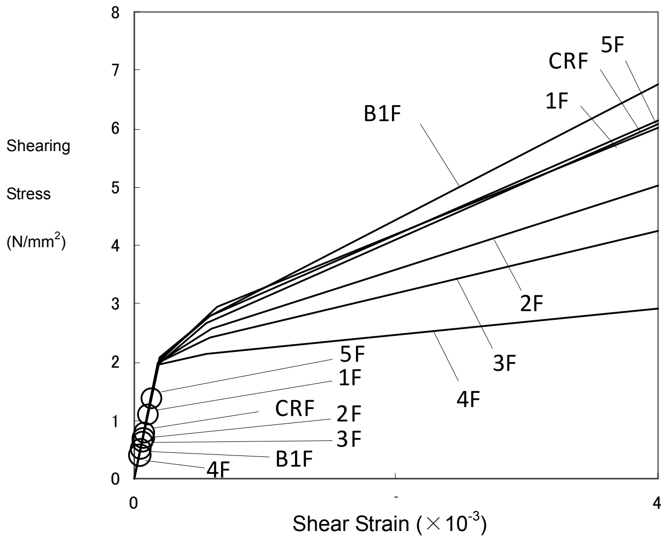


Figure 2. Shear strain of seismic wall (N-S)

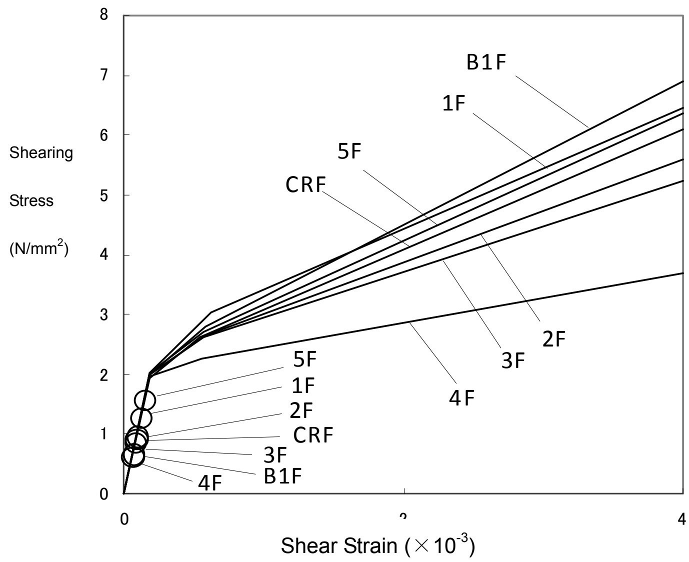


Figure 3. Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 4, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, were below the figures from the seismic safety analysis. The seismic performance of the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table-1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

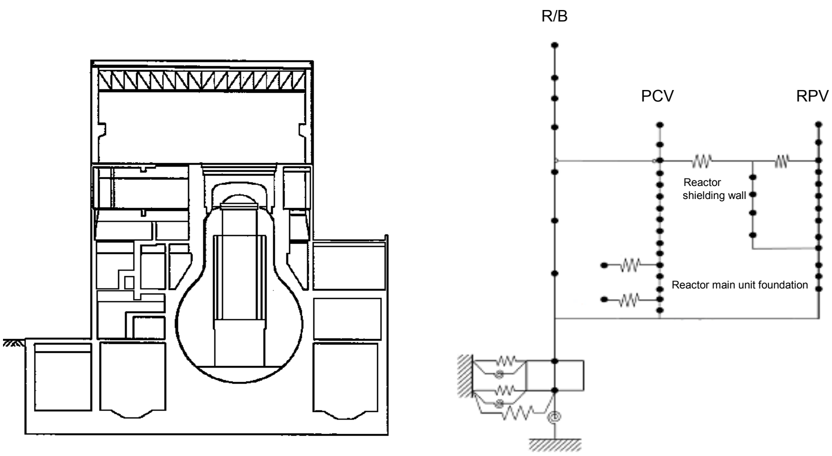
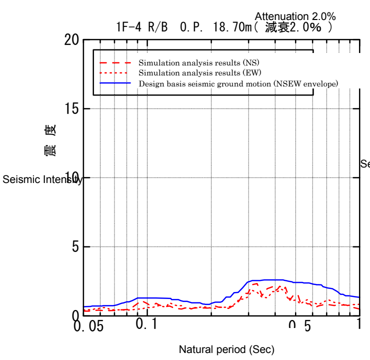
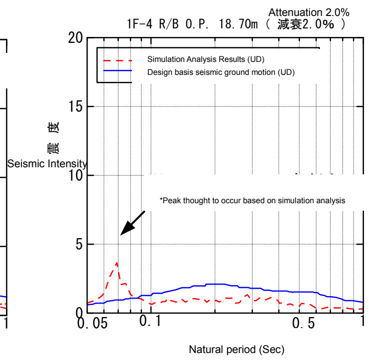
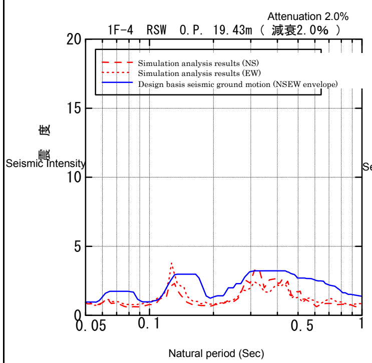
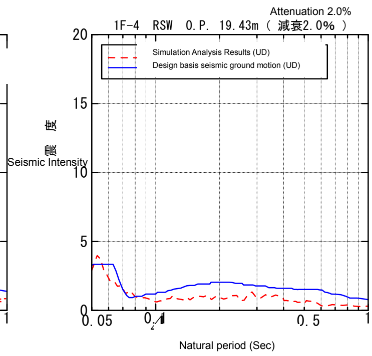
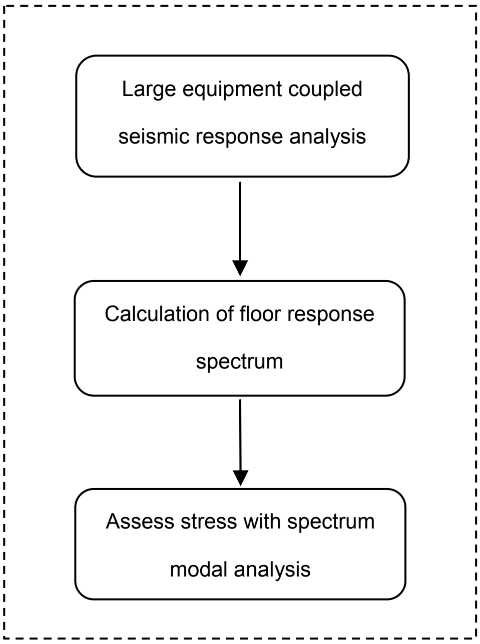


Figure 4. Example of large equipment coupled seismic response analysis model

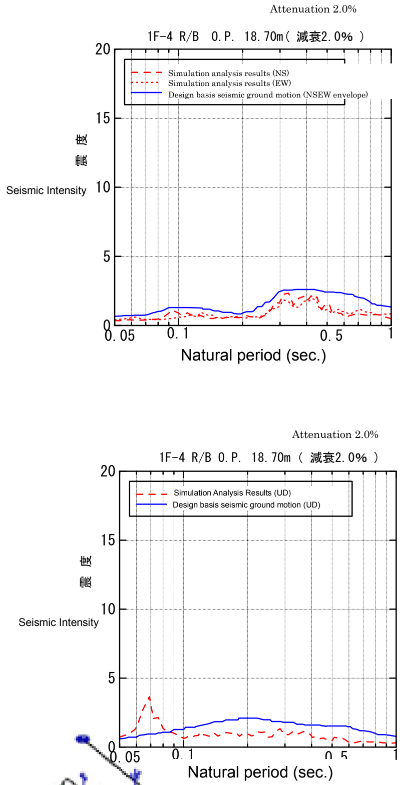
Table 1. Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 4)

Facility		Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	4790	4000	RPV (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	38900	28000	
		Axial force	(kN)	6660	6020	
	PCV foundation	Shear force	(kN)	6840	4910	PCV (drywell) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	113000	79900	
		Axial force	(kN)	2460	1170	
	Core shroud foundation	Shear force	(kN)	No core shroud as it was undergoing replacement work at the time of earthquake		—
		Moment	(kN・m)			
		Axial force	(kN)			
	Fuel assembly	Relative displacement	(mm)	All fuel assemblies were removed as Unit 4 was undergoing the outage at the time of earthquake		—
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.96	0.68	RHR cooling system pump (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Seismic intensity (vertical)	(G)	0.58	0.71	
	Base mat	Seismic intensity (horizontal)	(G)	0.55	0.39	
		Seismic intensity (vertical)	(G)	0.52	0.25	
Floor response spectrum (R/B)	<Middle level (O.P.18.70m)>  (horizontal)  (vertical)					Main steam piping **Assessment unnecessary as piping is isolated as part of the safety measures for the shroud replacement work** RHR piping Calculated value: 124MPa Assessment standard value: 335MP
Floor response spectrum (R/B shielding wall)	<Reactor shielding wall (O.P.19.43m)>  (horizontal)  (vertical)					

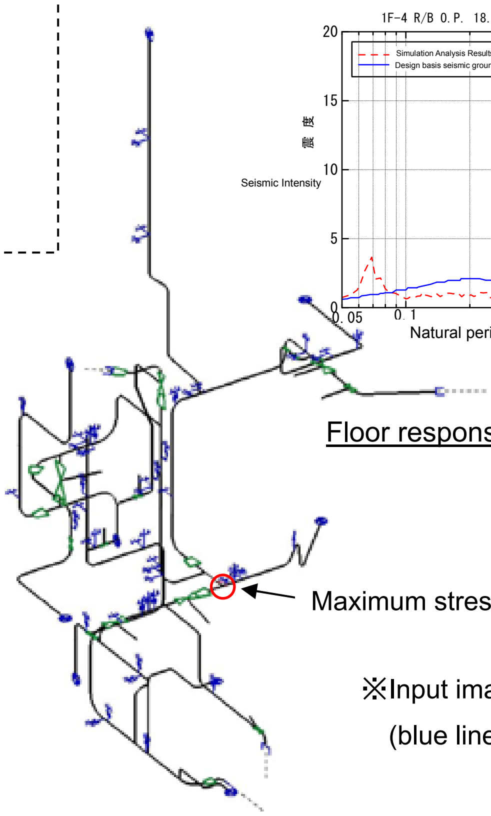
(Reference) Overview of seismic performance assessment
(Example of RHR piping)



Assessment flow



Floor response spectrum



Maximum stress assessment point

※Input image of anchor and supports (blue lines in the figure)

RHR piping model

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
RHR piping	Piping itself	Primary	137※	335※	Detailed	Primary	124※	335※	Detailed

※Since the part assessed in the Interim Report had its functions stopped as part of safety measures, at the time of the earthquake, this assessment was made with a different piping model. The comparison of the assessment results is only for reference.

Fukushima Daiichi Nuclear Power Station Unit 5 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 5.The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on August 18, 2011.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 5 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.36×10^{-3} (E-W direction, fifth floor) and that the stress and deformation conditions for all seismic walls, excluding those in the E-W direction on the crane floor and fifth floor, were at or below the first flexion point on the skeleton curve (Figure 2, 3).

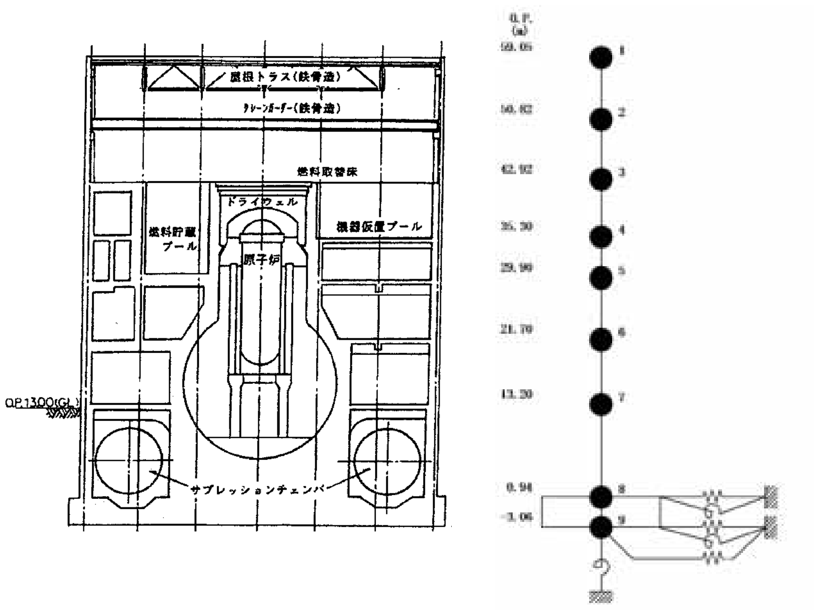


Figure 1. Unit 5 R/B (model drawing)

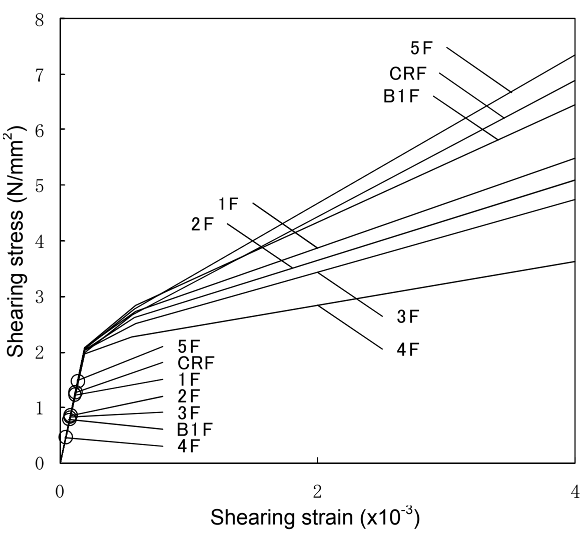


Figure 2. Shear strain of seismic wall (N-S)

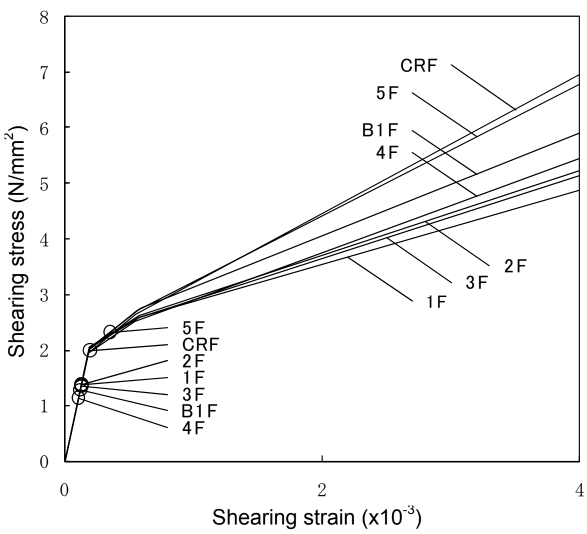


Figure 3. Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 5, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake partially exceeded some of such figures from the seismic safety analysis. However, the seismic performance of major facilities with safety-critical functions such as "shutting down" and "cooling down" the reactor, as well as "confining inside" radioactive material was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table 1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

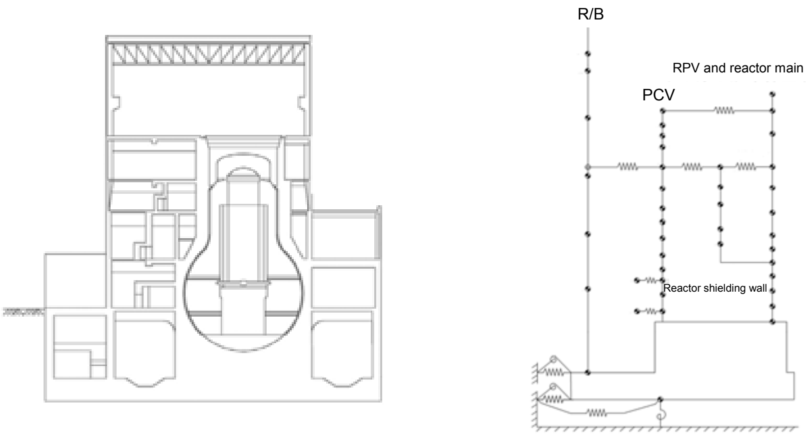
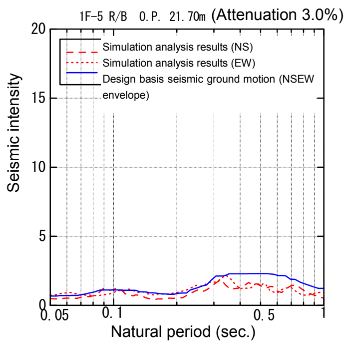


Figure 4. Example of large equipment coupled seismic response analysis model

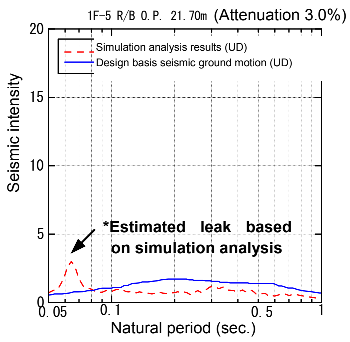
Table 1. Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 5)

Facility		Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	5200	6830	RPV (foundation bolt) Calculated value: 53MPa Assessment standard value: 222MPa
		Moment	(kN・m)	32200	43500	
		Axial force	(kN)	5940	5060	
	PCV foundation	Shear force	(kN)	8290	8830	PCV (drywell) **<u>PCV boundary unnecessary to maintain function because of open vessel</u>**
		Moment	(kN・m)	150000	169000	
		Axial force	(kN)	3320	1820	
	Core shroud foundation	Shear force	(kN)	2640	2820	Core support structure (shroud support) Calculated value: 84MPa Assessment standard value: 300MPa
		Moment	(kN・m)	16600	15700	
		Axial force	(kN)	754	842	
	Fuel assembly	Relative displacement	(mm)	All control rods were inserted as Unit 5 was undergoing the outage at the time of earthquake		—
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.94	1.17	RHR cooling system pump (motor bolt) Calculated value: 44MPa Assessment standard value: 185MPa
		Seismic intensity (vertical)	(G)	0.55	0.68	
	Base mat	Seismic intensity (horizontal)	(G)	0.56	0.67	
		Seismic intensity (vertical)	(G)	0.53	0.32	
Floor response spectrum (R/B)	< R/B (O.P.21.70m) >					Main steam piping Calculated value: 244MPa Assessment standard value: 417MPa RHR piping Calculated value: 189MPa Assessment standard value: 364MPa

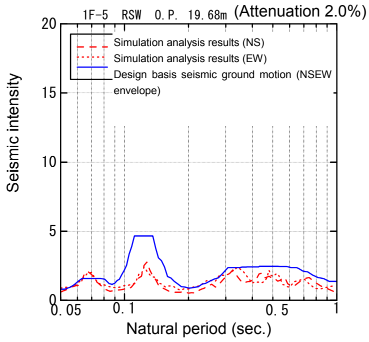
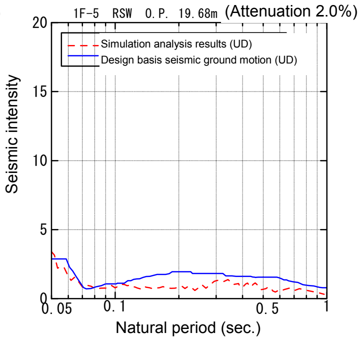
< R/B (O.P.21.70m) >



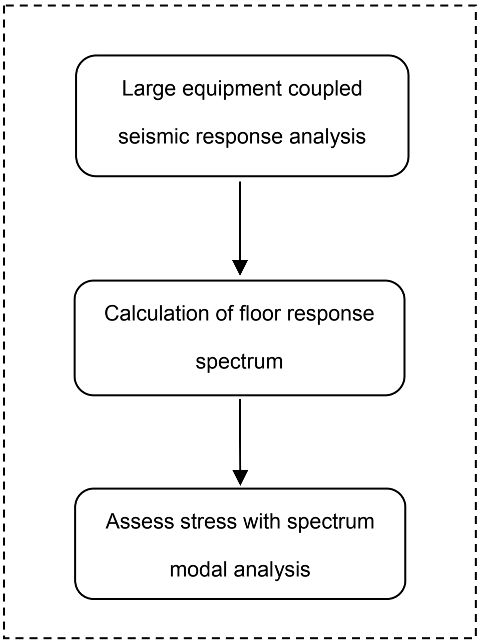
(horizontal)



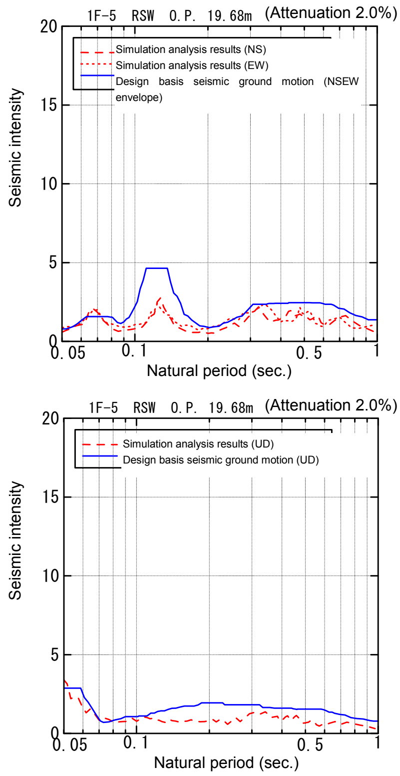
(vertical)

Floor response spectrum (R/B shielding wall)	< Reactor shielding wall (O.P.19.68m) >  (horizontal)  (vertical)	

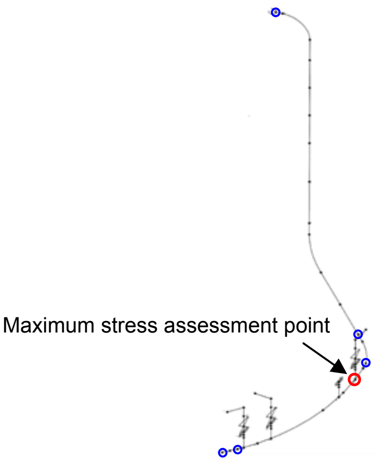
(Reference) Overview of seismic performance assessment
(Example of main steam piping)



Assessment flow



Floor response spectrum



*Input image of anchor and supports (blue lines in the figure)

Main steam piping model (portion)

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	356	417	Detailed	Primary	244	417	Detailed

Fukushima Daiichi Nuclear Power Station Unit 6 Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daiichi NPS Unit 6.The analysis results for R/B and equipment and piping systems important to seismic safety were reported to NISA on August 18, 2011.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daiichi NPS Unit 6 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model is defined that would adequately express the characteristics of the buildings, structures and ground (Figure 1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.16×10^{-3} (E-W direction, fourth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure 2, 3).

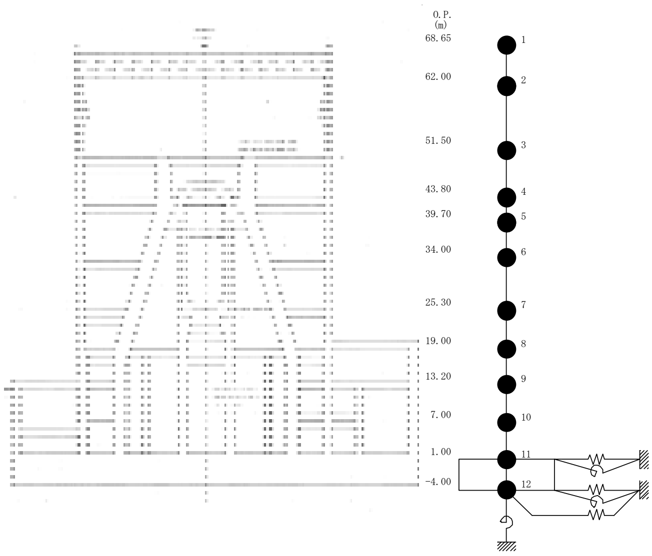


Figure 1 Unit 6 R/B (model drawing)

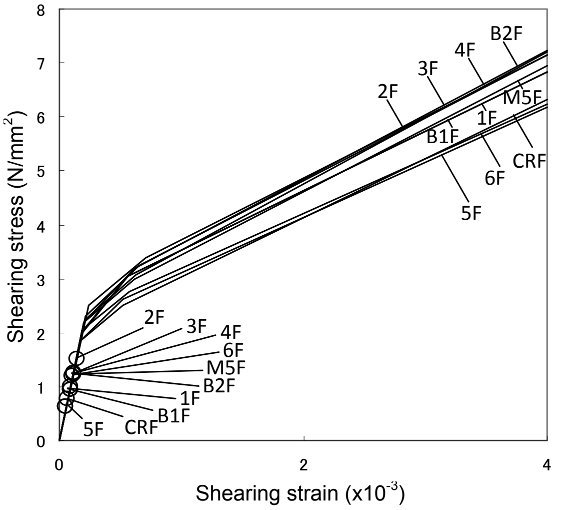


Figure 2 Shear strain of seismic wall (N-S)

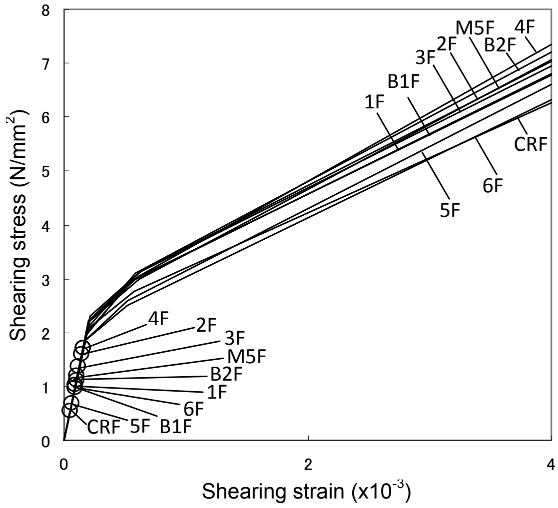


Figure 3 Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daiichi NPS Unit 6, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, were below the figures from the seismic safety analysis. The seismic performance of the main steam system piping and the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table 1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

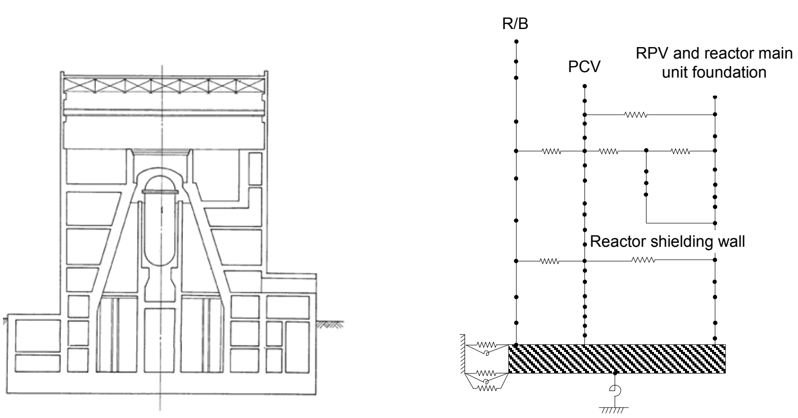
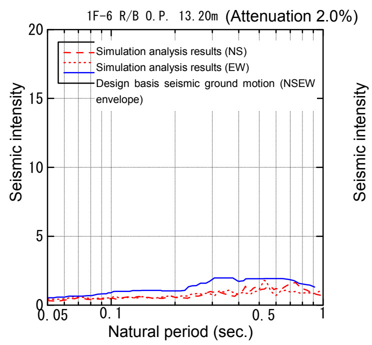
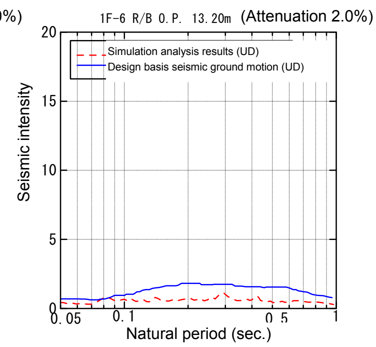


Figure 4 Example of large equipment coupled seismic response analysis model

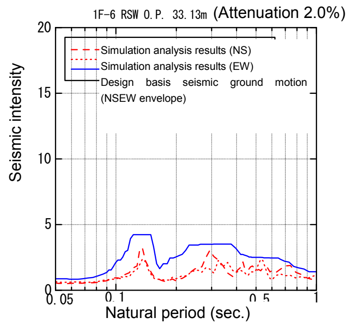
Table 1 Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daiichi NPS Unit 6)

<table>
<tr><th colspan="2">Facility</th><th colspan="2">Seismic response load</th><th>Design basis seismic ground motion Ss</th><th>Simulation calculated result</th><th>Seismic performance assessment result</th></tr>
<tr><td rowspan="10">Seismic load and others</td><td rowspan="3">RPV foundation</td><td>Shear force</td><td>(kN)</td><td>5260</td><td>3950</td><td rowspan="3">RPV
(foundation bolt)
Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss</td></tr>
<tr><td>Moment</td><td>(kN・m)</td><td>18500</td><td>11700</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>9470</td><td>5930</td></tr>
<tr><td rowspan="3">PCV foundation</td><td>Shear force</td><td>(kN)</td><td>21400</td><td>17700</td><td rowspan="3">PCV
(drywell)
PCV boundary unnecessary to maintain function because of open vessel</td></tr>
<tr><td>Moment</td><td>(kN・m)</td><td>403000</td><td>314000</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>5570</td><td>3200</td></tr>
<tr><td rowspan="3">Core shroud foundation</td><td>Shear force</td><td>(kN)</td><td>6110</td><td>3880</td><td rowspan="3">Core support structure
(shroud support)
Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss</td></tr>
<tr><td>Moment</td><td>(kN・m)</td><td>36000</td><td>23800</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>1190</td><td>882</td></tr>
<tr><td>Fuel assembly</td><td>Relative displacement</td><td>(mm)</td><td colspan="2">All control rods were inserted as Unit 6 was undergoing the outage at the time of earthquake</td><td>—</td></tr>
<tr><td rowspan="4">Seismic intensity for assessment</td><td rowspan="2">Refueling floor</td><td>Seismic intensity (horizontal)</td><td>(G)</td><td>1.14</td><td>0.71</td><td rowspan="4">RHR cooling system pumps
(motor bolt)
Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss</td></tr>
<tr><td>Seismic intensity (vertical)</td><td>(G)</td><td>0.67</td><td>0.41</td></tr>
<tr><td rowspan="2">Base mat</td><td>Seismic intensity (horizontal)</td><td>(G)</td><td>0.55</td><td>0.53</td></tr>
<tr><td>Seismic intensity (vertical)</td><td>(G)</td><td>0.51</td><td>0.20</td></tr>
<tr><td>Floor response spectrum (R/B)</td><td colspan="5"><R/B (O.P.13.20m)>

(Horizontal)

(Vertical)</td><td>Main steam piping
Calculated value: 211MPa
Assessment standard value: 375MPa

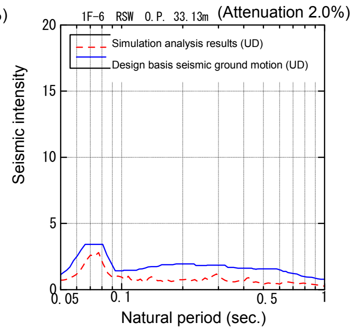
RHR piping
Calculated value: 88MPa
Assessment standard value: 335MPa</td></tr>
</table>

Floor response spectrum (R/B shielding wall)

<Reactor shielding wall (O.P.33.13m)>

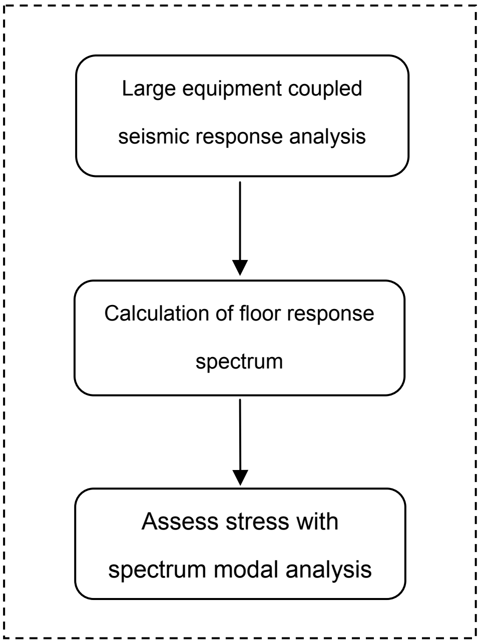


(Horizontal)

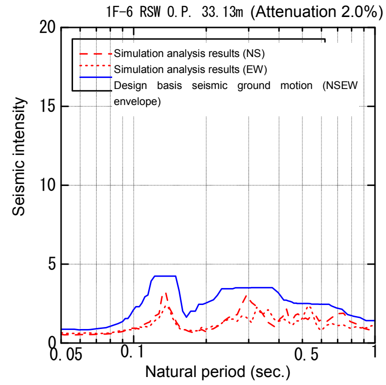


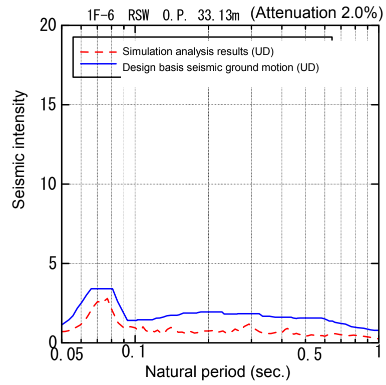
(Vertical)

(Reference) Overview of seismic performance assessment (Example of main steam piping)

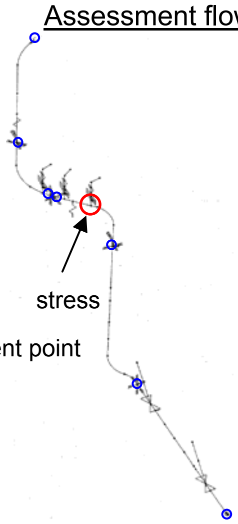


Assessment flow





Floor response spectrum



Maximum stress assessment point

*Input image of anchor and supports (blue lines in the figure)

Main steam piping model (portion)

Structural Strength Assessment Results

Target facility	Assessed part	Stress type				Calculated value (MPa)			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	292	375	Detailed	Primary	211	375	Detailed

Partial Unrecorded Observation Records for the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake at Fukushima Daiichi Nuclear Power Station

For the Reactor Building (R/B) of Fukushima Daiichi Nuclear Power Station (NPS) Units 1 to 6, seismic response analysis was performed using the observation records obtained during the Tohoku-Chihou-Taiheiyo-Oki Earthquake. From the analysis, it can be assumed that major facilities with safety-critical functions maintained conditions that ensured safety functions during the earthquake and immediately afterwards.

Some of the observation records obtained at Fukushima Daiichi NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake stopped from about 130sec. to 150sec. after it started to record due to deficiency with the system that records seismometer data.

However, although time history data was not available during and after the unrecorded period for observation points on the R/B base mat, it has been verified that the maximum acceleration at these observation points occurred within the time period when time history data was recorded (See Reference-1).

In addition, for Fukushima Daiichi Unit 6, there were two observation points located close to one another on the R/B base mat, which provided both records with and without missing data. It has been confirmed that the maximum acceleration and response spectrum are roughly the same for both (See Reference-2). .
Based on the above, it is believed that there is no problem posed by the content of the assessment regardless of the fact that there was missing data.

(Reference 1)
Verification of maximum acceleration for seismic observation records on Reactor Building base mat of Fukushima Daiichi Nuclear Power Station

Observation records for Fukushima Daiichi Units 1 to 6 Reactor Building (R/B) base mats stopped between 130sec. to 150sec. after they started to record the main earthquake. However, based on the results of investigations and considerations as shown below, it is believed that the maximum acceleration occurred within the time range where time histories are available for all units.

- The specifications of the seismic observation devices installed on the base mat allow the maximum acceleration data to be transmitted and recorded separate from the time history data. During the main earthquake, system deficiency caused time history data to remain unrecorded during and after the unrecorded period; however, it recorded the maximum acceleration after the unrecorded period, thus those values were examined.
- For the main earthquake, maximum acceleration up to unrecorded period (Record①) and maximum acceleration after the unrecorded period (Record②) were obtained. Such maximum accelerations obtained are indicated in Table-1.1.
- Figure-1.1. indicates the time range for which Record① and Record② was obtained. The time range for which Record② was obtained started 30 seconds before the unrecorded period. Within these 30 seconds, there is an overlap between Record① and Record② in terms of the time range.
- As shown in Figure-1.1, it is possible to categorize the size relationships of Record① and ②into Group A, B, C from the time at which maximum acceleration is recorded. The maximum acceleration observations points categorized as Group A or B occurs within the time range for which time history data was recorded.
- Table-1.2 indicates the categorization results for each observation point. From Table 1-2, it can be verified that all observation points are categorized as A or B, and as indicated in Figure-1.2 and 1.3, the maximum acceleration value occurred within the time range for which time history data was available.

Table-1.1 Maximum acceleration of main earthquake on R/B base mat

(Units:Gal)

Unit	Observation point name	Max. acceleration up to unrecorded period (Record①)			Max. acceleration after unrecorded period (Record②)		
		NS	EW	Vertical	NS	EW	Vertical
1	1-R2	460.3	447.5	258.3	460.3	447.5	258.3
2	2-R2	348.3	549.8	302.0	348.3	549.8	302.0
3	3-R2	321.9	507.0	231.0	321.9	507.0	224.3
4	4-R2	280.7	319.0	199.6	280.7	319.0	199.6
5	5-R2	311.1	547.4	255.7	311.1	547.4	255.7
6	6-R2	298.1	443.8	170.7	298.1	443.8	170.7

Note: The maximum accelerations indicated in the above table are preliminary values before baseline correction, therefore, the values are different from those in the “Report of Analysis of Observed Seismic Data Collected at Fukushima Daiichi NPS Pertaining to the Tohoku-Taiheiyo-Oki Earthquake” (submitted May 16, 2011) due to correction and rounding.

Table-1.2 Categorization by comparing Record① and Record②

Unit	Observation point name	Category of time when maximum acceleration occurred		
		NS	EW	Vertical
1	1-R2	B	B	B
2	2-R2	B	B	B
3	3-R2	B	B	A
4	4-R2	B	B	B
5	5-R2	B	B	B
6	6-R2	B	B	B

<Legend>

A: Record①>Record②　Maximum acceleration occurred within the time range for which time history data was recorded.

B: Record①＝Record② Maximum acceleration occurred within the time range for which time history data was recorded.

C: Record①<Record② Maximum acceleration occurred outside of the time range for which time history data was recorded.

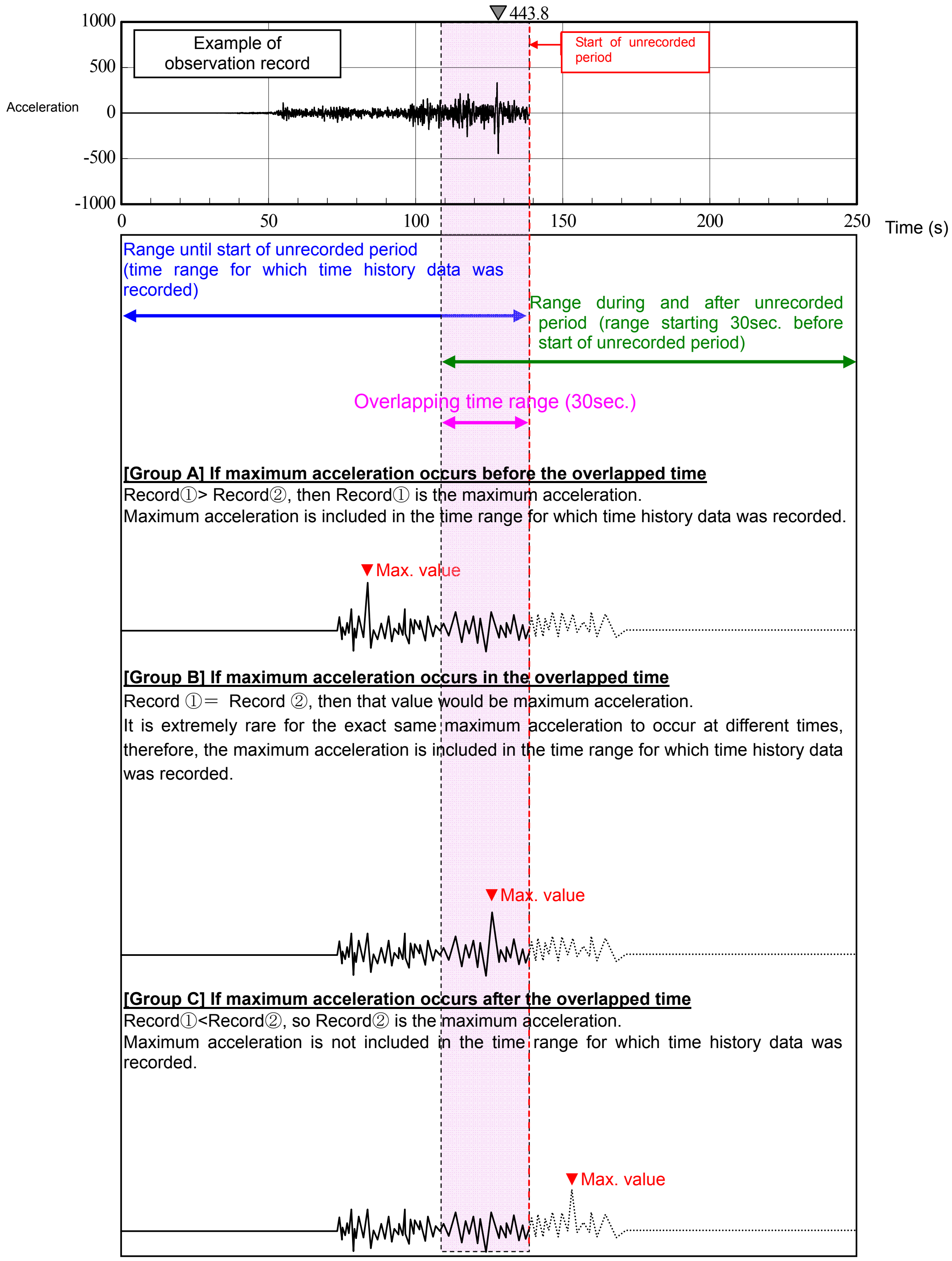


Figure-1.1 Time range for Record ① and ② and categorization by time when maximum acceleration occurred

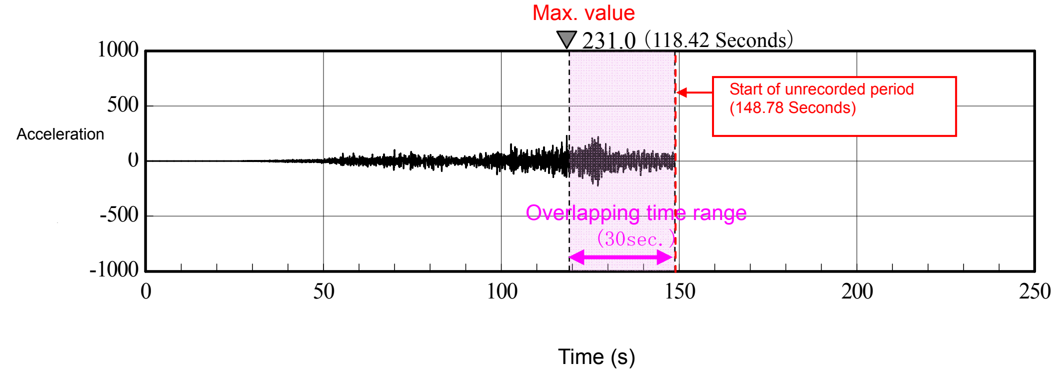


Figure-1.2 Group A Record (observation point 3-R2, vertical direction)

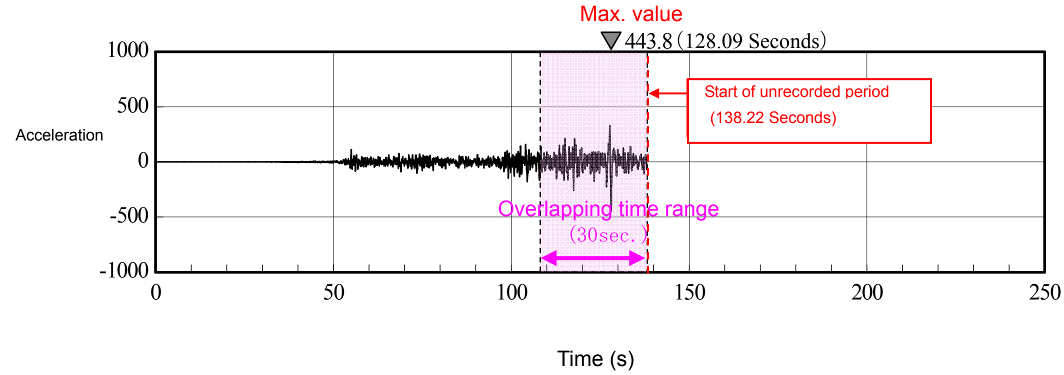


Figure-1.3 Group B Record
(Example of observation point 6-R2, east-west direction)

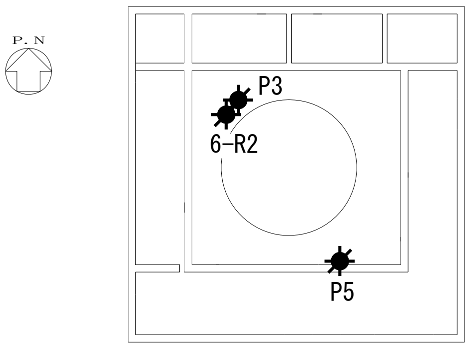
(Reference 2)
Comparison of seismic observation records from
Unit 6 Reactor Building base mat of Fukushima Daiichi Nuclear Power Station

Some of the observation records obtained at Fukushima Daiichi Nuclear Power Station (NPS) during the Tohoku-Chihou-Taiheiyo-Oki Earthquake stopped from about 130sec. to 150sec. after it started to record due to deficiency with the system that records seismometer data.

For observation point 6-R2 on the Unit 6 Reactor Building (R/B) base mat, whose observation records ceased in the middle, complete records were available for observation point P3 which was located nearby. Therefore, these two records were compared. The seismometer layout for Unit 6 R/B base mat is indicated in Figure-2.1.

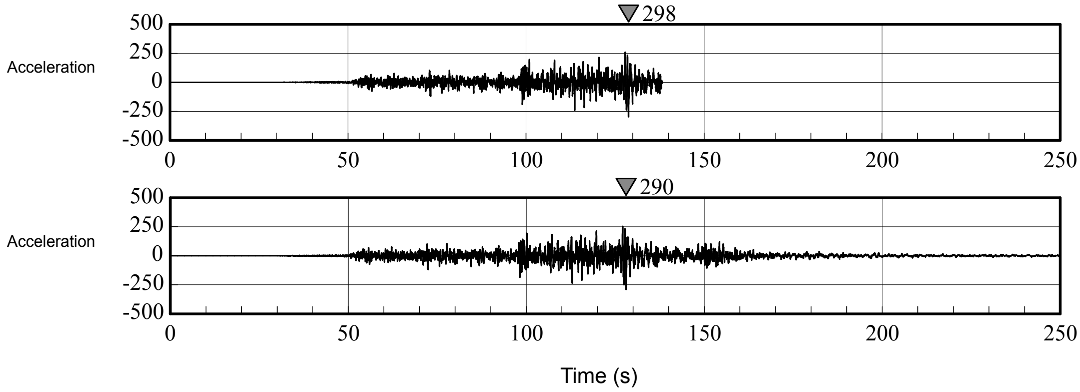
Figure-2.2 compares the acceleration time history waveforms observed at observation points 6-R2 and P3. Their response spectra are compared in Figure-2.3.

According to Figure-2.2 and -2.3, the maximum acceleration and response spectra are roughly the same for both.

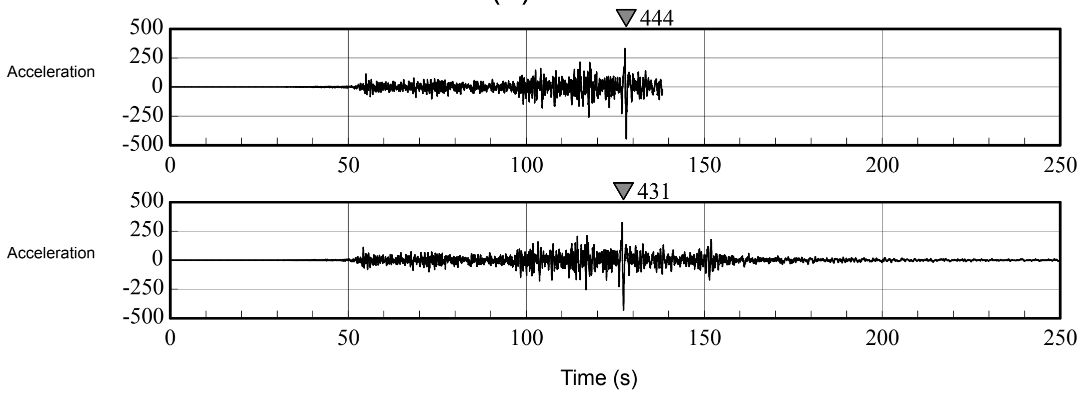


B2F (on basemat)

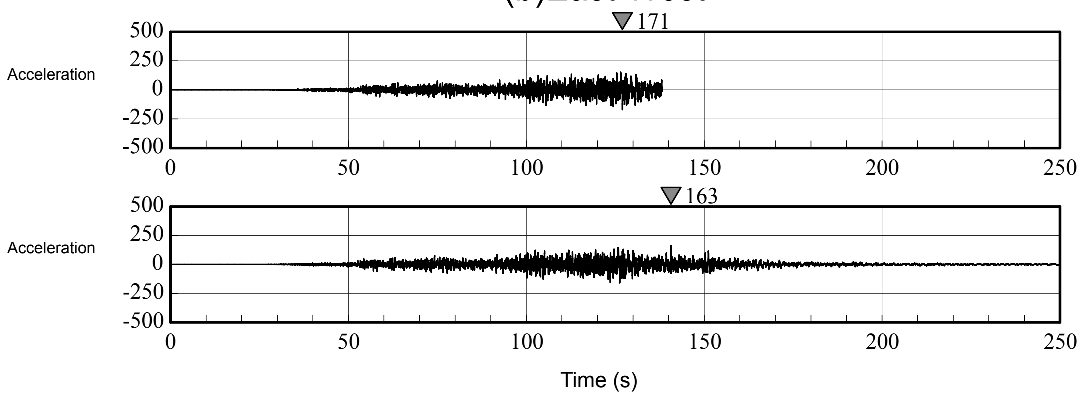
Figure-2.1 Layout of seismometers (Unit 6 R/B)



(a)North-South



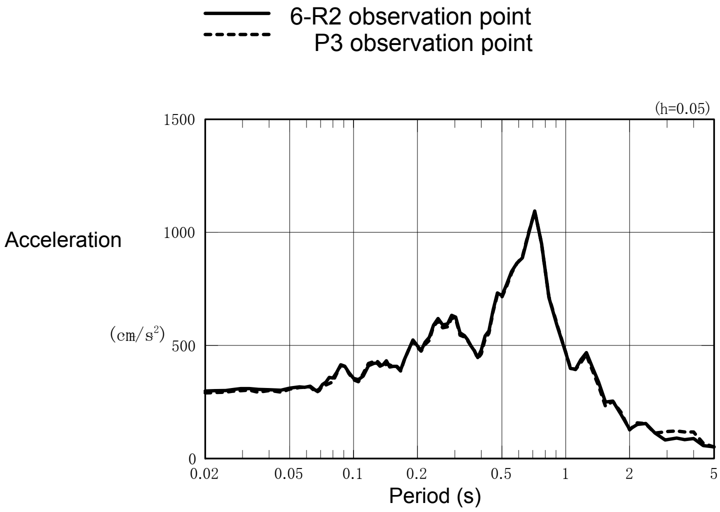
(b)East-West



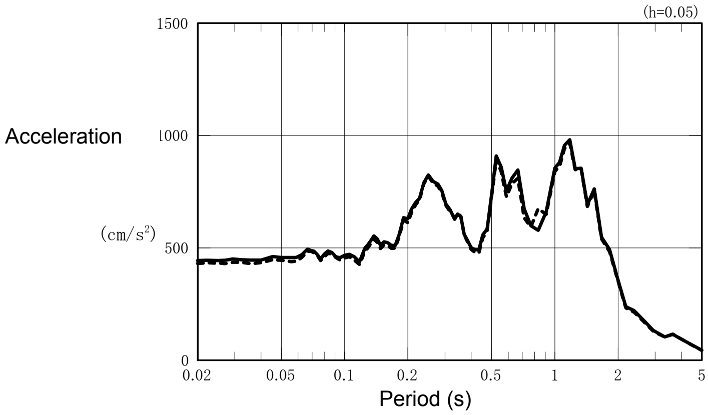
(c)Vertical

Note: Top is observation point 6-R2 and bottom is observation point P3 for all.

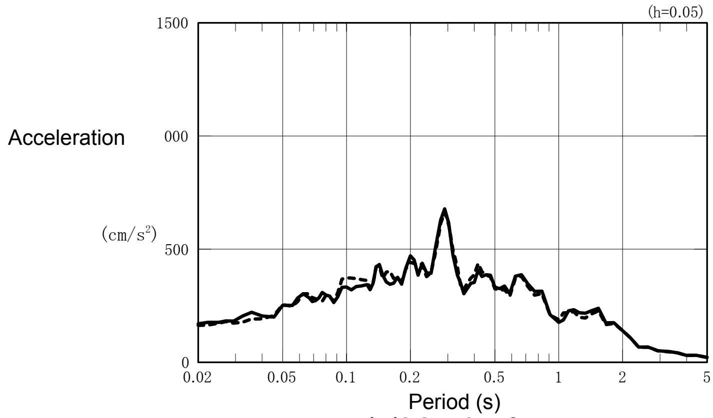
Figure-2.2 Comparison of acceleration time history waveforms of observation points closely located (on Unit6 R/B base mat)



(a)North-south



(b)East-west



(c)Vertical

Figure-2.3 Comparison of acceleration response spectra of closely located observation points (h=0.05)
(on Unit 6 R/B base mat)

Fukushima Daini Nuclear Power Station Unit 1
Report on Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake (Summary)

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the Reactor Building (R/B) base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daini Nuclear Power Station (NPS) Unit 1. This is to report the summarized analysis results for R/B and equipment and piping systems important to seismic safety.

*Written order
"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daini NPS Unit 1 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure-1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.09×10^{-3} (N-S direction, sixth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure-2, 3).

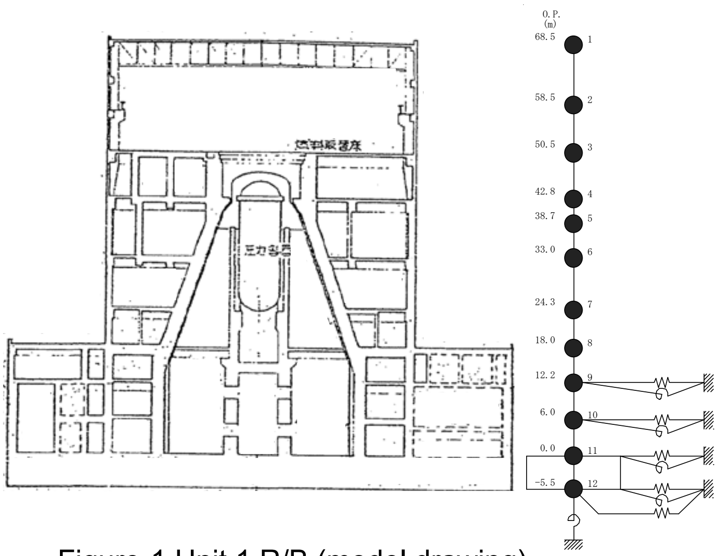


Figure-1 Unit 1 R/B (model drawing)

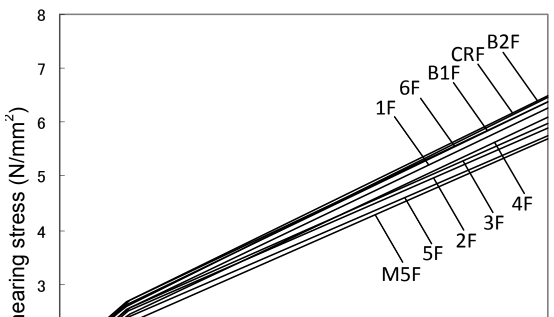


Figure-2 Shear strain of seismic wall (N-S)

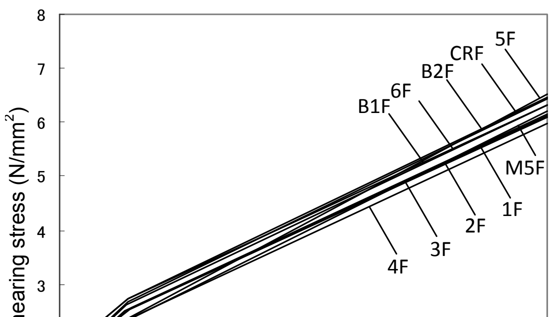
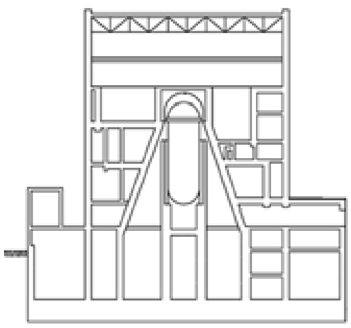


Figure-3 Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daini NPS Unit 1, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, were below the figures from the seismic safety analysis. The seismic performance of the main steam system piping and the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table-1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.



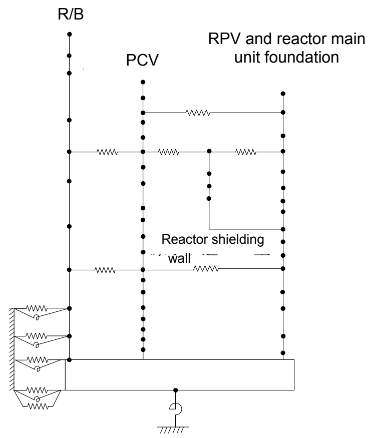
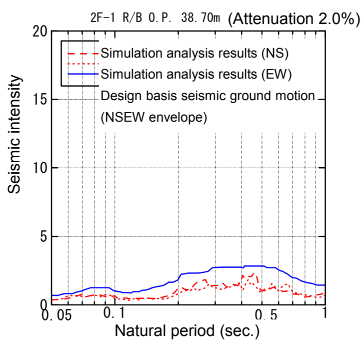


Figure-4 Example of large equipment coupled seismic response analysis model

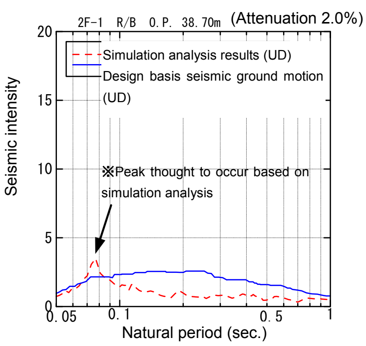
Table-1 Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daini NPS Unit 1)

	Facility	Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	5340	3860	RPV (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	15000	11000	
		Axial force	(kN)	9410	7930	
	PCV foundation	Shear force	(kN)	20300	11800	PCV (drywell) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	341000	185000	
		Axial force	(kN)	6460	3170	
	Core shroud foundation	Shear force	(kN)	6550	4740	Core support structure (shroud support) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	41800	29800	
		Axial force	(kN)	1180	1110	
	Fuel assembly	Relative displacement	(mm)	14.2	9.1	Control rods (insertability) Assessment standard value: 40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	1.02	0.66	RHR cooling system pumps (motor bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Seismic intensity (vertical)	(G)	0.80	0.48	
	Base mat	Seismic intensity (horizontal)	(G)	0.54	0.32	
		Seismic intensity (vertical)	(G)	0.63	0.24	
Floor response spectrum (R/B)	<R/B (O.P.38.70m)>					Main steam piping Calculated value: 272MPa Assessment standard value: 375MPa RHR piping Calculated value: 161MPa Assessment standard value: 335MPa

<R/B (O.P.38.70m)>



(Horizontal)



(Vertical)

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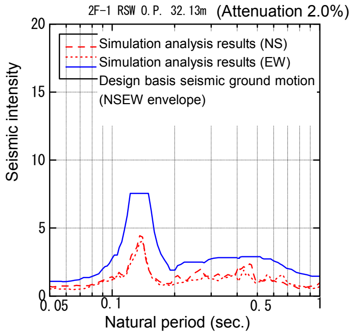
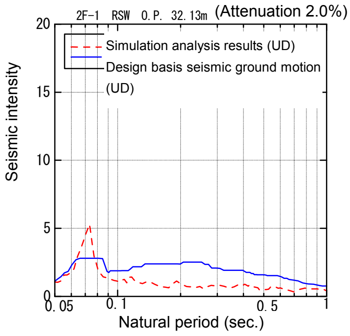


(Horizontal)


(Vertical)</td>
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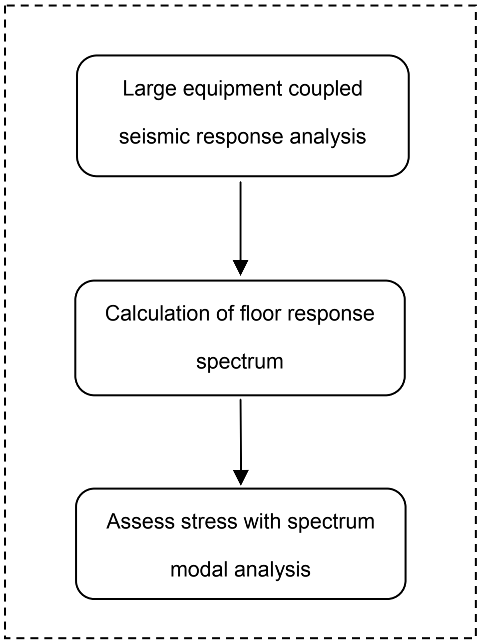
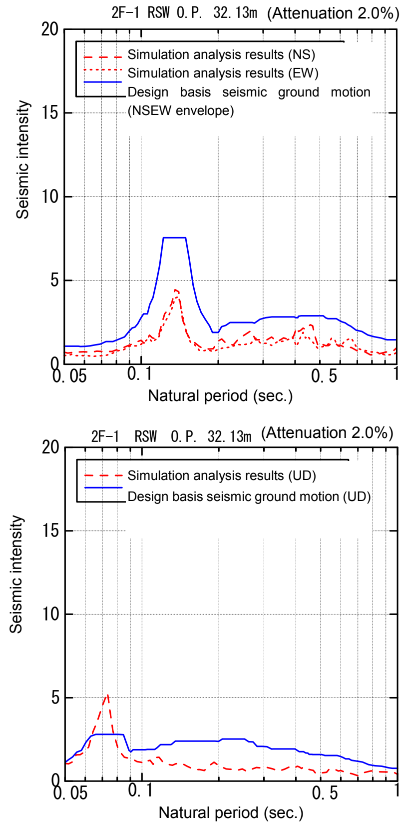
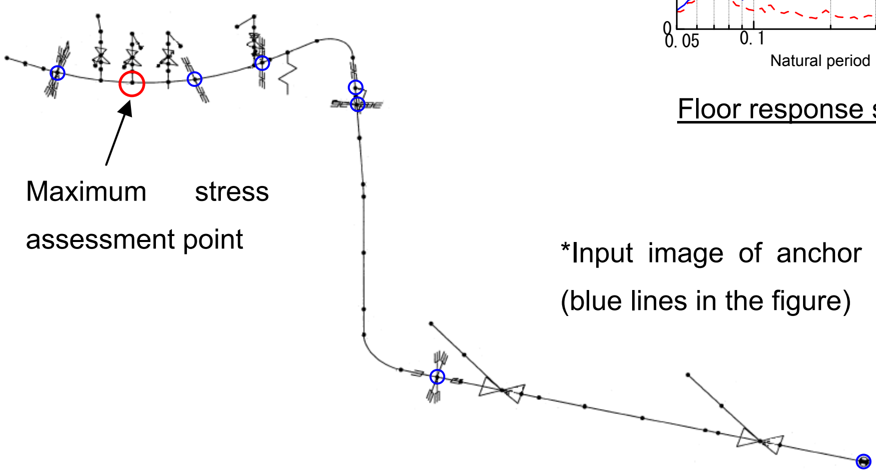
(Reference) Overview of seismic performance assessment
(Example of main steam piping)



Assessment flow



Floor response spectrum



*Input image of anchor and supports (blue lines in the figure)

Main steam piping model

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	281	375	Detailed	Primary	272	375	Detailed

Fukushima Daini Nuclear Power Station Unit 2
Report on Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake (Summary)

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daini Nuclear Power Station (NPS) Unit 2. This is to report the summarized analysis results for Reactor Building (R/B) and equipment and piping systems important to seismic safety.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daini NPS Unit 2 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure-1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.10×10^{-3} (N-S direction, sixth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure-2, -3).

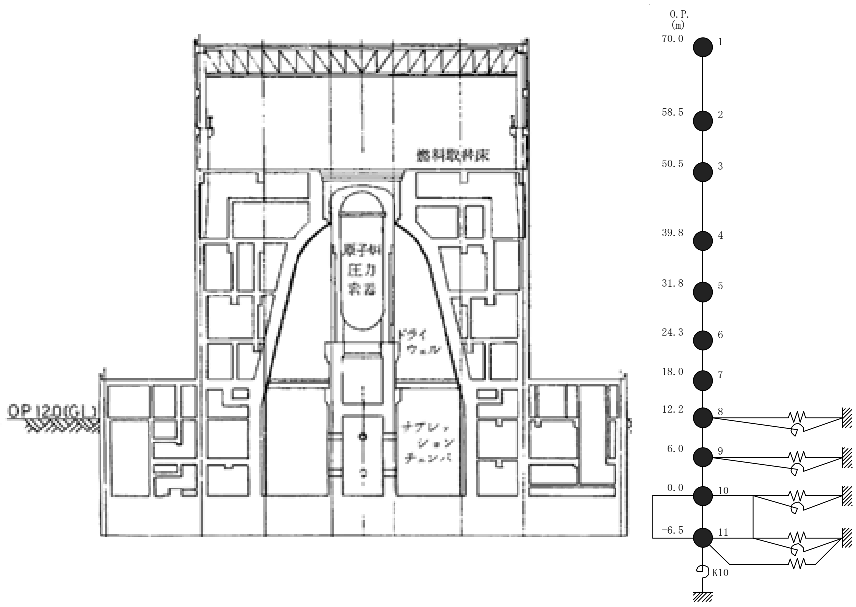


Figure-1 Unit 2 R/B (model drawing)

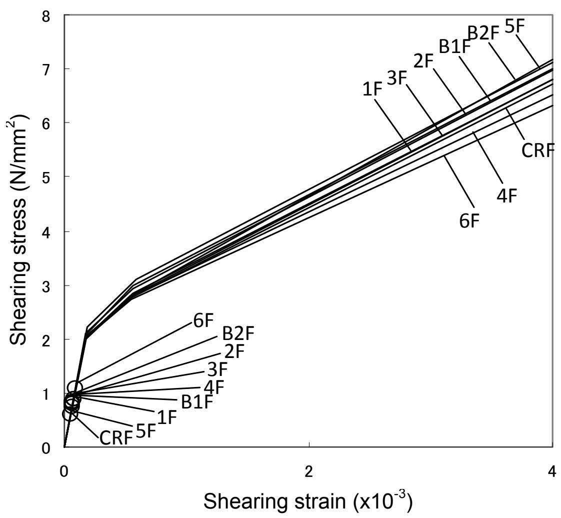


Figure-2 Shear strain of seismic wall (N-S)

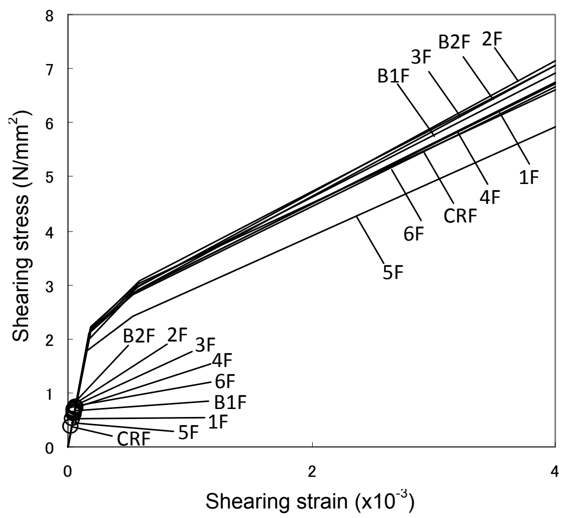


Figure-3 Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daini NPS Unit 2, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki

Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, were below the figures from the seismic safety analysis. The seismic performance of the main steam system piping and the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table-1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

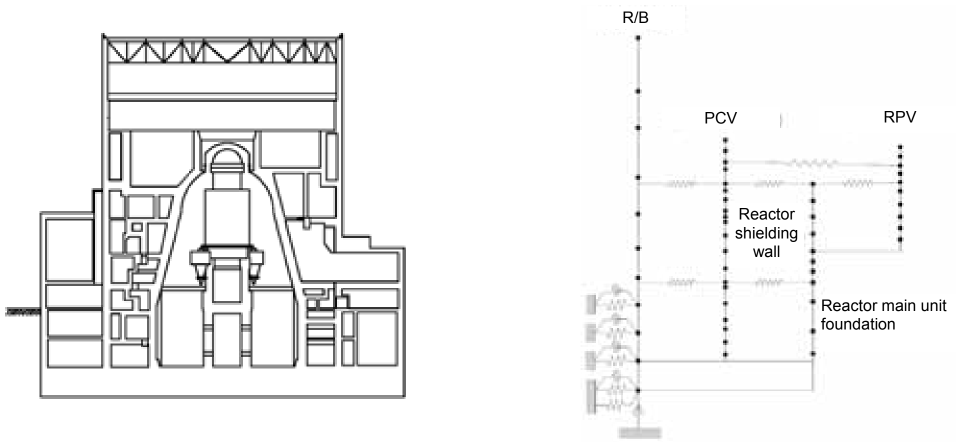
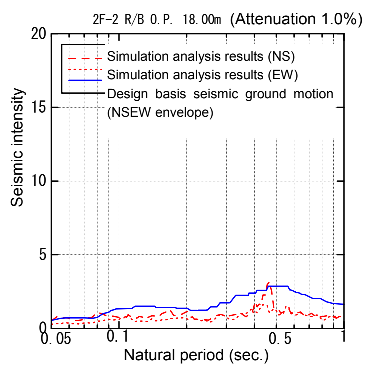
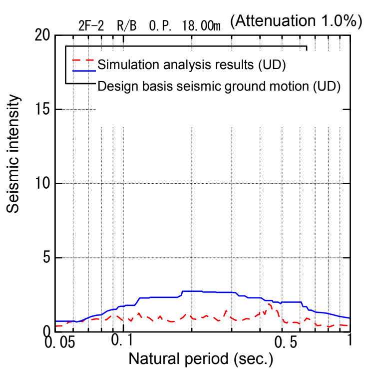
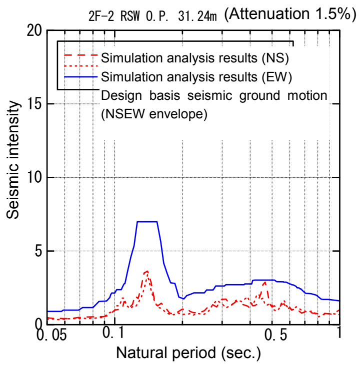
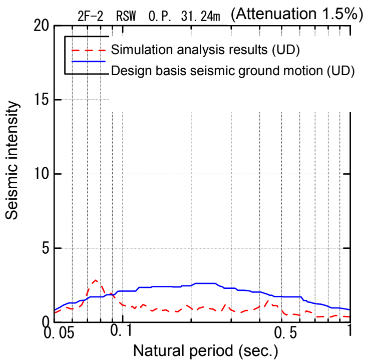


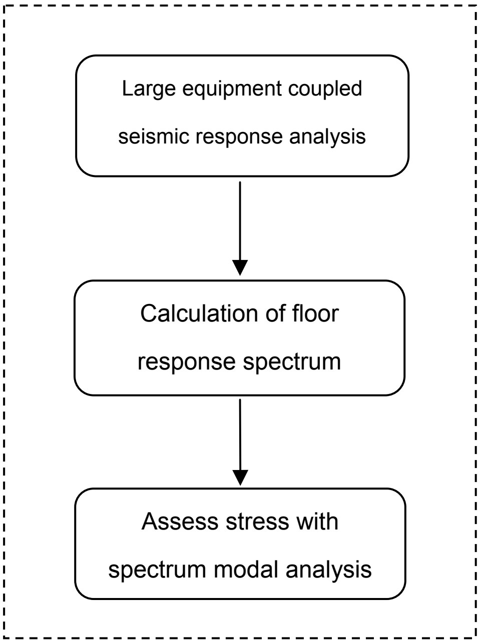
Figure-4 Example of large equipment coupled seismic response analysis model

Table-1 Overview of the impact assessment for equipment & piping systems important to seismic safety (Fukushima Daini NPS Unit 2)

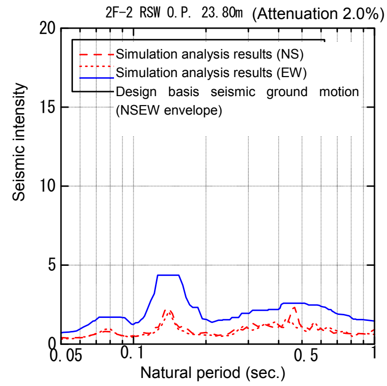
Facility		Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	4730	2420	RPV (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	15200	12100	
		Axial force	(kN)	8440	5280	
	PCV foundation	Shear force	(kN)	25000	15100	PCV (drywell) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	381000	228000	
		Axial force	(kN)	13800	8410	
	Core shroud foundation	Shear force	(kN)	3420	2760	Core support structure (shroud support) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	21000	19400	
		Axial force	(kN)	1310	819	
	Fuel assembly	Relative displacement	(mm)	14.4	7.2	Control rods (insertability) Assessment standard value: 40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.92	0.75	RHR cooling system pumps (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Seismic intensity (vertical)	(G)	0.70	0.43	
	Base mat	Seismic intensity (horizontal)	(G)	0.53	0.30	
		Seismic intensity (vertical)	(G)	0.62	0.28	
Floor response spectrum (R/B)	<R/B (O.P.18.00m)>  (Horizontal)  (Vertical)					Main steam piping Calculated value: 164MPa Assessment standard value: 374MPa RHR piping Calculated value: 104MPa Assessment standard value: 364MPa

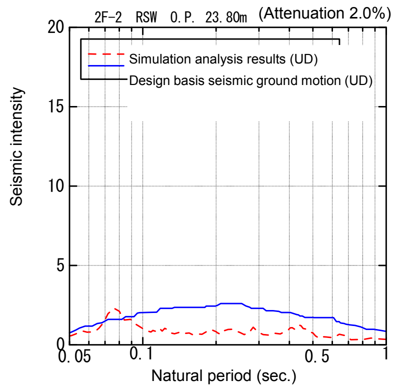
Floor response spectrum (R/B shielding wall)	<Reactor shielding wall (O.P.31.24m)>  (Horizontal)  (Vertical)	

(Reference) Overview of seismic performance assessment (Example of main steam piping)

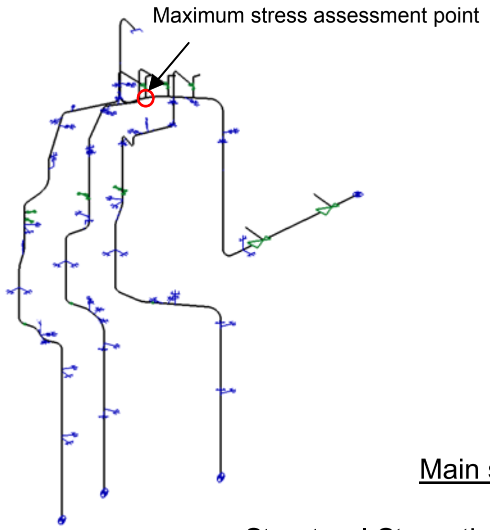


Assessment flow





Floor response spectrum



*Input image of anchor and supports (blue lines in the figure)

Main steam piping model

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	217	309※	Detailed	Primary	164	374※	Detailed

※ : Since the material of piping at the maximum stress assessment point (point with minimum margin) is different for the assessment of design basis seismic ground motion Ss and the recent March 11 earthquake, the assessment standard value is different

Fukushima Daini Nuclear Power Station Unit 3 Report on Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake (Summary)

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daini Nuclear Power Station (NPS) Unit 3. This is to report the summarized analysis results for Reactor Building (R/B) and equipment and piping systems important to seismic safety.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daini NPS Unit 3 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure-1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.11×10^{-3} (N-S direction, fourth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure-2, -3).

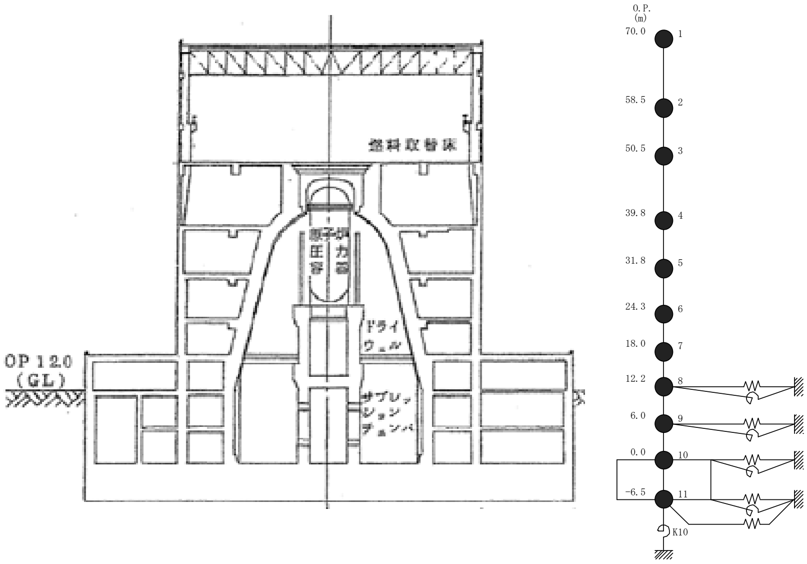


Figure-1 Unit 3 R/B (model drawing)

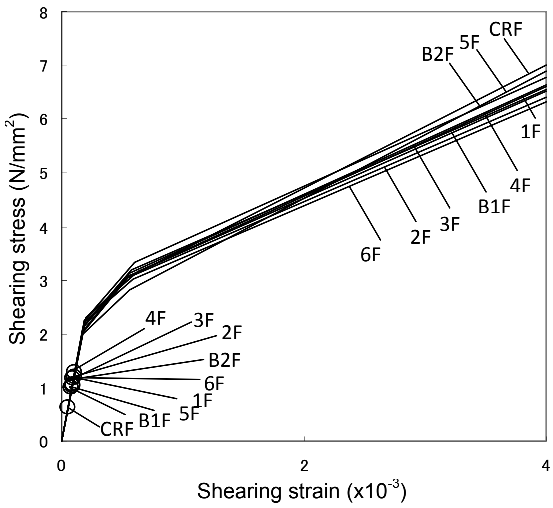


Figure-2 Shear strain of seismic wall (N-S)

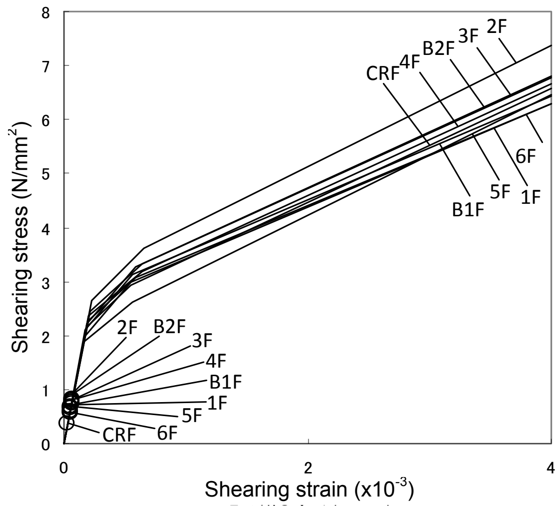


Figure-3 Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daini NPS Unit 3, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, were below the figures from the seismic safety analysis. The seismic performance of the main steam system piping and the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table-1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

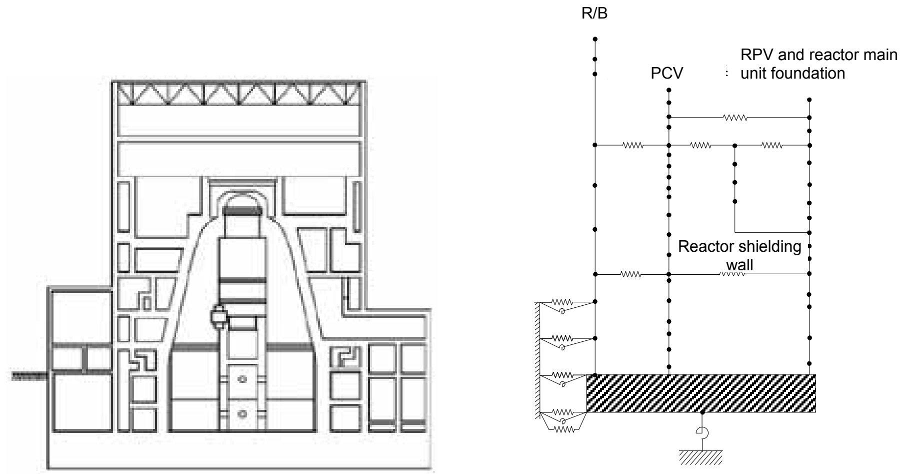
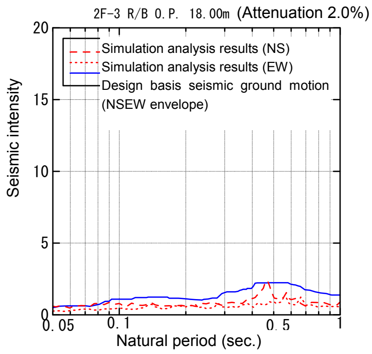
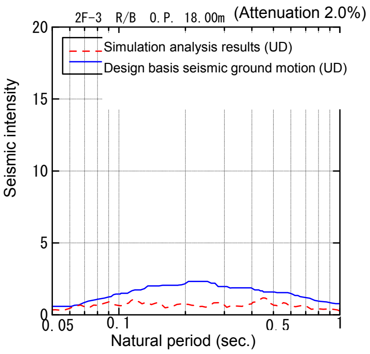
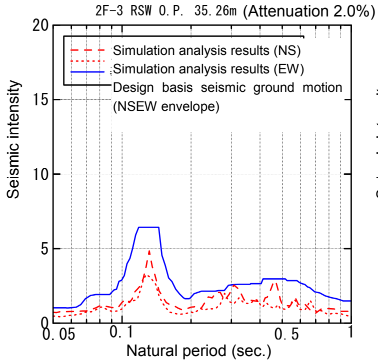
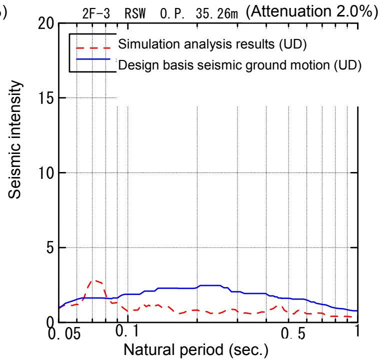


Figure-4 Example of large equipment coupled seismic response analysis model

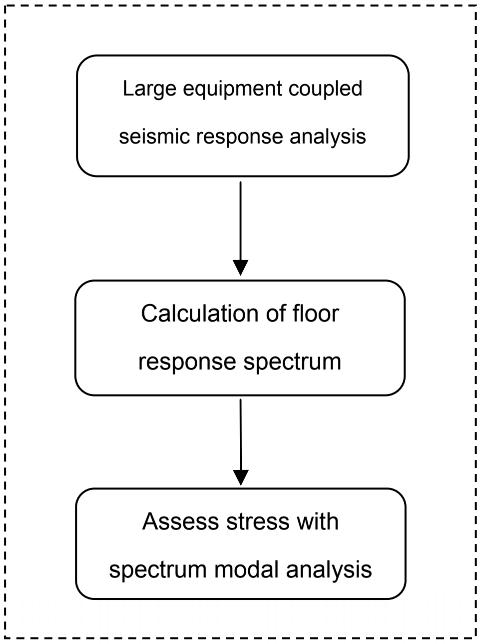
Table-1 Overview of the impact assessment for equipment & piping systems important to seismic safety

(Fukushima Daini NPS Unit 3)

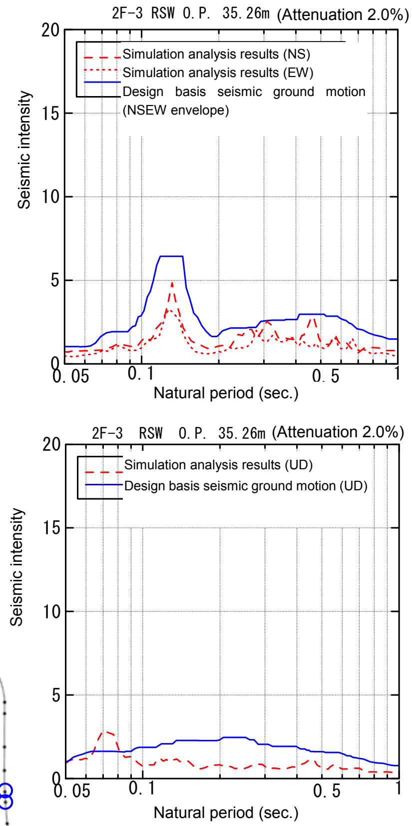
Facility		Seismic response load	Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force (kN)	5220	4060	RPV (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment (kN・m)	17900	11800	
		Axial force (kN)	8700	6120	
	PCV foundation	Shear force (kN)	26700	16400	PCV (drywell) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment (kN・m)	433000	325000	
		Axial force (kN)	9740	6420	
	Core shroud foundation	Shear force (kN)	4990	2980	Core support structure (shroud support) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment (kN・m)	31800	19000	
		Axial force (kN)	1080	787	
	Fuel assembly	Relative displacement (mm)	15.5	9.9	Control rods (insertability) Assessment standard value: 40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal) (G)	0.91	0.72	RHR cooling system pumps (motor bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Seismic intensity (vertical) (G)	0.70	0.56	
	Base mat	Seismic intensity (horizontal) (G)	0.53	0.34	
		Seismic intensity (vertical) (G)	0.62	0.26	
Floor response spectrum (R/B)	<R/B (O.P.18.00m)>  (Horizontal)  (Vertical)				Main steam piping Calculated value: 319MPa Assessment standard value: 375MPa RHR piping Calculated value: 111MPa Assessment standard value: 327MPa

Floor response spectrum (R/B shielding wall)	<Reactor shielding wall (O.P.35.26m)>  (Horizontal)  (Vertical)	

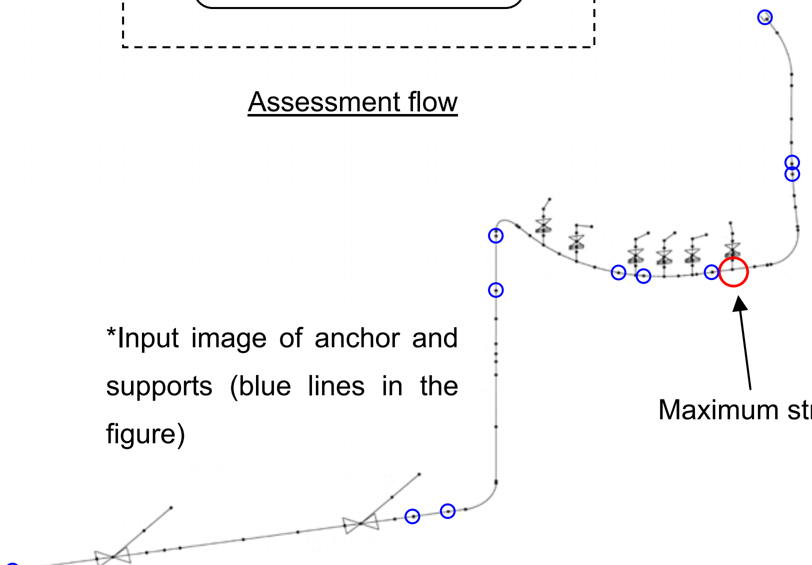
(Reference) Overview of seismic performance assessment
(Example of main steam piping)



Assessment flow



Floor response spectrum



Main steam piping model (portion)

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	316	375	Detailed	Primary	319	375	Detailed

Fukushima Daini Nuclear Power Station Unit 4
Report on Results of Seismic Response Analysis for Reactor Building and Equipment & Piping Systems Important to Seismic Safety Using Observation Records from the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake (Summary)

1. Introduction

There are numerous seismic observation records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred on March 11, 2011 such as from the R/B base mat.

Based on written order* from NISA, seismic response analysis was conducted using seismic observation records from Fukushima Daini Nuclear Power Station (NPS) Unit 4. This is to report the summarized analysis results for Reactor Building (R/B) and equipment and piping systems important to seismic safety.

*Written order

"Actions following the analysis of seismic data collected at Fukushima Daiichi NPS and Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake (ORDER)" (May 16, 2011, NISA No.6)

2. Reactor Building (R/B)

To conduct seismic response analysis considering the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake for Fukushima Daini NPS Unit 4 R/B, the observation records from the building's base mat was used for analysis to verify the conditions of the building at the time of the earthquake.

To conduct the seismic response analysis, a model was defined that would adequately express the characteristics of the buildings, structures and ground (Figure-1).

Results of the analysis verified that the maximum shear strain for the seismic wall was 0.09×10^{-3} (N-S direction, sixth floor) and that the stress and deformation conditions for all seismic walls were at or below the first flexion point on the skeleton curve (Figure-2, -3).

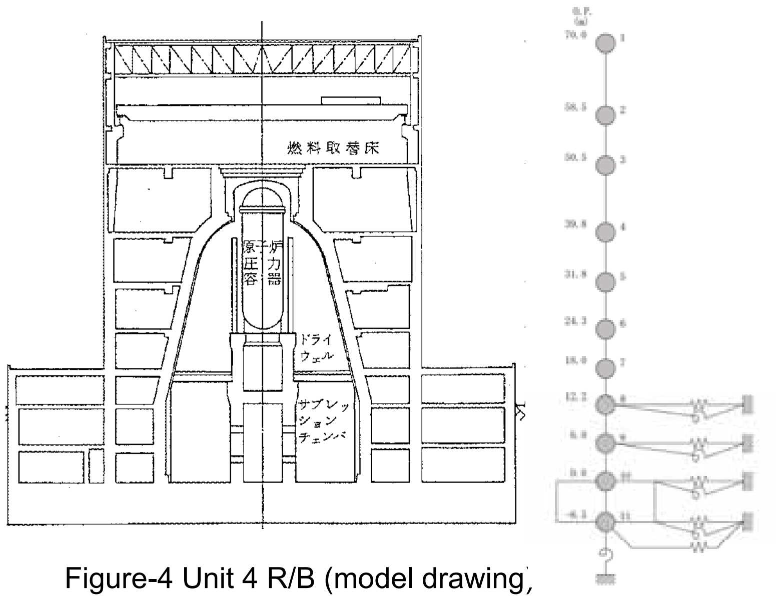


Figure-4 Unit 4 R/B (model drawing)

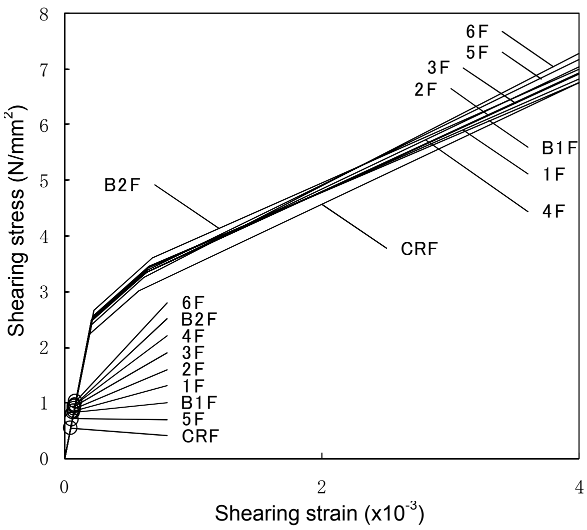


Figure-2 Shear strain of seismic wall (N-S)

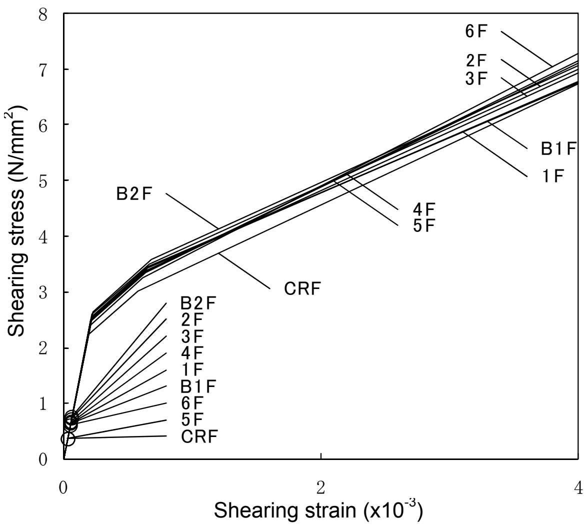


Figure-3 Shear strain of seismic wall (E-W)

3. Equipment and piping systems important to seismic safety

For large equipment such as the reactor for Fukushima Daini NPS Unit 4, seismic response analysis using observed records from the Tohoku-Chihou-Taiheiyo-Oki Earthquake was conducted. The resulting seismic load and other values were compared against those calculated from the seismic safety assessment using the existing design basis seismic ground motion, Ss.

The comparison showed that the seismic load and other factors caused by this earthquake, excluding some of the floor response spectrum peak, fell below the figures from the seismic safety analysis. The seismic performance of the main steam system piping and the residual heat system piping was also assessed, which verified that the calculated stress and other values were below the assessment standard values (Table-1). Based on the above results, it can be assumed that major facilities with safety-critical functions maintained their safety functions during and immediately after the earthquake.

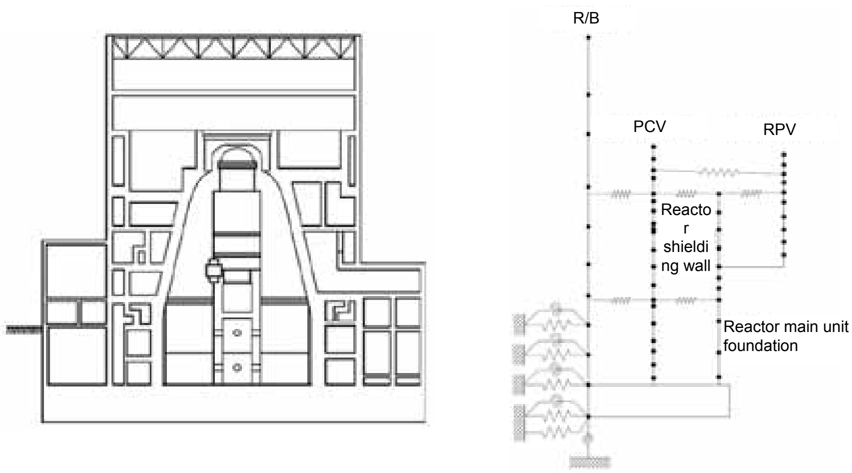
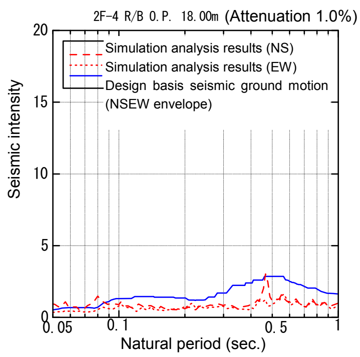
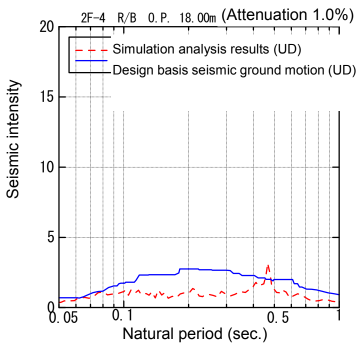


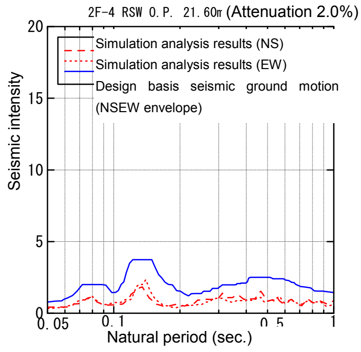
Figure-4 Example of large equipment coupled seismic response analysis model

Table-1 Overview of the impact assessment for equipment & piping systems important to seismic safety

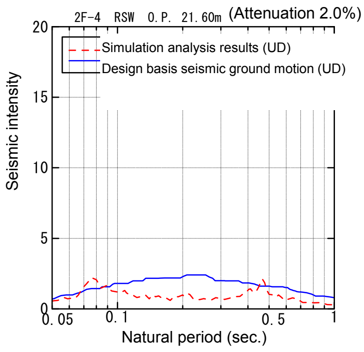
(Fukushima Daini NPS Unit 4)

Facility		Seismic response load		Design basis seismic ground motion Ss	Simulation calculated result	Seismic performance assessment result
Seismic load and others	RPV foundation	Shear force	(kN)	4360	2980	RPV (foundation bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	16200	9640	
		Axial force	(kN)	8420	5980	
	PCV foundation	Shear force	(kN)	25400	14000	PCV (drywell) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	396000	236000	
		Axial force	(kN)	13700	9670	
	Core shroud foundation	Shear force	(kN)	5270	4660	Core support structure (shroud support) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Moment	(kN・m)	34300	28800	
		Axial force	(kN)	1330	930	
	Fuel assembly	Relative displacement	(mm)	14.1	7.3	Control rods (insertability) Assessment standard value: 40.0mm
Seismic intensity for assessment	Refueling floor	Seismic intensity (horizontal)	(G)	0.91	0.57	RHR cooling system pumps (motor bolt) **Assessment unnecessary as the calculated result is smaller than the load for design basis seismic ground motion Ss**
		Seismic intensity (vertical)	(G)	0.68	0.51	
	Base mat	Seismic intensity (horizontal)	(G)	0.51	0.26	
		Seismic intensity (vertical)	(G)	0.62	0.36	
Floor response spectrum (R/B)	<R/B (O.P.18.00m)>  (Horizontal)  (Vertical)					Main steam piping Calculated value: 140MPa Assessment standard value: 374MPa RHR piping Calculated value: 123MPa Assessment standard value: 321MPa

Floor response spectrum (R/B shielding wall)	<Reactor shielding wall (O.P.21.60m)>	

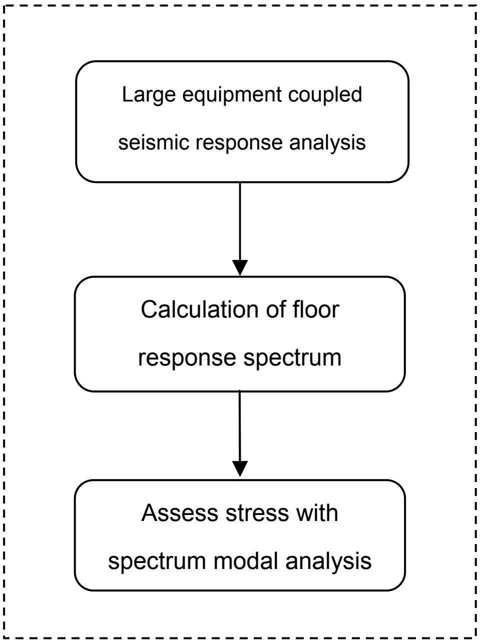


(Horizontal)

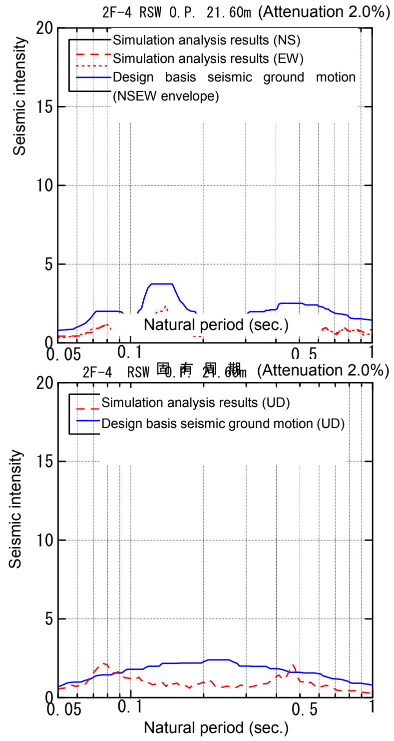


(Vertical)

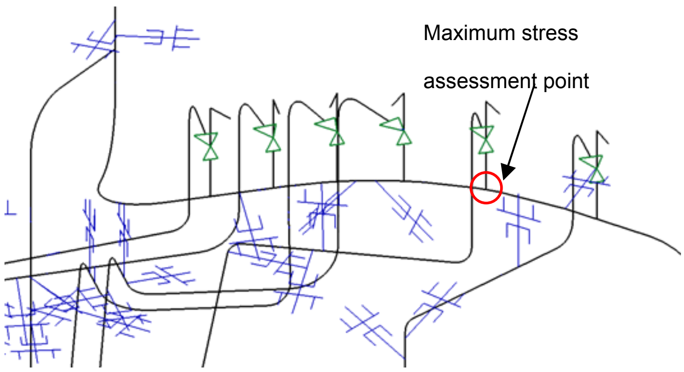
(Reference) Overview of seismic performance assessment
(Example of main steam piping)



Assessment flow



Floor response



*Input image of anchor and supports (blue lines in the figure)

Main steam piping model (Portion)

Structural Strength Assessment Results

Target facility	Assessed part	Design basis seismic ground motion Ss				March 11 earthquake			
		Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method	Stress type	Calculated value (MPa)	Assessment standard value (MPa)	Assessment method
Main steam piping	Piping itself	Primary	157	309※	Detailed	Primary	140	374※	Detailed

※: Since the material of piping at the maximum stress assessment point (point with minimum margin) is different for the assessment of design basis seismic ground motion Ss and the recent March 11 earthquake, the assessment standard value is different

Partial Unrecorded Observation Records for the 2011 Tohoku-Chihou-Taiheiyo-Oki Earthquake at Fukushima Daini Nuclear Power Station

For the Reactor Building (R/B) of Fukushima Daini Nuclear Power Station (NPS) Units 1 to 4, seismic response analysis was performed using the observation records obtained during the Tohoku-Chihou-Taiheiyo-Oki Earthquake. From the analysis, it can be assumed that major facilities with safety-critical functions maintained conditions that ensured safety functions during the earthquake and immediately afterwards.

Some of the observation records obtained at Fukushima Daini NPS during the Tohoku-Chihou-Taiheiyo-Oki Earthquake stopped from about 130sec. to 140sec. after it started to record due to deficiency with the system that records seismometer data.

However, though time history data was not available during and after the unrecorded period for observation points on the R/B base mat, it has been verified that the maximum acceleration at these observation points occurred within the time period when time history data was recorded (See Reference-1).

Based on the above, it is believed that there is no problem posed by the content of the assessment regardless of the fact that there was missing data.

(Reference)

Verification of maximum acceleration for seismic observation records on R/B base mat of Fukushima Daini Nuclear Power Station

Observation records for Fukushima Daini Units 3 and 4 Reactor Building (R/B) base mats stopped between 130sec. to 140sec. after they started to record the main earthquake. However, based on the results of investigations and considerations as shown below, it is believed that the maximum acceleration occurred within the time range where time histories are available.

- The specifications of the seismic observation devices installed on the base mat allow the maximum acceleration data to be transmitted and recorded separate from the time history data. During the main earthquake, (system) deficiency caused time history data to remain unrecorded during and after the unrecorded period; however, it recorded the maximum acceleration after the unrecorded period, and those values were examined.
- For the main earthquake, maximum acceleration up to unrecorded period (Record ①) and maximum acceleration after the unrecorded period (Record②) were obtained. Such maximum accelerations obtained are indicated in Table-1.1.
- Figure-1.1. indicates the time range for which Record① and Record② was obtained. The time range for which Record② was obtained started 30 seconds before the unrecorded period. With these 30 seconds, there is an overlap between Record① and Record②in terms of the time range.
- As shown in Figure-1.1, it is possible to categorize the size relationships of Record① and ②into Group A, B, C from the time at which maximum acceleration is recorded. The maximum acceleration observations records categorized as Group A or B occurs within the time range for which time history data was recorded.
- Table-1.2 indicates categorization results. From Table 1-2, it can be verified that all observation points are categorized as B, and as indicated in Figure-1.2, the maximum acceleration value occurred within the time range for which time history data was available.

Table-1.1 Maximum acceleration of main earthquake on R/B base mat

(Units:Gal)

Unit	Observation point name	Max. acceleration up to unrecorded period (Record①)			Max. acceleration after unrecorded period (Record②)		
		NS	EW	Vertical	NS	EW	Vertical
3	3-R2	276.6	216.2	208.5	276.6	216.2	208.5
4	4-R2	209.7	205.2	287.7	209.7	205.2	287.7

Note: The maximum accelerations indicated in the above table are preliminary values before baseline correction, therefore, the values are different from those in the “Report of Analysis of Observed Seismic Data Collected at Fukushima Daini NPS Pertaining to the Tohoku-Taiheiyo-Oki Earthquake” (submitted May 16, 2011) due to correction and rounding.

Table-1.2 Categorization by comparing Record① and Record②

Unit	Observation point name	Category of time when maximum acceleration occurred		
		NS	EW	Vertical
3	3-R2	B	B	B
4	4-R2	B	B	B

<Legend>

A: Record①>Record② Maximum acceleration occurred within the time range for which time history data was recorded.

B: Record①＝Record② Maximum acceleration occurred within the time range for which time history data was recorded.

C: Record①<Record② Maximum acceleration occurred outside of the time range for which time history data was recorded.

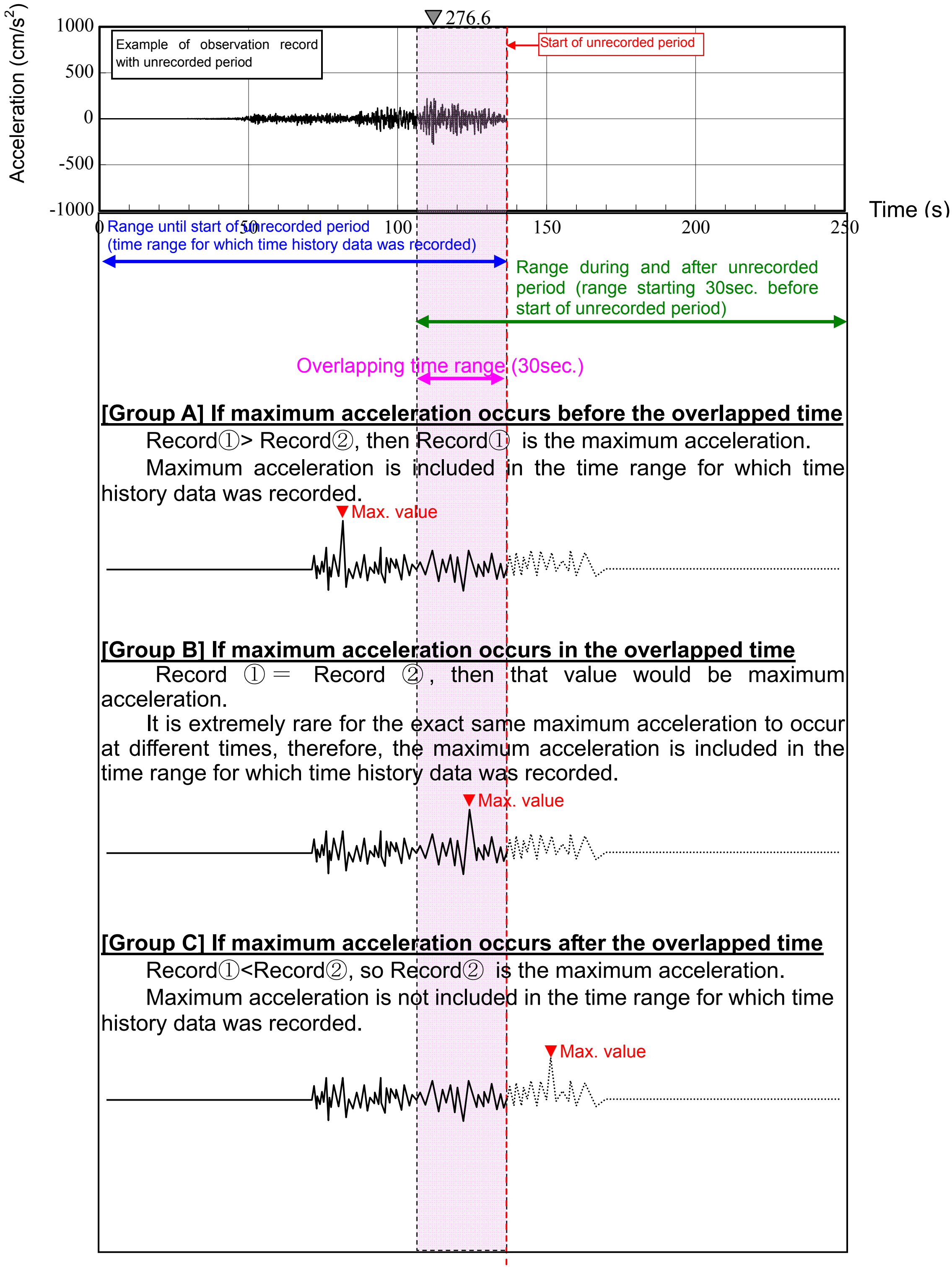


Figure-1.1 Time range for Record ① and ② and categorization by time when maximum acceleration occurred

Seismic intensity for assessment

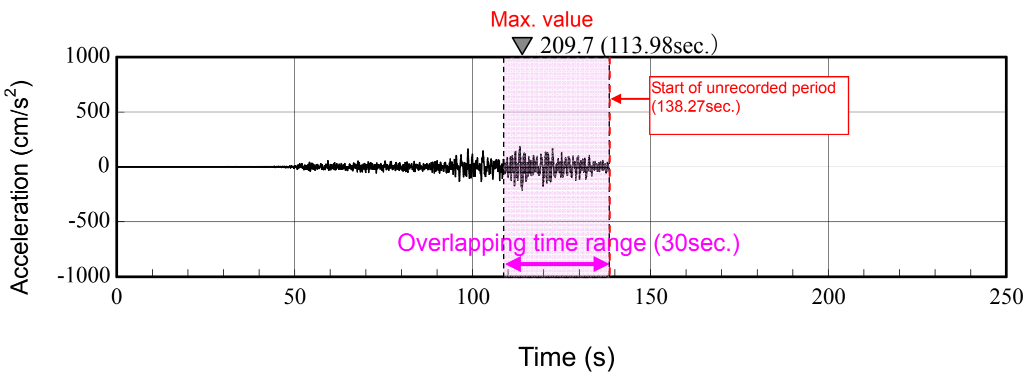


Figure-1.2 Group B Record
(Example of observation point 4-R2, south-north direction)

Outline of "Reports about the study regarding current seismic safety and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (1)"

[Positioning]

This report is based on the "Collection of reports pursuant to Section 67.1 of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" (April 13, 2011) and is regarding the implementation of studies on the current seismic safety and reinforcements of the reactor buildings (R/B) of Fukushima Daiichi NPS. Assessment for Units 1 and 4 were completed at this time, and the results have been compiled in this report and submitted to the Nuclear and Industrial Safety Agency (NISA) of the Ministry of Economy, Trade and Industry (METI) on this day (May 28). The results for other units will be compiled and reported when the assessment results are available.

[Assessment overview]

○ Unit 1 R/B

・For Unit 1 R/B, an event apparently being a hydrogen explosion occurred on March 12, the day after the Tohoku-Chihou-Taiheiyo-Oki Earthquake, which caused damage to the top of the fifth floor, operating floor. This information was incorporated into the lumped mass model to analyze the time history response of the design basis seismic ground motion, Ss, and to study whether the seismic wall would reach ultimate conditions of shear failure (Figure 1).

・As a results of time history response analysis using design basis seismic ground motion Ss, the maximum shear strain generated for the remaining seismic wall on the fifth floor and lower floors is 0.12×10^{-3} (Ss-1, Ss-2, NS direction, 1F) and is significantly below 4×10^{-3}, the assessment standard value. Therefore, it is assessed that there is sufficient safety (Figure 2).

○ Unit 4 R/B

・Though the causes have not been identified, on March 15, the Unit 4 R/B lost the majority of the fifth floor roof slab and walls with only frame structure of pillars and beams and roof truss remaining. It was also found that the majority of the walls of the fourth floor and some of the walls of third floor were damaged. For Unit 4, the walls on the fifth and lower floors are damaged, which is different from Unit 1. Therefore, it was decided that this information would be incorporated into the lumped mass model to conduct time history response analysis using the design basis seismic ground motion Ss and overall assessment of whether the seismic walls would reach ultimate conditions of shear failure (Figure 3).

Based on this, it was decided to conduct local assessment with three-dimensional (3D) FEM analysis including the spent fuel pool. The maximum values obtained from time history response analysis by the lumped mass model is input as seismic load. Temperature load and other loads were combined for assessment.

・Results of time history response analysis using design basis seismic ground motion Ss for lumped mass model indicated that the maximum shear strain of the remaining seismic walls on or above the fifth floor is 0.17×10^{-3} (Ss-1, Ss-2, EW direction, 1F), which is significantly lower than 4×10^{-3}, the assessment standard value. Therefore, it is assessed that there is sufficient safety (Figure 4).

・Results of seismic safety assessment using 3D FEM analysis (Figure 5) showed that the maximum strain on rebars of the spent fuel pool was 1230×10^{-6} when combining the seismic load due to the design basis seismic ground motion Ss and other loads. This has significant margin against the assessment standard value of 5000×10^{-6} of plastic limit strain. The stress generated at the location where the out-of-plane shear force has the smallest margin is 800 (N/mm) and has sufficient margin against 1150 (N/mm), the assessment standard value. Therefore, it is assessed that there is sufficient safety.

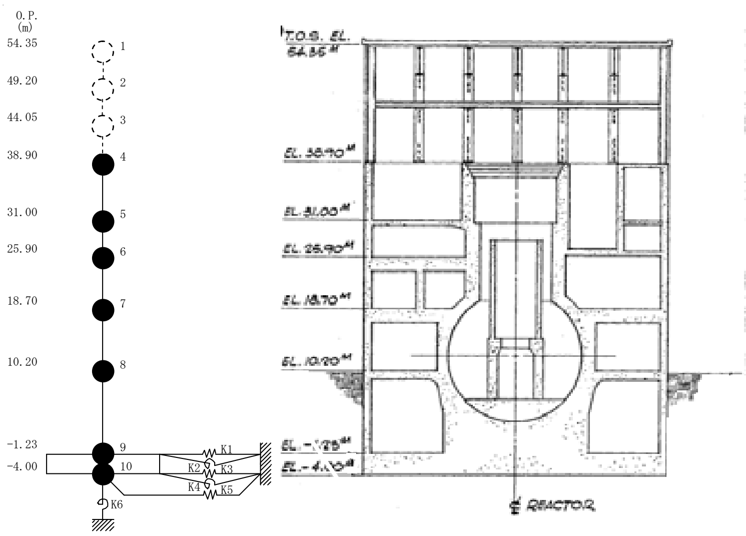


Figure 1.Unit 1 R/B seismic response analysis model (NS)

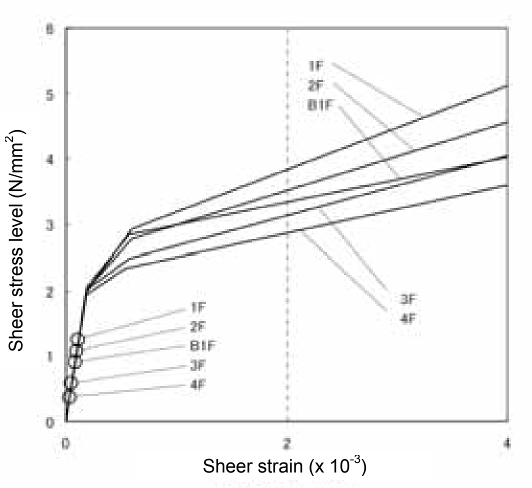


Figure 2. Maximum response value on shear skeleton curve (Unit 1, Ss-1, NS)

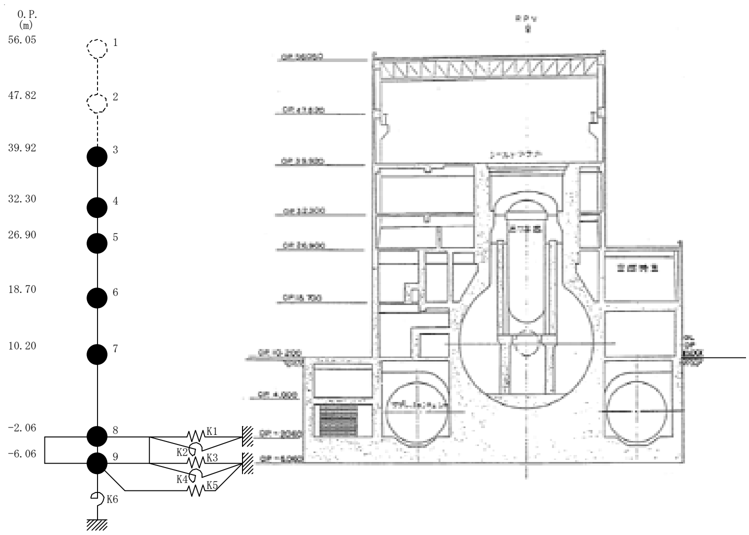


Figure 3. Unit 4 R/B seismic response analysis model (EW)

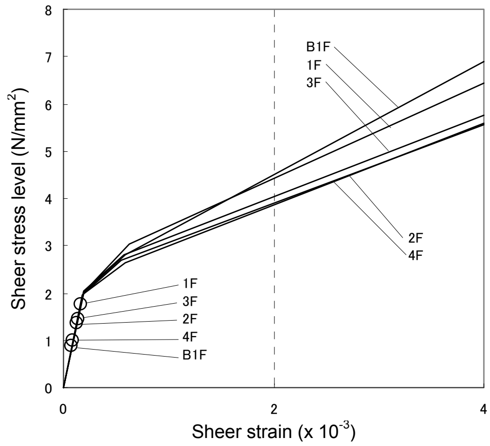


Figure 4. Maximum response value on shear skeleton curve (Unit 4, Ss-1, EW)

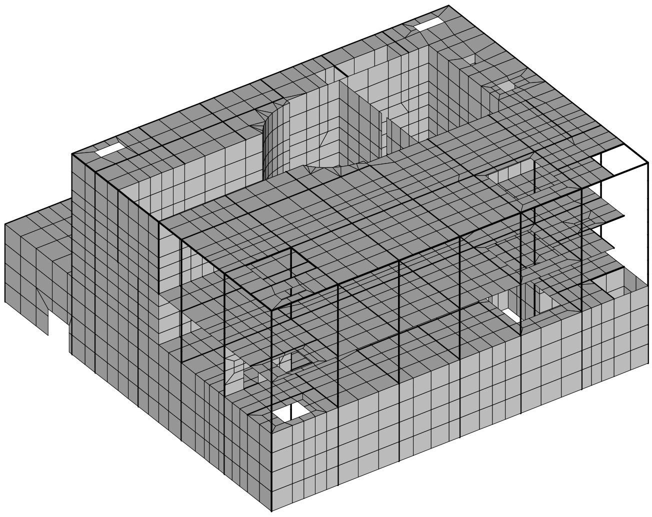


Figure 5. 3D FEM local assessment model (Unit 4)

End

Outline of "Reports about the study regarding current seismic safety and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (2)"

[Positioning]

This report is based on the "Collection of reports pursuant to Section 67.1 of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" (April 13, 2011) and is regarding the implementation of studies on the current seismic safety and reinforcements of the reactor buildings (R/B) of Fukushima Daiichi NPS. Report (1) was submitted to the Nuclear and Industrial Safety Agency (NISA) of the Ministry of Economy, Trade and Industry (METI) on May 28 for Units 1 and 4 whose assessment was completed in advance. The assessment for Unit 3, which was significantly damaged, has been completed at this time, the results compiled and submitted to METI's NISA on this day (July 13).

[Assessment overview]

・For Unit 3 reactor building (R/B), the fifth floor, operating floor and above were damaged due to an event on March 14 thought to be a hydrogen explosion. The majority of the building on the fifth floor and above has steel frames and concrete members that collapsed after the explosion lying on top of one another. In addition, the floor on the northwest side of the fifth floor was damaged, and part of the collapsed steel frames and concrete members were lying on top of each other on the floor of the fourth floor. Major portions of the walls of the fourth floor were also damaged. This information was incorporated into the lumped mass model to analyze the time history response of the design basis seismic ground motion, Ss, and to conduct an overall assessment of whether the seismic wall would reach ultimate conditions of shear failure.
Based on this, it was decided to conduct local assessment with three-dimensional (3D) FEM analysis including the spent fuel pool. The maximum values obtained from time history response analysis is input as the seismic load. Temperature load and other loads were combined for assessment (Figure 1).

・Results of time history response analysis using design basis seismic ground motion Ss for lumped mass model indicated that the maximum shear strain of the remaining seismic walls on the fifth and lower floors is 0.14×10^{-3} (Ss-1, Ss-2, NS direction, 1F), which is significantly lower than 4×10^{-3}, the assessment standard value (figure 2).

・Results of seismic safety assessment using 3D FEM analysis (Figure 3) showed that the maximum strain on rebars of the spent fuel pool was 1303×10^{-6} when combining the seismic load due to the design basis seismic ground motion Ss and other loads. This has a significant margin against the assessment standard value of 5000×10^{-6} of plastic limit strain. The stress generated at the location where the out-of-plane shear force has the smallest margin is 1,689 (N/mm) and has sufficient margin against 3,130 (N/mm), the assessment standard value. Therefore, it is assessed that there is sufficient safety.

・ A similar assessment was conducted for the shell wall on the outer side of the RPV. The maximum strain on rebars was 469×10^{-6} and has sufficient margin against the assessment standard value of 5000×10^{-6} of plastic limit strain. The stress generated at the location where the out-of-plane shear force has the smallest margin is 2,475 (N/mm) and has sufficient margin against 3,270 (N/mm), the assessment standard value. Therefore, it is assessed that there is sufficient safety.

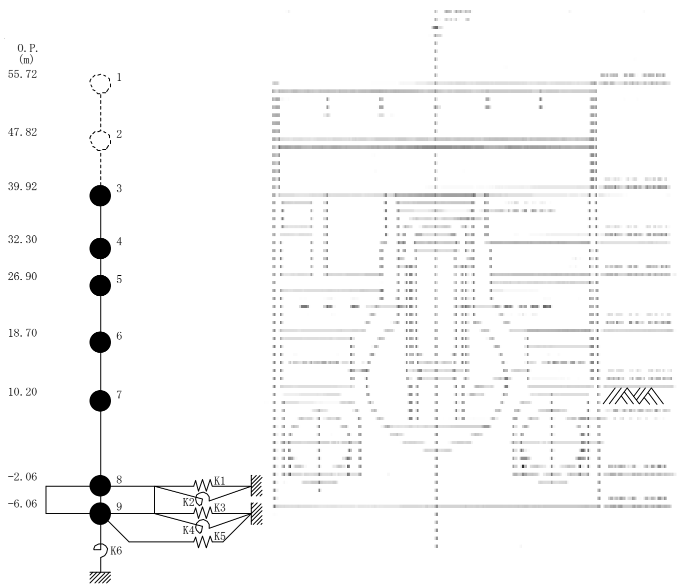


Figure 1. Unit 1 R/B seismic response analysis model(NS)

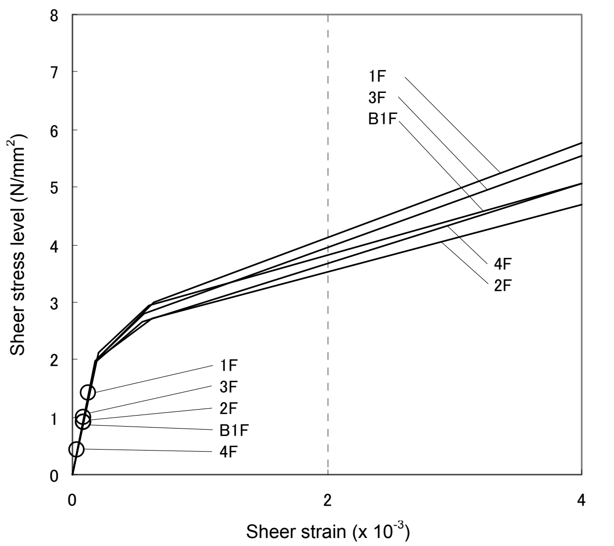


Figure 2. Maximum response value on shear skeleton curve (Unit 3, Ss-2, NS)

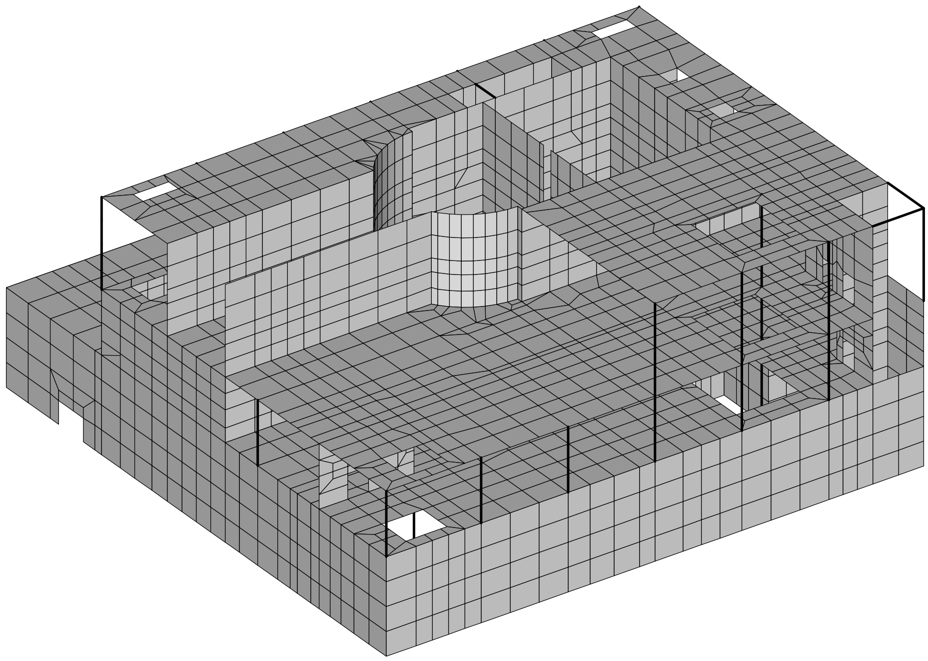


Figure 3. 3D FEM local assessment model (Unit 3)

End

Outline of "Reports about the study regarding current seismic safety and reinforcement of reactor buildings at Fukushima Daiichi Nuclear Power Station (3)"

[Positioning]

This report is based on the "Collection of reports pursuant to Section 67.1 of the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors" (April 13, 2011) and is regarding the implementation of studies on the current seismic safety and reinforcements of the reactor buildings (R/B) of Fukushima Daiichi NPS. Report (1) was submitted to the Nuclear Industrial Safety Agency (NISA) of the Ministry of Economy, Trade and Industry (METI) on May 28 for Units 1 and 4 whose assessment was completed in advance. Report (2) for Unit 3 was submitted on July 13 to NISA, METI. Assessment for Units 2, 5, and 6 was completed at this time, the results compiled in this report and submitted to NISA, METI on this day (August 26).

[Assessment overview]

○ Unit 2 R/B

・For Unit 2 R/B, though the blow-out panel on the exterior wall of the east-side was released, there is no visible external damage. Access to the interior of the building is restricted due to high radiation, so the conditions are unclear but it is understood that there is no damage at this point. Considering such conditions, the seismic performance of the building was assessed using the analysis results for the seismic back-check as-is ('Fukushima Daiichi NPS Interim Report on seismic safety assessment results pursuant to the revision of "Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities"(Revision 2)' April 19, 2010)

・As results of implementing the time history response analysis using the design basis seismic ground motion Ss for the seismic back check, the maximum shear strain for the seismic wall is 0.17×10^{-3} (Ss-1, EW, 5F), which is significantly lower than 4×10^{-3}, the assessment standard value. Therefore, it is assessed that there is sufficient safety.

・A parameter study was conducted for assurance by considering the possibility of lower rigidity of the shell wall due to the temporary rise in temperature in the PCV and the abnormal sound near the suppression chamber on the basement floor on March 15. It was found that there are slight value variations but there are no significant differences in analysis results.

○ Unit 5 and 6 R/B

- For Units 5 and 6, they have already maintained cold shutdown conditions, there is no external damages, and no information is available for structural damage though no detailed inspections have been conducted for the interior areas. Therefore, when considering the above conditions, assessment was performed by applying the analysis results of the seismic back check similarly to Unit 2 from the perspective of seismic performance of buildings.
- Results of time history response analysis using design basis seismic ground motion Ss for the seismic back check show that the maximum shear strain of the Unit 5 seismic wall is 0.19×10^{-3} (Ss-1, EW, fifth floor) while the maximum shear strain of the Unit 6 seismic wall is 0.33×10^{-3} (Ss-1, NS, second floor). Both are significantly lower than 4×10^{-3}, the assessment standard value. Therefore, it is assessed that there is sufficient safety.

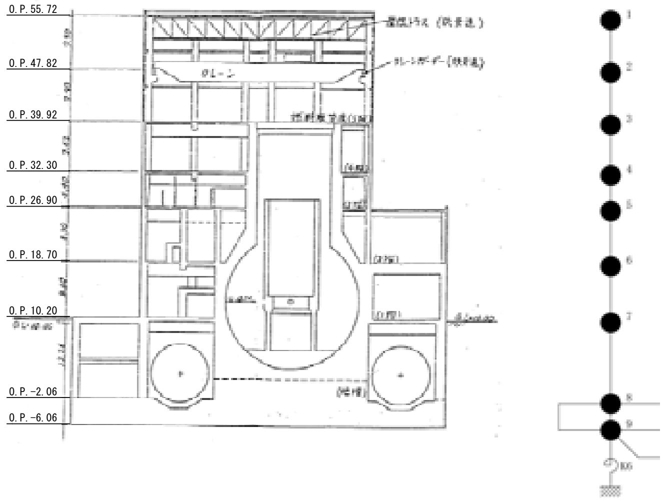


Figure 1. Seismic response analysis model (Unit 2 example)

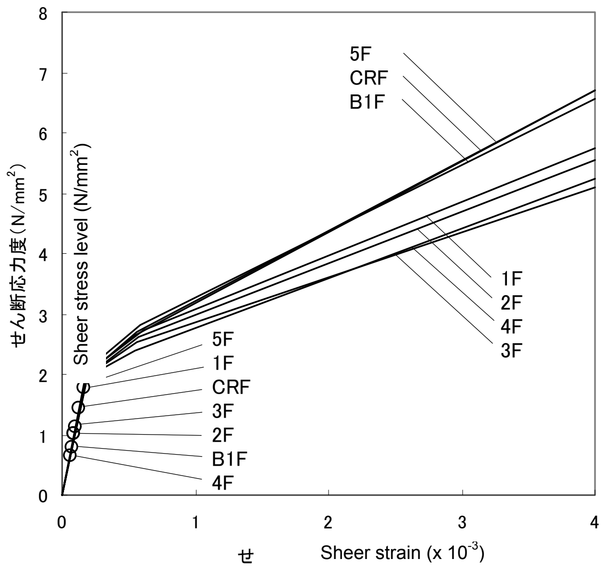


Figure 2. Maximum response value on shear skeleton curve (Unit 2, Ss-1, EW)

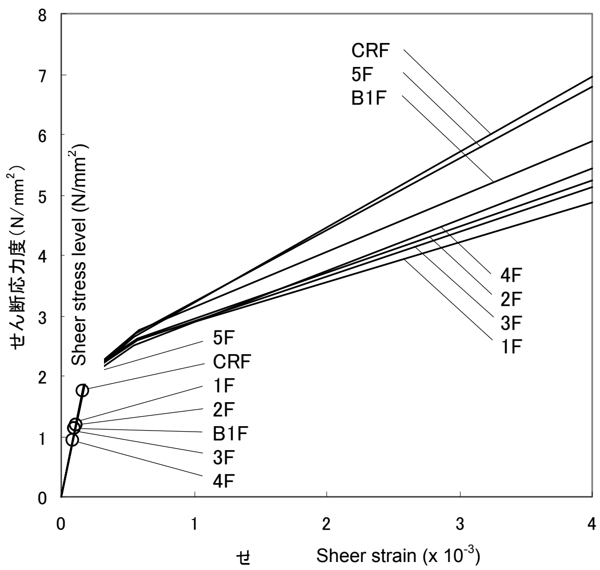


Figure 3. Maximum response value on shear skeleton curve (Unit 5, Ss-1, EW)

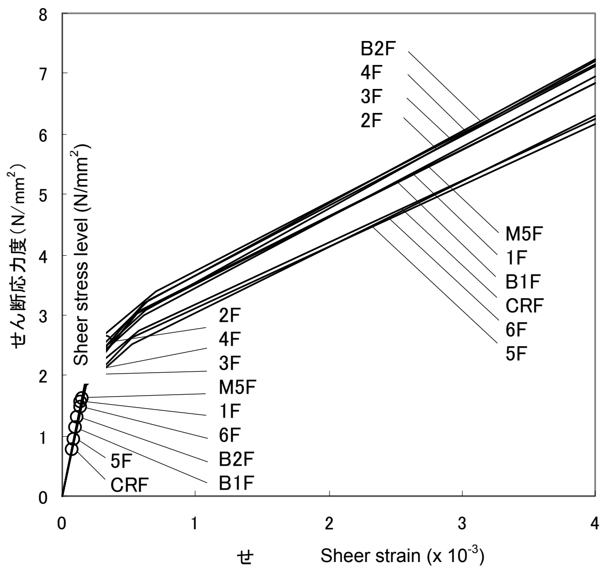


Figure 4. Maximum response value on shear skeleton curve (Unit 6, Ss-1, NS)

End

Fukushima Daiichi Nuclear Power Station
Pipe Fatigue Assessment

A characteristic of the Tohoku-Chihou-Taiheiyo-Oki Earthquake was that its duration was relatively long. When the earthquake duration is long, force is repeatedly applied on facilities and leads to concerns in degraded strength of facilities due to cumulative damage. Fatigue assessment of the piping was conducted using observation records to check this impact.

For the fatigue assessment, ground observations records which did not have missing records like those for the R/B were used. The subject plant is Unit 5 which experienced relatively stronger motion during the March 11 earthquake compared to the other plants located near the point where records were being collected.

(1) Seismic response analysis using ground observation records

The free surface wave of the base stratum estimated from the ground seismic observation records (Figure 2) was used for large equipment coupled seismic response analysis to obtain time history acceleration response of the main earthquake (Figure 1).

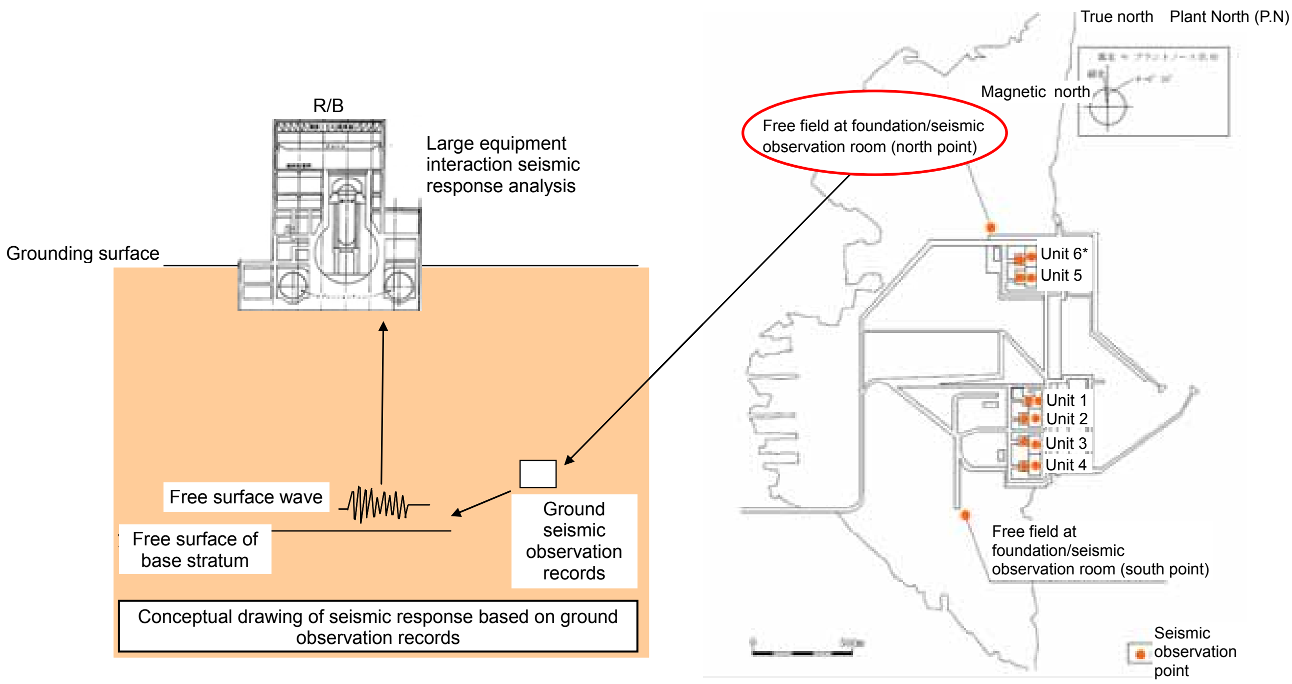
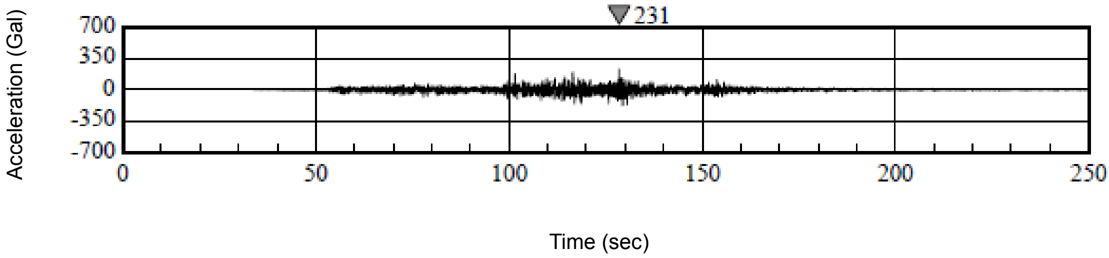
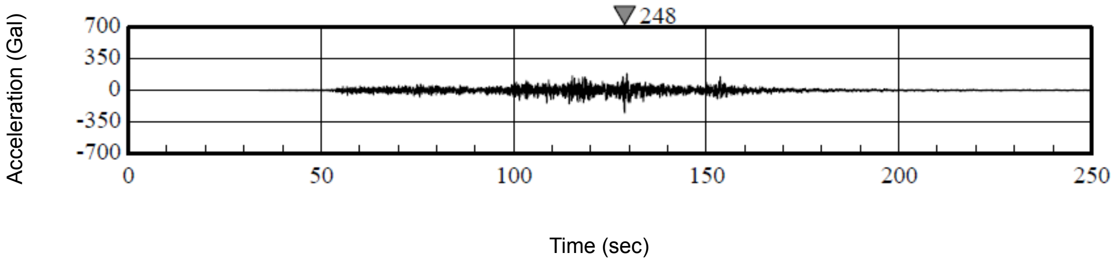


Figure 1. Conceptual drawing of seismic response analysis based on ground observation records



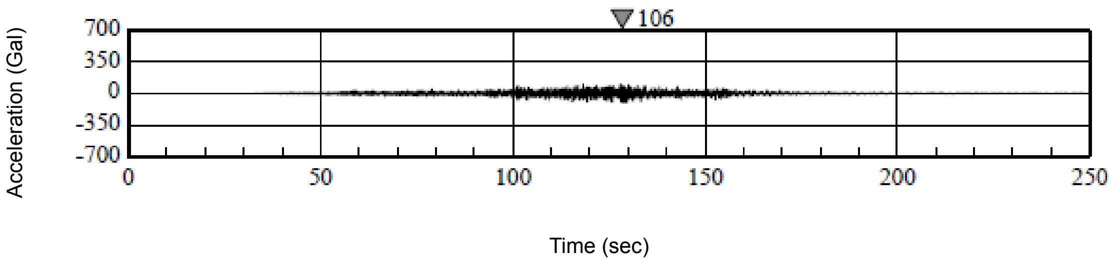
(e) GN5 observation point (O.P. -300m)

(NS direction)



(e) GN5 observation point (O.P. -300m)

(EW direction)



(e) GN5 observation point (O.P. -300m)

(UD direction)

Figure 2. Acceleration time history wave of free field at foundation observation point (north point)

(2) Subject for assessment

Assessment was performed on the feedwater pipings (branch points) because they are installed in a wide area spanning the RPV to the T/B via the R/B and is assumed to be significantly impacted by fatigue due to relative displacement between large structures (Figure 3).

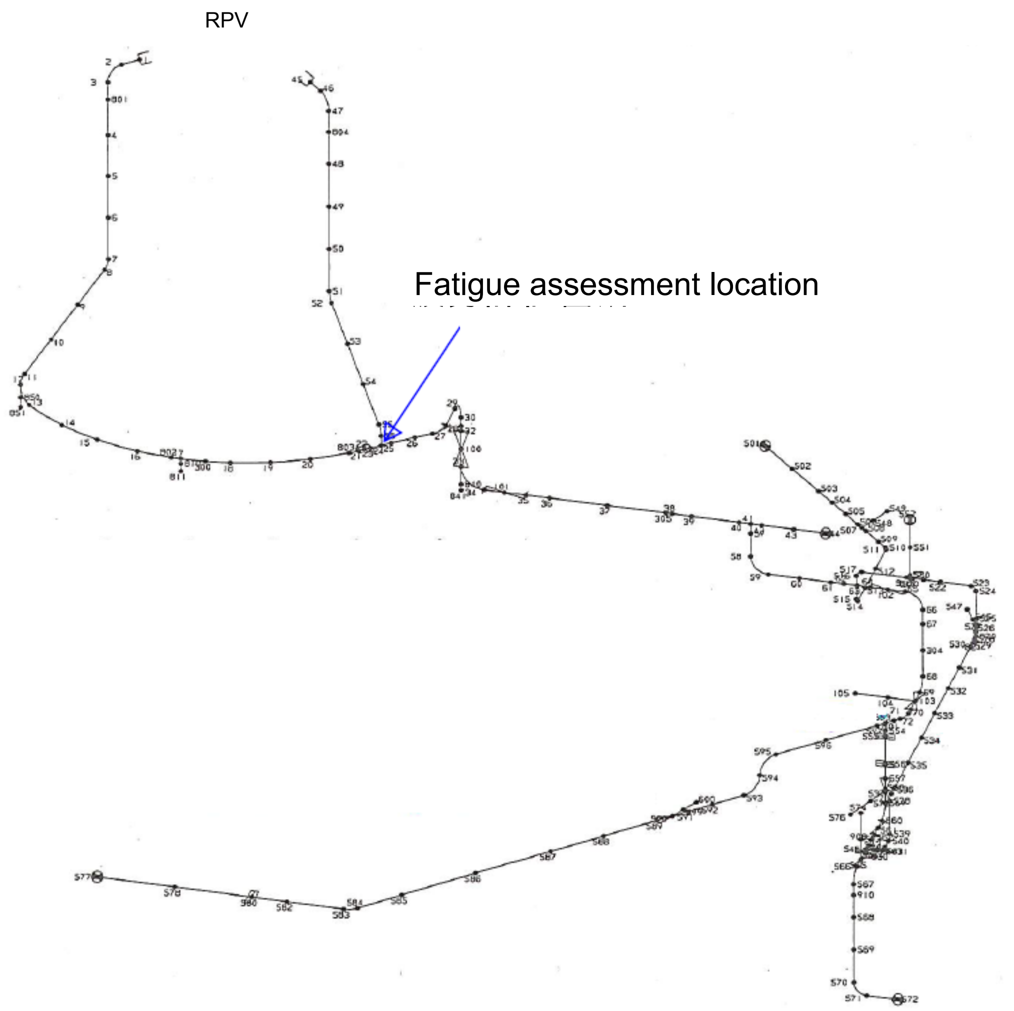


Figure 3. Model drawing of feedwater system piping

(3) Procedures for fatigue assessment

a. Fatigue assessment procedure (Figure 4) (3 direction simultaneous time history analysis)

①Conduct 3-direction simultaneous time history response analysis for pipes to obtain the time history response for recurring peak stress intensity during the earthquake.

②From peak values of time history response of recurring peak stress intensity, calculate usage factor (UF) using design fatigue diagram.

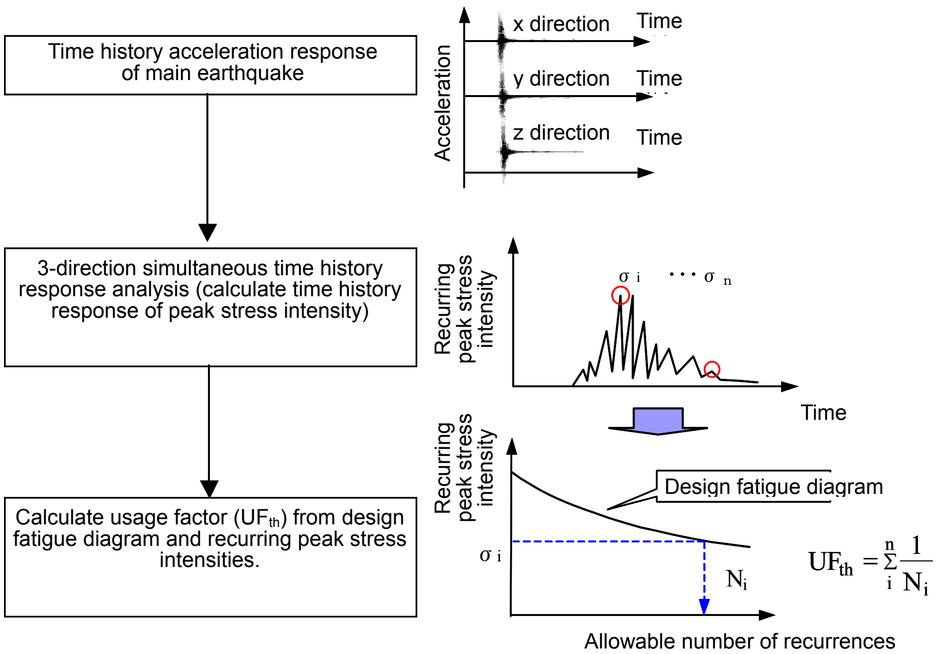


Figure 4. Procedure for fatigue assessment

(3-direction simultaneous time history analysis)

b. Calculation of equivalent number of recurrence (Figure 5)

The equivalent number of recurrence (Ne) for the main earthquake is calculated by multiplying the usage factor (UF) by the allowable number of recurrence (N) for the maximum recurring peak stress intensity obtained by the 3-direction simultaneous time history response analysis.

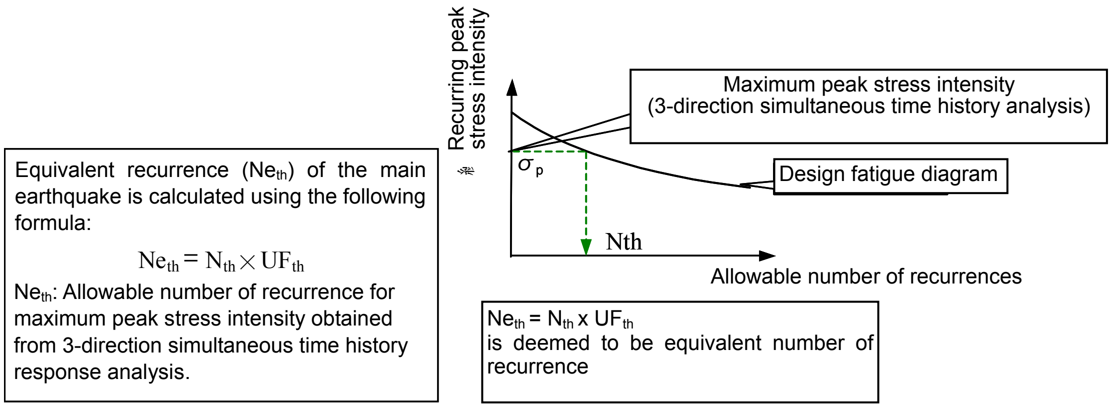


Figure 5. Calculation of equivalent recurrence

(4) Assessment result (Table 1)

Results of the fatigue assessment showed that the usage factor for the main earthquake was 0.00001 or less, which was sufficiently low.

Table 1. Assessment results
(Fukushima Daiichi Unit 5 feedwater system piping)

Assessed facilities	Tohoku-Chihou-Taiheiyo-Oki Earthquake (main earthquake)				Assessment standard value
	Maximum peak stress intensity [MPa]	equivalent number of recurrence	Allowable number of recurrence	Usage factor: UF	
Feedwater piping	80	2	9.0×10^5	0.00001 or less	1

(5) Conclusions

To verify the impact of cumulative damage due to the Tohoku-Taiheiyo-Oki Earthquake, which had a long duration, complete observation records were used for fatigue assessment of the pipes that would be susceptible to cumulative damage by the earthquake.

Of the seismic class S pipes in Unit 5 subject to relatively stronger motion, pipes that would be more susceptible to cumulative damage due to the earthquake were selected for assessment. The assessment results showed that the cumulative damage was largely negligible. Even when considering the subsequent aftershocks, it is estimated that the impact is extremely minor and that there is no need for similar assessments to be performed in the future.

End

Attachment 6-9 (1)

Fukushima Daiichi Unit 5 Facility Status Verification Results

Photos taken 2011.8.18～8.30

R/B

4F / 3F

R/B component cooling pump
・No external equipment abnormality
(A) operating (B)(C) standby

Flammability control system
・No external equipment abnormality
3F

Fuel pool cleaning & cleanup pump
・No external equipment abnormality despite slight corrosion (rusted) on both units.
(A) operating, (B) standby

Standby liquid control system
・No external equipment abnormality
4F

2F / 1F

MSIV
・No external equipment abnormality
1F

Hydraulic control unit
・No external equipment abnormality

RCIC pump
No external equipment abnormality
2F

R/B component cooling heat exchanger
No external equipment abnormality

B1F

Core spray pump
・No external equipment abnormality
・Accumulated water on floor
・Area wall penetration has leak marks

RHR pump
・No external equipment abnormality
・Accumulated water on floor

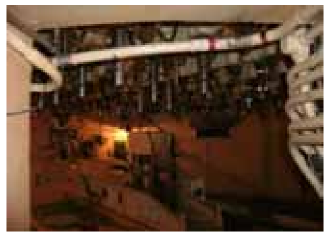
HPCI
・No external equipment abnormality
・Accumulated water on floor

CRD pump
・No external equipment abnormality

In PCV

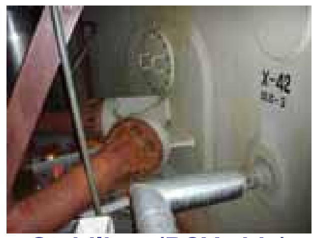
MSIV
・No external equipment abnormality

SRV
・No external equipment abnormality



In pedestal
・No external equipment abnormality

RPV support skirt
・Despite rust on foundation bolts, no external equipment abnormality



Stabilizer (PCV side)
・No external equipment abnormality

Stabilizer (RPV side)
・No external equipment abnormality

Reactor recirculation riser
・No external equipment abnormality

T/B

2F

High pressure turbine
・Cracks near front standard foundation bolt

Turbine-driven reactor feedwater pump
・No external equipment abnormality

1F

Instrumentation air compressor
・No external equipment abnormality
(A) operating, (B)operating

T/B component cooling pump
・No external equipment abnormality
(A)Inoperable due to power
(B)supply submersion
(B) operating, (C)standby

Moisture separator
・Removal of insulation, Support dislodged

Piping around moisture separator
・Damage to small diameter pipes branching from No. 3 moisture separator drain pipe

B1F

6.9kV M/C
・Drained, installed ditches, cleaned, and receiving power after flooding by tsunami

EDG 5A,5B
・No external equipment abnormality

480V P/C
・P/C6B-1 panel completely damaged by water and unusable

Motor-driven reactor feedwater pump
・No external equipment abnormality

Fukushima Daiichi Unit 6 Facility Status Verification Results

Photos taken: (outside of PCV 2011.8.18~8.30, in PCV 2011.10.31~12.15)

Combined building (including reactor block)

6F / 5F / 4F

Fuel pool cooling & clean up pump
・No external equipment abnormality

Reactor block 4F

Flammability control system
・Subsystem A has no external equipment abnormality
・Subsystem B (installed on 3F) has had defect in cooler in B-2 recombiner since before earthquake

SLCS pump
・No external equipment abnormality

Reactor block 5F

SPF
・No external equipment abnormality
(covered for condensation)

Reactor block 6F

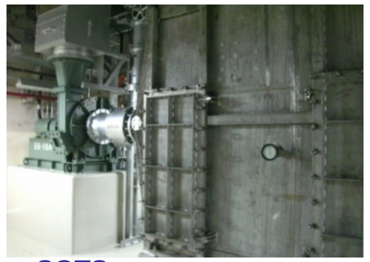
3F / 2F

MSIV
・No external equipment abnormality

Reactor clean-up water pump
・No external equipment abnormality

Reactor block 2F

Hydraulic control unit
・No external equipment abnormality



SGTS
・No external equipment abnormality
A/B alternating operation

Reactor block 3F

B1F

CRD pump
・No external equipment abnormality

RHR heat exchanger
・No external equipment abnormality

Reactor block B1F

RHR pump
・No external equipment abnormality

LPCI pump
・No external equipment abnormality

HPCS pump
・No external equipment abnormality

Reactor block B2F

In PCV

MSIV
・No external equipment abnormality

SRV
・No external equipment abnormality

In pedestal
・No external equipment abnormality

Stabilizer (in PCV)
・No external equipment abnormality

RPV support skirt
・No external equipment abnormality though some rust on foundation bolts.

Reactor recirculation pump
・No external equipment abnormality thought some rust on mount bolts and nuts.

B2F

EDG 6A
・No external equipment abnormality
・Standby

EDG (HPCS)
・No external equipment abnormality

B2F

T/B

2F

Low pressure turbine
・Sliding marks on No.3 bearing high pressure side rotor
・Sliding marks on No.3, No.8 bearing rotor
・Sliding marks on No.8 bearing generator side rotor

Turbine-driven reactor feedwater pump
・No external equipment abnormality

1F

Reactor component cooling pump
No external equipment abnormality

Turbine component cooling pump
・No external equipment abnormality

Motor-driven reactor feedwater pump
・No external equipment abnormality

Moisture separator
・No external equipment abnormality

B1F

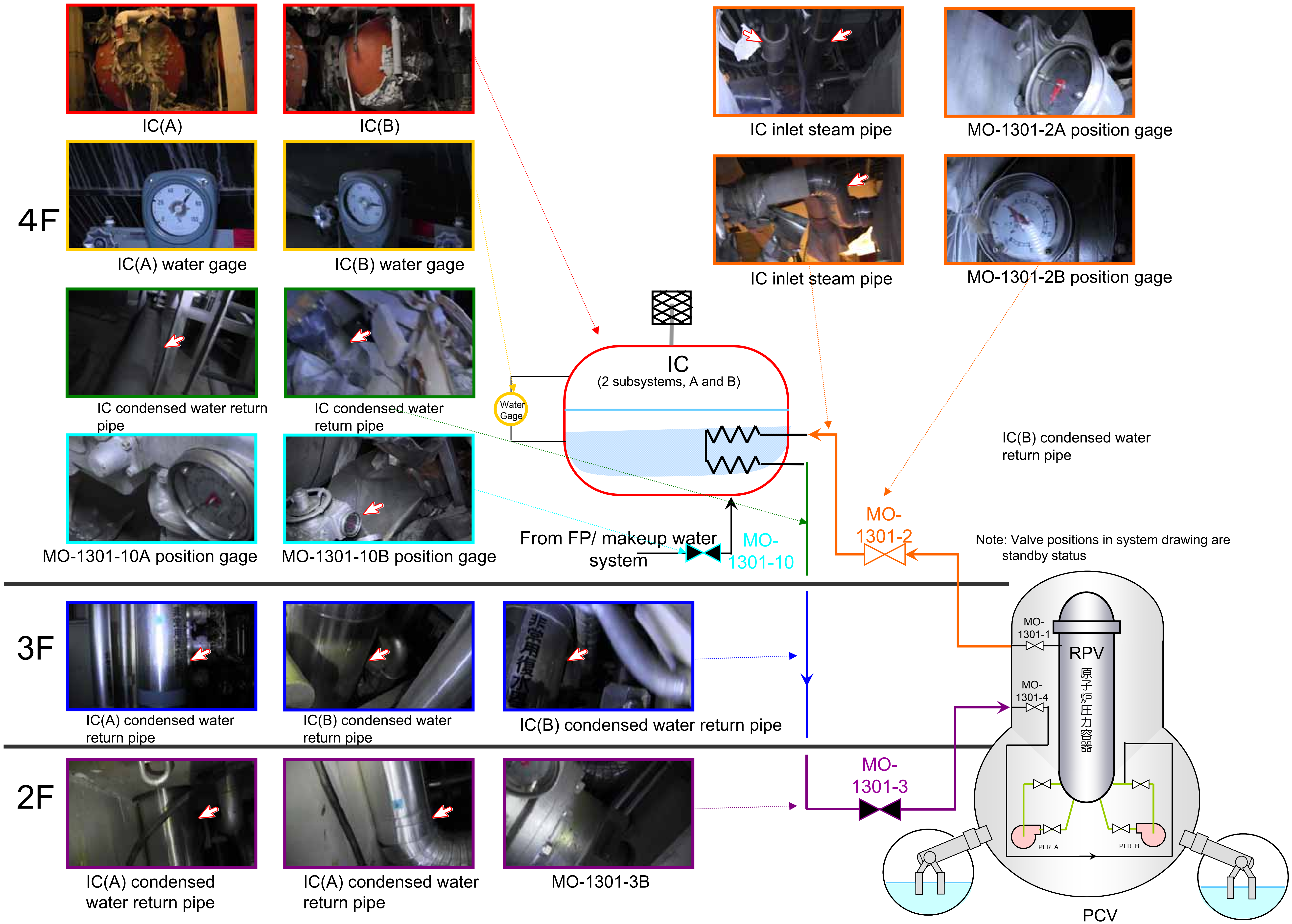
Instrumentation air compressor
・No external equipment abnormality

Feedwater heater
・There is slight cracking on the fixed leg foundation for feedwater heater 5B but there is no other external equipment damage.

Low pressure condensate pump
・No external equipment abnormality

High pressure condensate pump
・No external equipment abnormality

Fukushima Daiichi Unit 1 Isolation Condenser (IC) Visual Check Results



Fukushima Daiichi Unit 2 Results of Checking Conditions in R/B with Robot

Photos taken 2011.10.20,2012.2.27

R/B

5F

Photo taken 2011.10.20

Partition fence

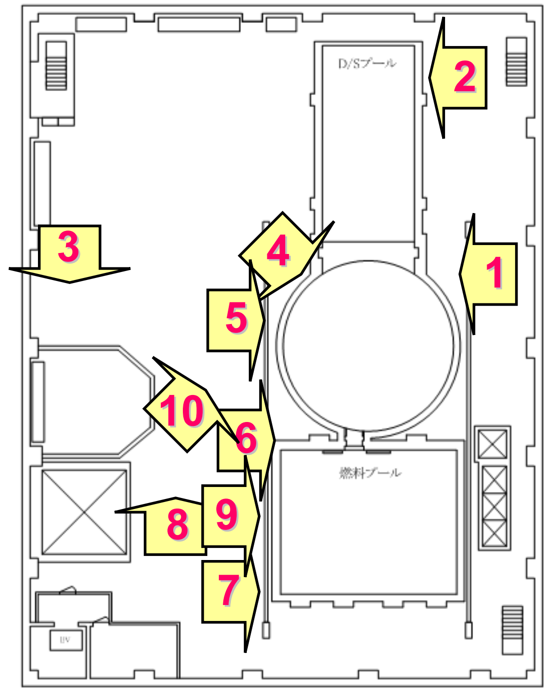
Work boots

Inundation prevention fence

Inundation prevention fence

Partition fence

Photos taken 2012.2.27



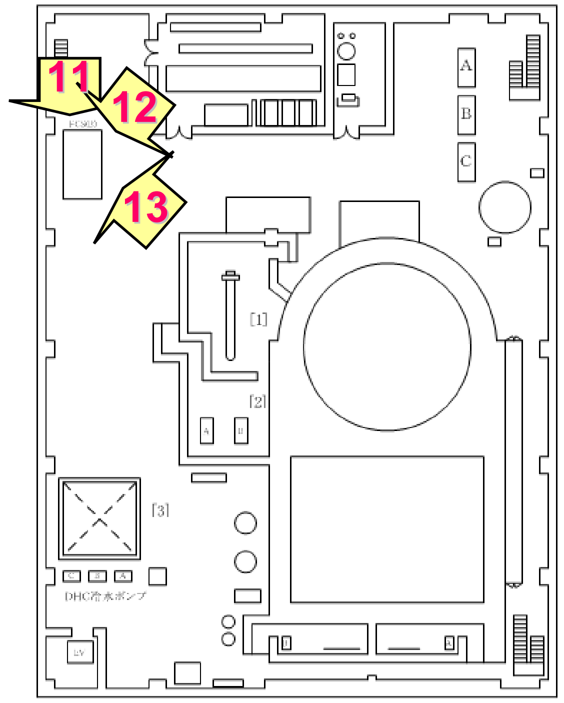
Around the SFP on the R?B 5F, inundation prevention fences and temporary partition fences on the outside were not damaged or fallen, Work boots were lined up on the floor in an organized manner.

3F

Flammability control system

・No external equipment damage found

Photos taken 2011.10.20



Fukushima Daiichi Unit 2 Results of Checking Conditions in Torus Room with Robot

Photos taken 2012.4.18

R/B basement floor torus room

Lower side in torus room

Southeast S/C manway

PCV direction

Northeast corridor

Northeast corridor upper area

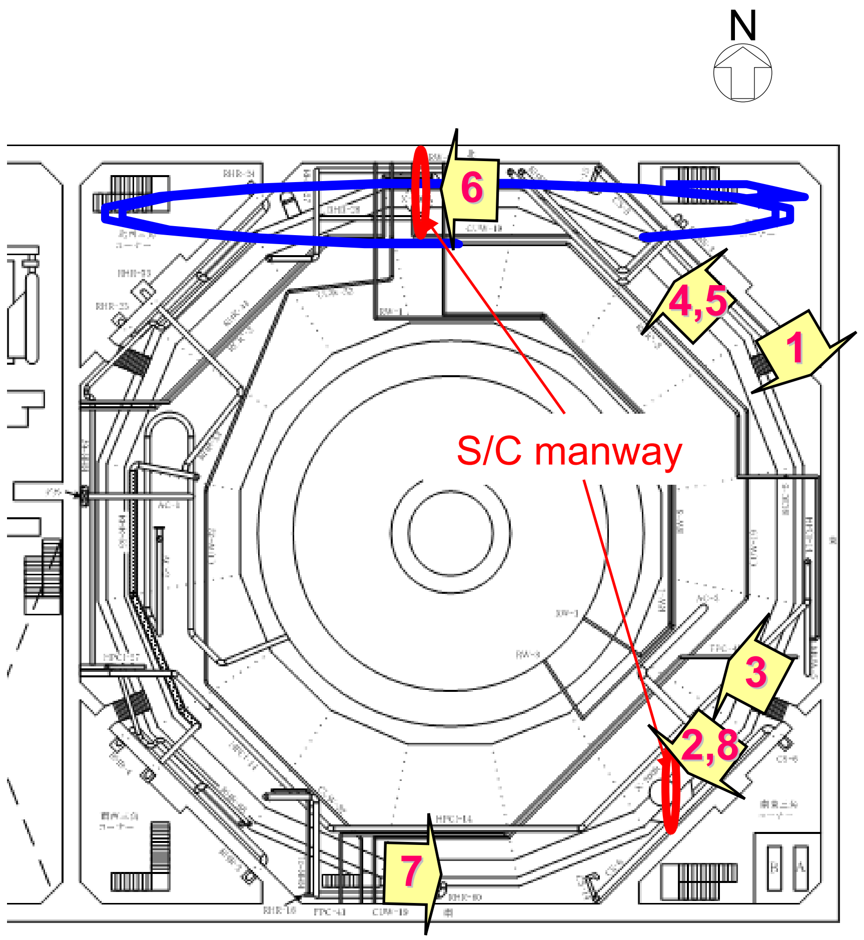
North S/C manway

・Removal of insulation cover

South corridor upper area

Southeast S/C manway upper area

・Removal of insulation cover



Robot access route

Fukushima Daiichi Unit 1, 2, 3 T/B Facility Condition Check Results

Photos taken August 24-26, 2011

2F

Unit 1

T/B closed cooling water system surge tank
・No major damage to equipment externally

HVAC duct
・HVAC duct is bulging
・Upper duct is damaged in some places

Unit 2

Jib crane support
・No major damage to equipment externally

Turbine driven reactor feedwater pump
・No major damage to equipment externally

Unit 3

Exciter room
・No major damage to equipment externally

T/B closed cooling system surge tank
・No major damage to equipment externally

1F

Unit 1

6.9kV M/C1A
・Tsunami watermark found
・No major damage to equipment externally

480V T/B MCC 1B
・Tsunami watermark found
・No major damage to equipment externally

Main turbine bypass valve
・No major damage to equipment externally

Feedwater heater
・No major damage to equipment externally

Stator cooling system
・Tsunami watermark found
・No major damage to equipment externally

Isolated phase bus cooling fan
・Tsunami watermark found
・No major damage to equipment externally

Unit 2

480V P/C 2A
・No major damage to equipment externally

480V T/B MCC 2B-1
・No major damage to equipment externally

Condenser vacuum pump
・No major damage to equipment externally

T/B closed cooling system pump
・No major damage to equipment externally

Local panel
・No major damage to equipment externally

Generator sealing oil system
・No major damage to equipment externally

Unit 3

Main turbine steam stop valve
・No major damage to equipment externally

Main turbine steam governing valve
・No major damage to equipment externally

Feedwater heater
・No major damage to equipment externally

T/B closed cooling water system heat exchanger
・No major damage to equipment externally

T/B closed cooling system pump
・No major damage to equipment externally

Instrumentation air compressor
・No major damage to equipment externally

Attachment 6-9 (7)

Fukushima Daiichi Units 1 to 4 Outdoor Facility Condition Check Results

Photos taken August 24-26, 2011


① Unit 1 seaside pumps

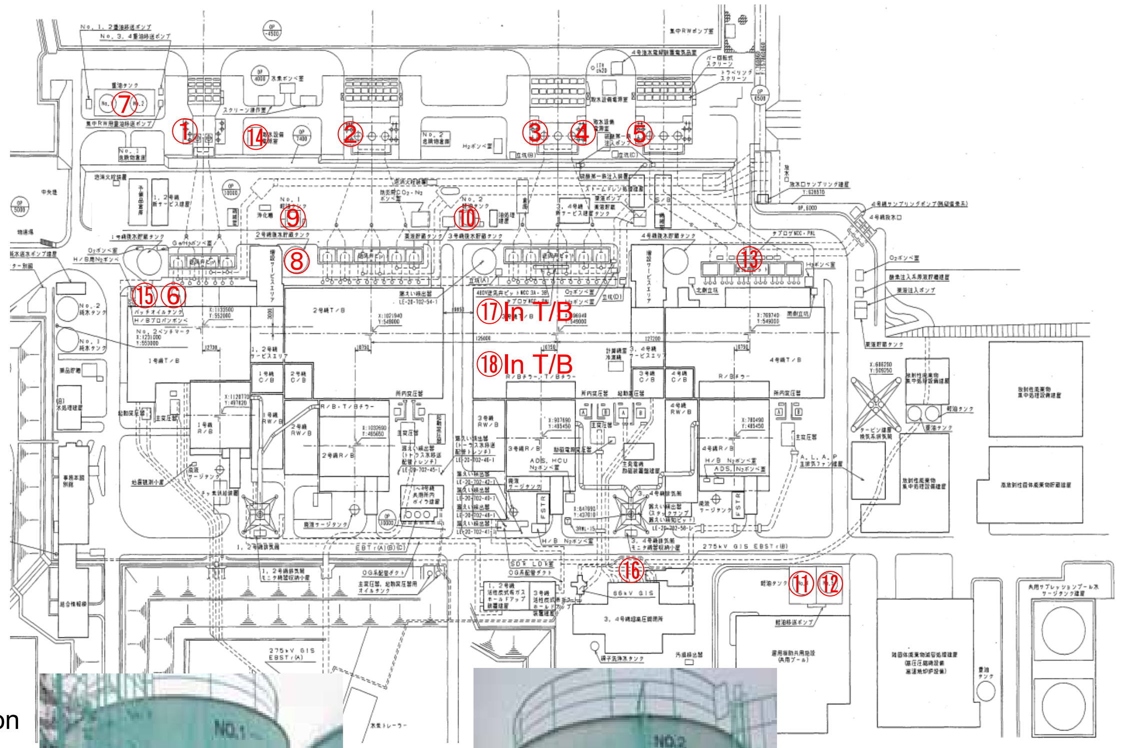

② Unit 2 seaside pumps


③ Unit 3 seaside pumps


④ Unit 3 seaside pumps
・No motor cover on Unit 3 RHR seawater pump (D)


⑤ Unit 4 seaside pump


⑥ Unit 1 batch oil tank
・No major external abnormalities including oil barrier




⑬ MCC in front of Unit 4 back wash valve
・MCC collapsed


⑭ Unit 2 intake facility power room
・Unit 2 power room collapsed


⑦ Former No.1, 2 heavy oil location


⑮ Unit 1 T/B east side rubble

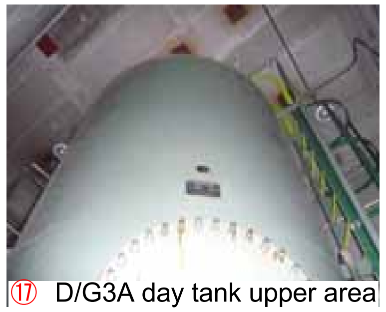

⑯ Common boiler transformer
・No major external damages


⑦ No.1,2 heavy oil tank oil barrier
・Found cracks in oil barrier

⑨ No.1 light oil tank

⑩ No.2 light oil tank


⑪ No.4 light oil tank oil barrier


⑰ D/G3A day tank upper area


⑱ D/G3B day tank upper area


⑧ Unit 2 Condensate storage tank lower ar
・Ground under tank collapsed. No leakage


⑨ No.1 light oil tank foundation


⑩ No.2 light oil tank foundation


⑫ No.5 light oil tank oil barrier

・Some subsidence of light oil tank foundation soil was found but no leakage.
・D/G3A, 3B fuel day tank is in the building but no external abnormalities were found.


⑰ D/G3A day tank lower area


⑱ D/G3B day tank lower area

Inside Unit 3 T/B

Fukushima Daiichi NPS Filtered Water Tank, Pure Water Tank Condition Check Results

② No.2 pure water tank

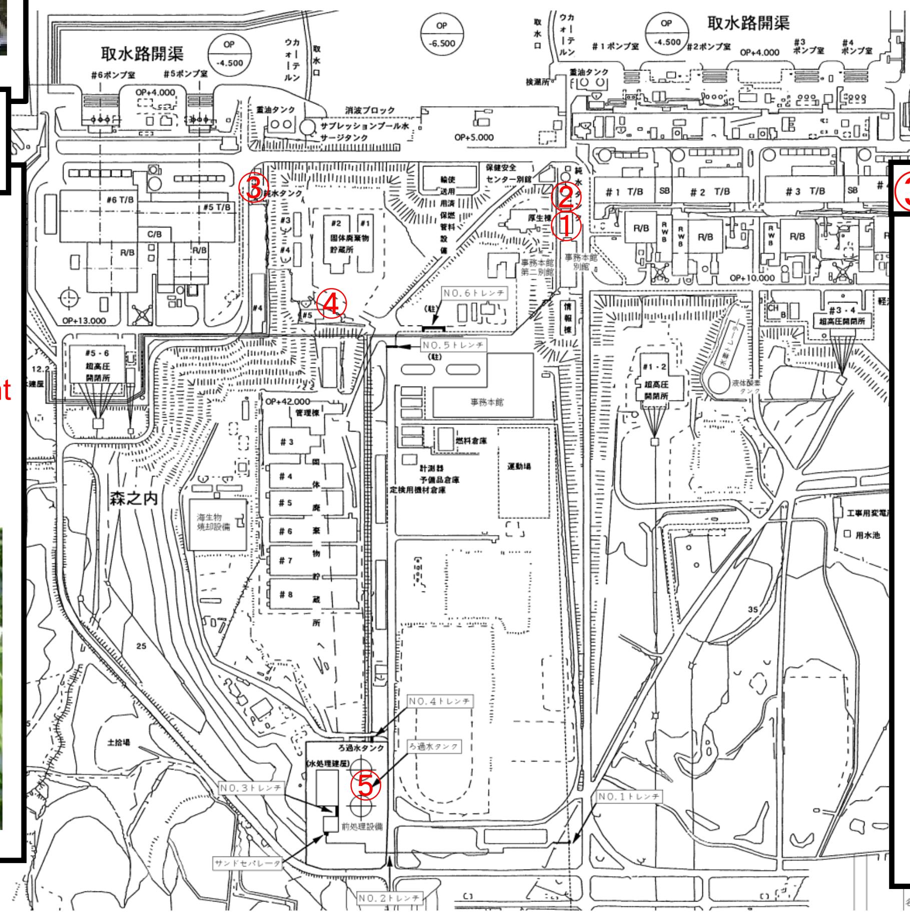
・Deformation due to collapse of tank lower area

・Leakage from bottom of tank

① No.1 pure water tank

・Deformation due to collapse of tank lower area

・Leakage after earthquake, tank outlet root valve open.



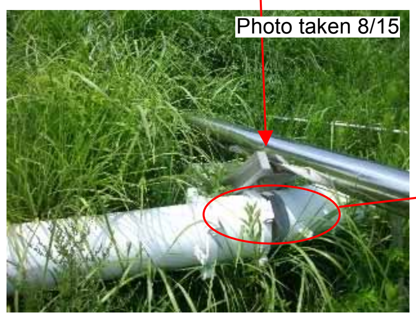
③ No.3 pure water tank

・Deformation due to collapse of tank lower area

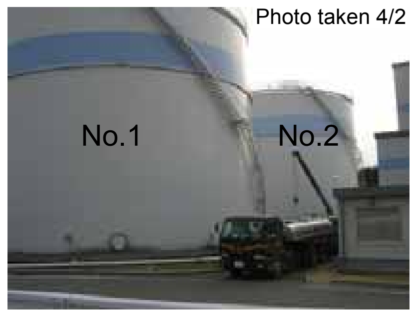
④ Transformer disaster prevention pipe leakage conditions

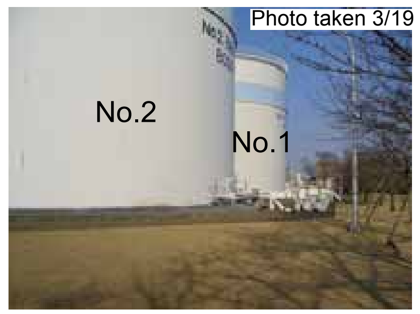
Transformer disaster prevention pipes

・Support for another pipe at a joint for the transformer disaster prevention pipe (filtered water tank source) became slanted due to collapse of the slope. Said joint made contact and caused leakage.



⑤ Filter water tank





・Deformation due to collapse of tank lower area

Fukushima Daiichi NPS Outdoor FP Pipes Condition Check Results

Photos taken August 24-26, 2011


① Fire plug (FO-20)


② Fire plug (FS-4)


③ Misc. water intake

・Intake damage (presumed to be tsunami impact)

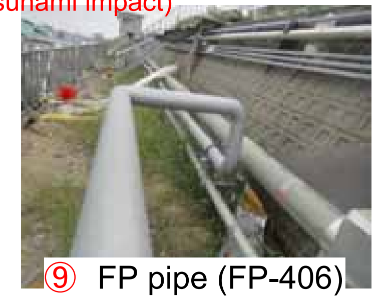

④ FP pipe (FP-420)


⑤ Fire plug (F3-5)


⑥ Fire plug (FX-07)


⑦ FP pipe (FP-106)


⑧ FP pipe (FP-201)


⑨ FP pipe (FP-406)

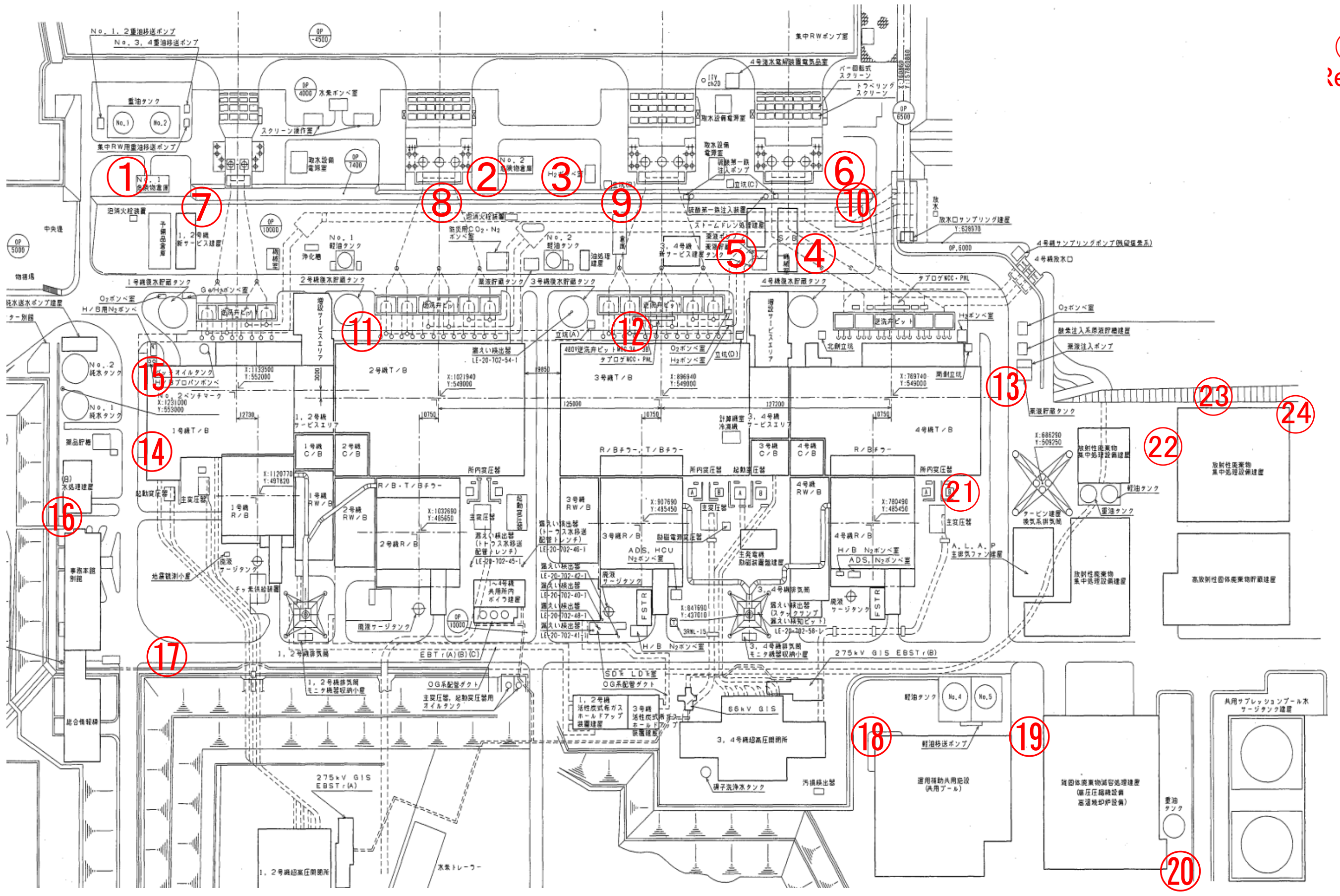

⑩ FP pipe (FP-407)

・FP pipe is deformed


⑪ Fire plug (FS-10)


⑫ FP pipe, others(FP-1,F3-9)

Significant damage of outdoor FP pipes caused by the tsunami was found on the seaside and southeast side with dislodged and deformed pipes.
No major damage to FP pipe in trenches was found.




⑬ Unit 4 water sampling outlet

Removal from foundation of sampling outlet (presumed to be tsunami impact)


⑭ FP pipe (inside trench)


⑮ FP pipe/ building interface

・ No major external damage to pipes in trench

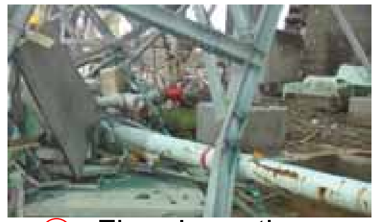

⑯ FP pipe, others


⑰ FP pipe, others


⑱ FP pipe (FP-8001)


⑲ Fire plug (G06)


⑳ FP pipe (FP-8001)


㉑ Fire plug, others (FX-04,FP-407)

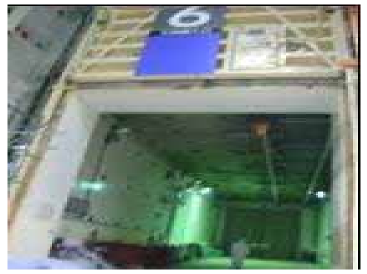
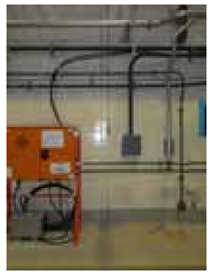

㉒ FP pipe(FP-8001)


㉓ FP pipe(FP-8001)


㉔ FP pipe(FP-8001)

・FP pipes removed from support and dislodged (presumed to be tsunami impact)

Fukushima Daiichi Units 5, 6 Building Visual Check Results

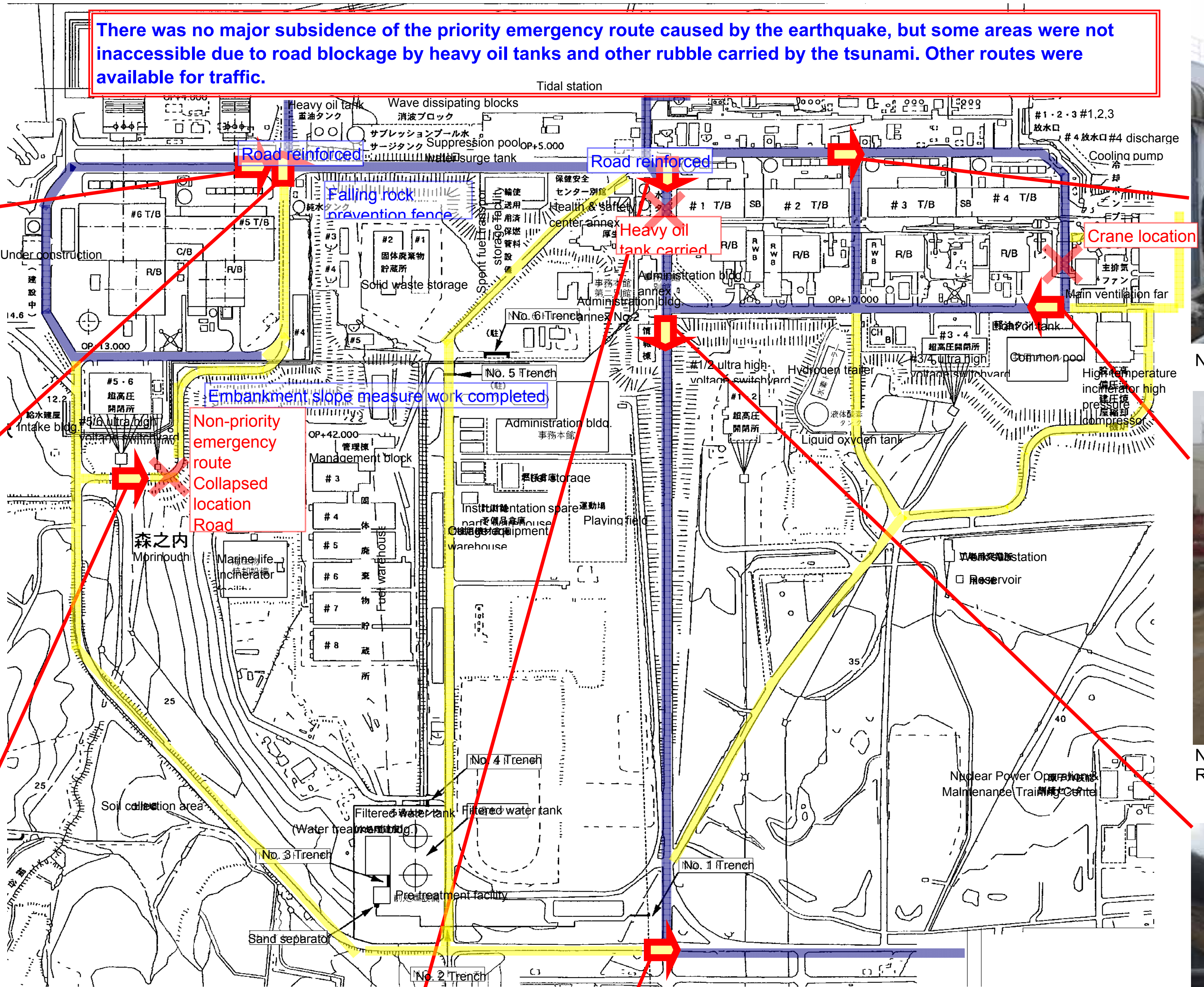
		Unit 5	Unit 6
R/B	Building exterior	 South side  West side  Northeast side ・No damages to major structures (pillars, beams, walls) including adverse structural cracks	 South side  West side  North side ・No damages to major structures (pillars, beams, walls) including adverse structural cracks
R/B	Building interior	 Truck bay ・Cracking and peeling of paint found  Truck bay ・No external damages	 East side connecting corridor ・Deformation of metal portion of expansion joint  Truck bay ・No external damages
T/B	Building exterior	 East side  South side ・No damages to major structures (pillars, beams, walls) including adverse structural cracks  East side between Unit 5/6 ・Damages to expansion cover	 East side  Northwest side ・No damages to major structures (pillars, beams, walls) including adverse structural cracks
T/B	Building interior	 Heater room west (BF) ・Damage to shielding block mortar  West side (2FL) ・Dislodged concrete fragments from partition wall	 Operating floor west side (2F) ・Damage to mortar around partition wall shielding block  Operating floor west side (2F) ・Deformation of metal portion of expansion joint  Unit 5/6 wall between turbines (2F) ・Deformation of metal portion of expansion joint

Fukushima Daiichi NPS Priority Emergency Route Condition Check Results

One side of the road on the seaside was cracked and subsided in parallel with road. West side was accessible. Photo taken 3/17

Reinforcement work was conducted on this road, but cracks and subsidence was found on both sides of the road which were not reinforced. Photo taken 3/17

Though not a priority emergency route, the slope failed and the road was blocked and impassable. Photo taken 3/20



No major damage to the road, but the heavy oil tank carried by the tsunami blocked the road making it impassable. Photo taken 3/17

No particular abnormality found with straight road from main gate. Photo taken 8/26

No particular abnormality with the road but scattered rubble. Photo taken 3/16

No particular abnormality with Units 1 to 4 west side road. Rubble was scattered when Units 1, 3, 4 R/B were damaged. Photo taken 3/20

Some rubble scattered but no particular damage to roads. Photo taken 3/20

Legend:
- Emergency priority route
- Non-emergency priority route major routes
- Impassable
- Photo location & direction

Fukushima Daiichi Unit 5 Major Facility Condition List

As of May 21, 2012

System	Facility	Building	Location	Facility condition	Actual operation*	Comments
Emergency diesel generator (D/G)	DG5A	T/B	B1F	◎	6/27/2011	No abnormality with external inspection, insulation resistance measurements
	D/G 5A SW pump A	Outdoors	—	Damage to motor (due to collapse of crane)	—	
	D/G 5A SW pump B	Outdoors	—	◎	6/22/2011	No abnormality with external pump inspection, startup after motor overhall (bearing replaced) (due to sand intrusion caused by tsunami)
	DG5B	T/B	B1F	◎	6/28/2011	No abnormality with external inspection, insulation resistance measurements
	D/G 5B SW pump C	Outdoors	—	◎	6/10/2011	No abnormality with external pump inspection, startup after motor overhall (bearing replaced) (due to sand intrusion caused by tsunami)
	D/G 5B SW pump D	Outdoors	—	○	—	
Reactor core isolation cooling system (RCIC)	Pump/ turbine	R/B	Basement (RCIC room)	○	—	
	Vacuum pump	R/B	Basement (RCIC room)	○	—	
	Condensate pump	R/B	Basement (RCIC room)	○	—	
High pressure core injection system (HPCI)	Pump/ turbine	R/B	Basement (HPCI room)	○	—	
	Vacuum pump	R/B	Basement (HPCI room)	○	—	
	Condensate pump	R/B	Basement (HPCI room)	○	—	
	Auxiliary oil pump	R/B	Basement (HPCI room)	○	—	
Core spray system (CS)	Pump A	R/B	Basement (northeast)	◎	1/20/2012	No abnormality with external inspection, insulation resistance measurements
	Pump B	R/B	Basement (southeast)	○	—	
Residual heat removal Subsystem A (RHR)	Pump A	R/B	Basement (northwest)	◎	12/21/2011	No abnormality with external inspection, insulation resistance measurements
	Pump C	R/B	Basement (northwest)	◎	3/19/2011	
Residual heat removal seawater Subsystem A (RHRS)	Pump A	Outdoors	—	Lubricating oil pipe dislodged and deformed	—	
	Pump C	Outdoors	—	Damage to motor (due to collapse of crane)	—	
Residual heat removal Subsystem B (RHR)	Pump B	R/B	Basement (southwest)	◎	12/13/2011	No abnormality with external inspection, insulation resistance measurements
	Pump D	R/B	Basement (southwest)	◎	7/15/2011	No abnormality with external inspection, insulation resistance measurements
Residual heat removal seawater Subsystem B (RHRS)	Pump B	Outdoors	—	◎	12/20/2011	No abnormality with external pump inspection, startup after motor overhall (bearing replaced) (due to sand intrusion caused by tsunami)
	Pump D	Outdoors	—	◎	7/15/2011	Startup after simple pump inspection (gland replaced), motor overhaul (bearing replaced) (due to sand intrusion caused by tsunami)
R/B cooling water system (RCW)	Pump A	R/B	3F	◎	6/4/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	R/B	3F	◎	6/4/2011	No abnormality with external inspection, insulation resistance measurements
	Pump C	R/B	3F	◎	6/4/2011	No abnormality with external inspection, insulation resistance measurements
T/B cooling water system (TCW)	Pump A	T/B	1F	○	—	Inoperable (power supply submerged)
	Pump B	T/B	1F	◎	5/23/2011	No abnormality with external inspection, insulation resistance measurements
	Pump C	T/B	1F	◎	5/23/2011	No abnormality with external inspection, insulation resistance measurements
Auxiliary seawater system (SW)	Pump A	Outdoors	—	○	—	
	Pump B	Outdoors	—	◎	12/22/2011	No abnormality with external pump inspection, startup after motor overhall (bearing replaced) (due to sand intrusion caused by tsunami)
	Pump C	Outdoors	—	◎	6/24/2011	Startup after simple pump inspection (gland replaced), motor overhaul (bearing replaced) (due to sand intrusion caused by tsunami)
Clean-up water system (CUW)	Recirculation pump A	R/B	2F	○	—	
	Recirculation pump B	R/B	2F	○	—	
Control rod drive hydraulic system (CRD)	Pump A	R/B	Basement (southeast)	○	—	
	Pump B	R/B	Basement (southeast)	○	—	
Standby liquid control system (SLC)	Pump A	R/B	4F	◎	11/25/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	R/B	4F	◎	11/30/2011	No abnormality with external inspection, insulation resistance measurements
Make up water system purified （MUWP）	Pump A	T/B	B1F	◎	3/17/2011	
	Pump B	T/B	B1F	◎	8/24/2011	No abnormality with external inspection, insulation resistance measurements
Make up water system condensate （MUWC）	Pump A	T/B	B1F	◎	3/13/2011	
	Pump B	T/B	B1F	◎	7/2/2011	No abnormality with external inspection, insulation resistance measurements
Fuel pool cooling clean-up system (FPC)	Pump A	R/B	3F	◎	8/16/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	R/B	3F	◎	6/24/2011	No abnormality with external inspection, insulation resistance measurements
Standby gas treatment system (SGTS)	Fan A	T/B	2F	◎	3/13/2011	No abnormality with external inspection, insulation resistance measurements
	Fan B	T/B	2F	◎	7/2/2011	No abnormality with external inspection, insulation resistance measurements
Station service area system (SA)	Compressor	T/B	1F	◎	5/11/2011	No abnormality with external inspection, insulation resistance measurements
Instrument air system (IA)	Compressor A	T/B	1F	◎	6/1/2011	No abnormality with external inspection, insulation resistance measurements
	Compressor B	T/B	1F	◎	3/31/2011	No abnormality with external inspection, insulation resistance measurements

◎: Operating or standby
○: Not on standby (no external abnormalities)
—: Not applicable
*: Indicates the day when it was first confirmed to be operable after the earthquake

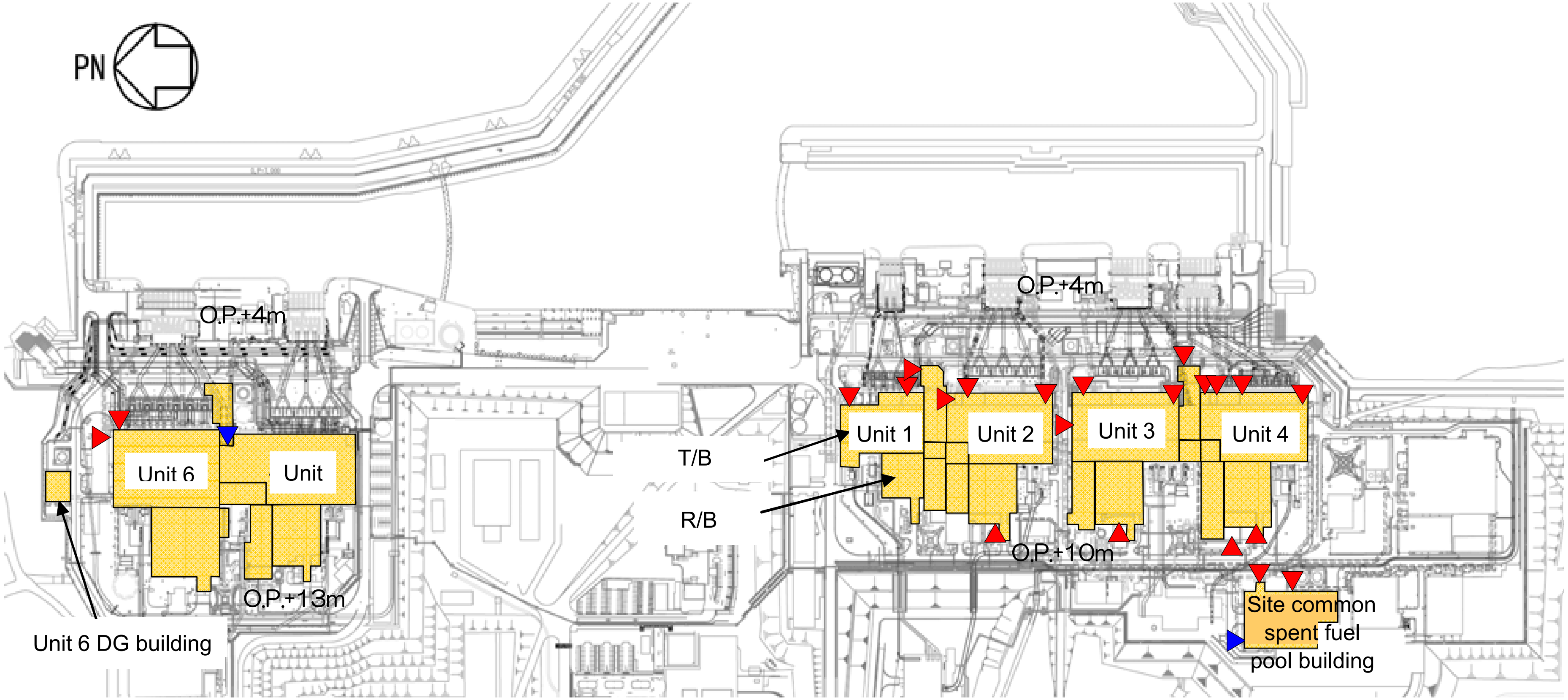
Fukushima Daiichi Unit 6 Major Facility Condition List

As of May 21, 2012

System	Facility	Building	Location	Facility condition	Actual operation	Comments
Emergency diesel generator (D/G)	DG6A	C/S	B1F	◎	3/19/2011	
	D/G 6A SW pump	Outdoor	―	◎	3/18/2011	No abnormality with external inspection, insulation resistance measurements
	DG6B	DG/B	1F	◎	3/11/2011	
	EECW pump	DG/B	B1F	◎	3/11/2011	
	HPCS D/G	C/S	B1F	○	―	
	HPCS D/G SW pump	Outdoor	―	Damage to motor	―	
Reactor core isolation cooling system (RCIC)	RCIC turbine/ pump	R/B	B2F	○	―	
	Vacuum pump	R/B	B2F	○	―	
	Condensate pump	R/B	B2F	○	―	
High pressure core spray system	Pump	R/B	B2F	○	―	
Low pressure core spray system (LPCS)	Pump	R/B	B2F	◎	12/15/2011	No abnormality with external inspection
Residual heat removal system Subsystem A	Pump A	R/B	B2F	◎	9/9/2011	No abnormality with external inspection
Residual heat removal seawater subsystem A (RHRS)	Pump A	Outdoor	―	◎	12/27/2011	No abnormality with external inspection, insulation resistance measurements
	Pump C	Outdoor	―	◎	9/9/2011	Startup after simple pump inspection (gland replaced), motor overhaul (bearing replaced) (due to sand intrusion caused by tsunami)
Residual heat removal Subsystem B (RHR)	Pump B	R/B	B2F	◎	3/19/2011	
Residual heat removal seawater Subsystem B (RHRS)	Pump B	Outdoor	―	Motor cooling water pipe ruptured	―	
	Pump D	Outdoor	―	○	―	
Residual heat removal system Subsystem C (RHR)	Pump C	R/B	B2F	◎	12/2/2011	No abnormality with external inspection
R/B cooling water system (RCW)	Pump A	T/B	1F	◎	3/17/2011	
	Pump B	T/B	1F	◎	3/17/2011	
	Pump C	T/B	1F	◎	8/16/2011	No abnormality with external inspection, insulation resistance measurements
T/B cooling water system (TCW)	Pump A	T/B	1F	◎	7/29/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	T/B	1F	◎	7/29/2011	No abnormality with external inspection, insulation resistance measurements
	Pump C	T/B	1F	◎	7/29/2011	No abnormality with external inspection, insulation resistance measurements
Auxiliary seawater system (SW)	Pump A	Outdoor	―	◎	9/15/2011	Startup after simple pump inspection (gland replaced), motor overhaul (bearing replaced) (due to sand intrusion caused by tsunami)
	Pump B	Outdoor	―	○	―	
	Pump C	Outdoor	―	◎	2/22/2012	Startup after simple pump inspection (gland replaced), motor overhaul (bearing replaced) (due to sand intrusion caused by tsunami)
Reactor water clean-up system (RWCU)	Recirculation pump A	R/B	2F	◎	10/7/2011	No abnormality with external inspection
	Recirculation pump B	R/B	2F	◎	1/13/2012	No abnormality with external inspection
Control rod drive hydraulic system (CRD)	Pump A	R/B	B1F	◎	10/7/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	R/B	B1F	◎	1/13/2012	No abnormality with external inspection, insulation resistance measurements
Standby liquid control system (SLC)	Pump A	R/B	5F	○	―	
	Pump B	R/B	5F	◎	11/8/2011	No abnormality with external inspection, insulation resistance measurements
Make up water system purified (MUWP)	Pump A	T/B	B1F	◎	7/27/2011	No abnormality with external inspection
	Pump B	T/B	B1F	◎	5/11/2011	No abnormality with external inspection, insulation resistance measurements
Make up water system condensate (MUWC)	Pump A	T/B	B1F	◎	7/12/2011	No abnormality with external inspection, insulation resistance measurements
	Pump B	T/B	B1F	◎	3/13/2011	
Fuel pool cooling clean-up system (FPC)	Pump A	R/B	4F	◎	3/16/2011	
	Pump B	R/B	4F	◎	8/17/2011	No abnormality with external inspection, insulation resistance measurements
Standby gas treatment system (SGTS)	Fan A	C/S	3F	◎	6/3/2011	No abnormality with external inspection, insulation resistance measurements
	Fan B	C/S	3F	◎	3/11/2011	
Station service area system (SA)	Compressor A	T/B	B1F	◎	9/21/2011	No abnormality with external inspection, insulation resistance measurements
	Compressor B	T/B	B1F	◎	9/21/2011	No abnormality with external inspection, insulation resistance measurements
Instrument air system (IA)	Compressor A	T/B	B1F	◎	9/21/2011	No abnormality with external inspection, insulation resistance measurements
	Compressor B	T/B	B1F	◎	9/21/2011	No abnormality with external inspection, insulation resistance measurements

◎: Operating or standby
○: Not on standby (no external abnormalities)
―: Not applicable
*: Indicates the day when it was first confirmed to be operable after the earthquake

Fukushima Daiichi Nuclear Power Station
Location of Openings That May Be Water Flow Pathways Into Major Buildings

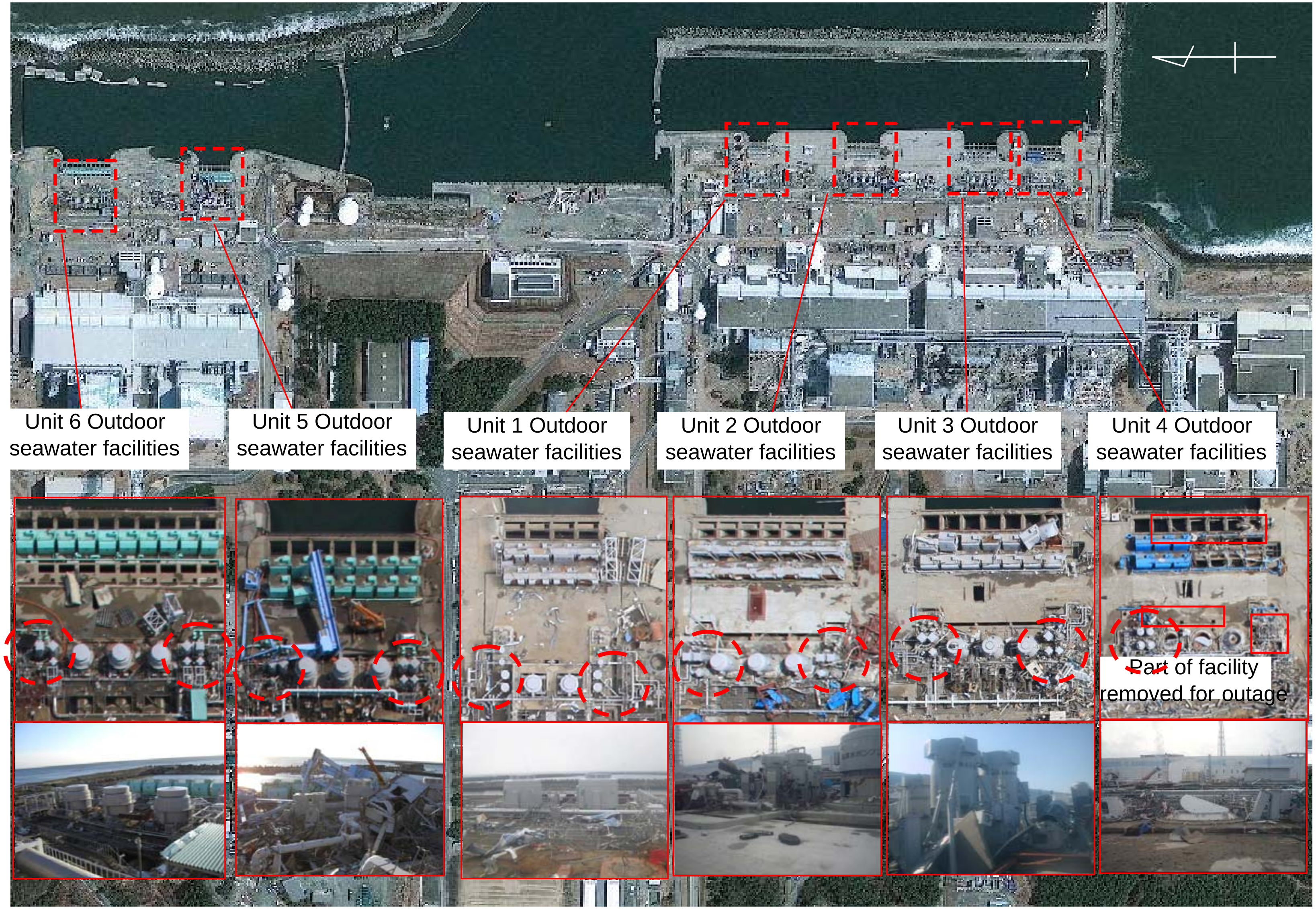


▼ : Above-ground openings assumed to be water flow pathways into major buildings
▼ : Openings connecting to underground trenches/ducts assumed to be water flow pathways into major buildings

Attachment 7-1

*1:Diesel Generator Sea Water pump
*2:Circulating Water pump
*3:Residual Heat Removal System Sea Water pump

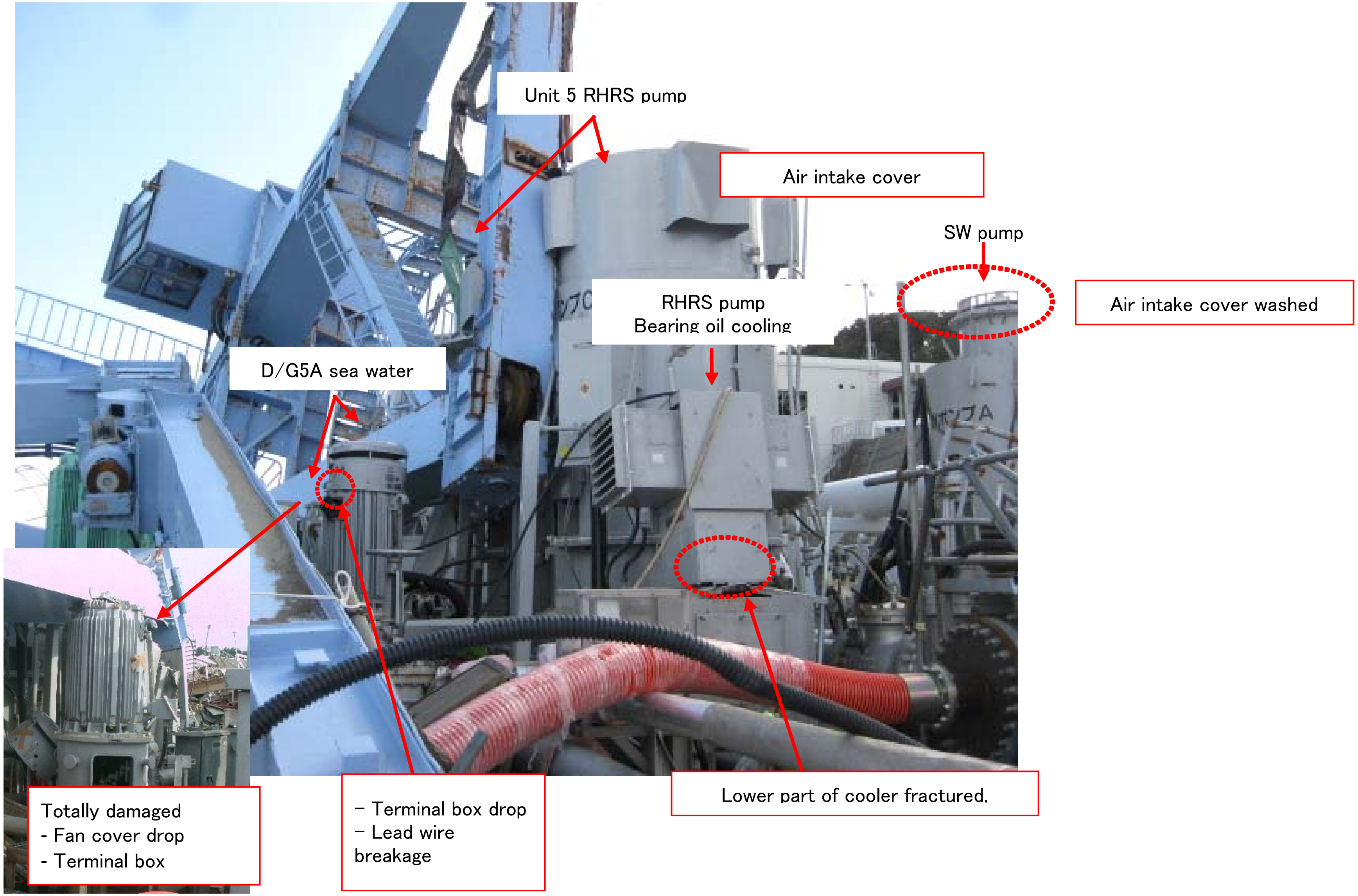
Facility configuration example



(C)GeoEye / Japan Space Imaging

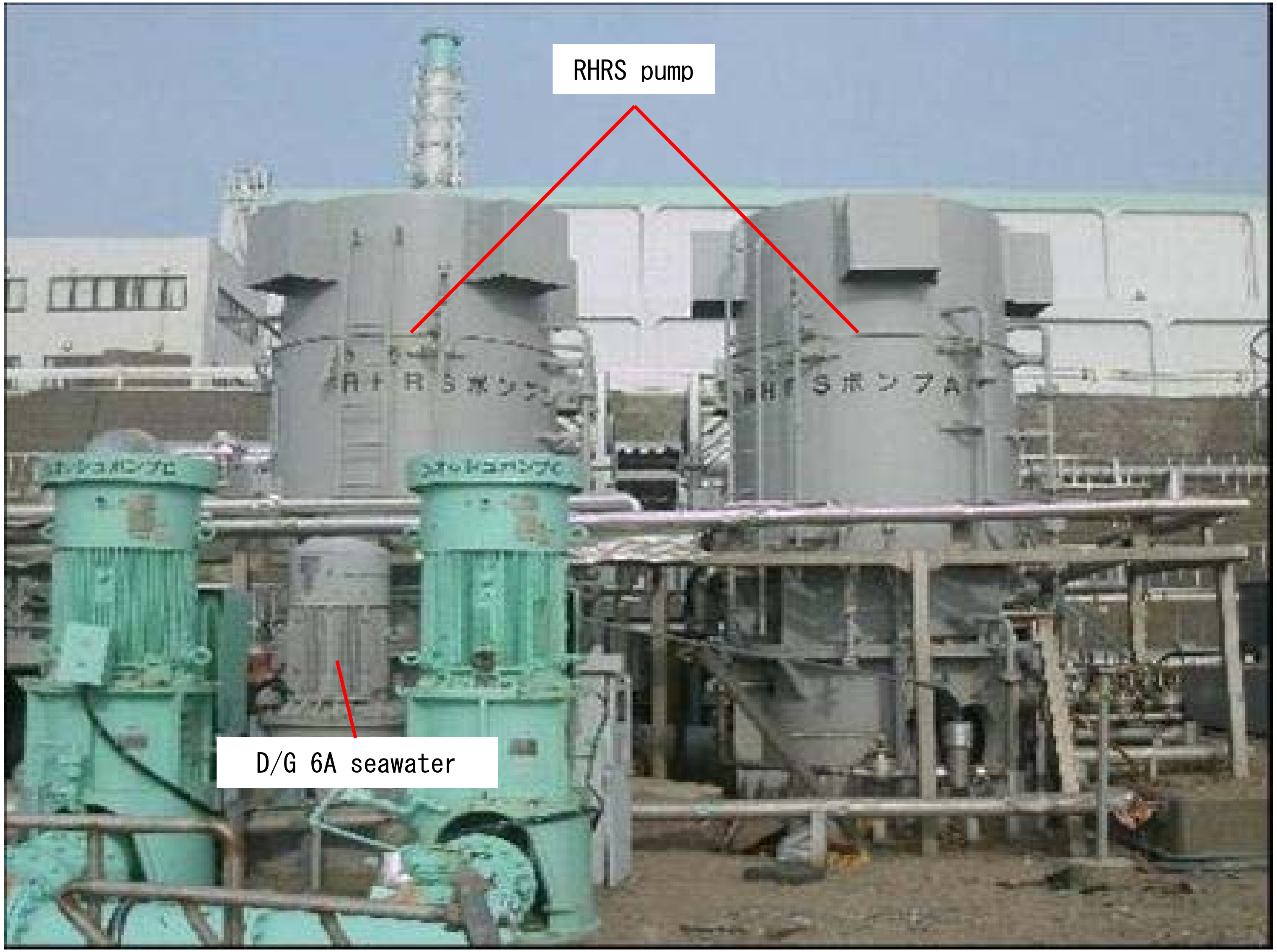
Emergency seawater system pump installation point

Fukushima Daiichi Nuclear Power Station Damage state of sea side, outdoor seawater



Fukushima Daiichi Nuclear Power Station Unit 5,6 damage state of seawater pump due to collapse of screen facility inspection crane

Attachment 7-2

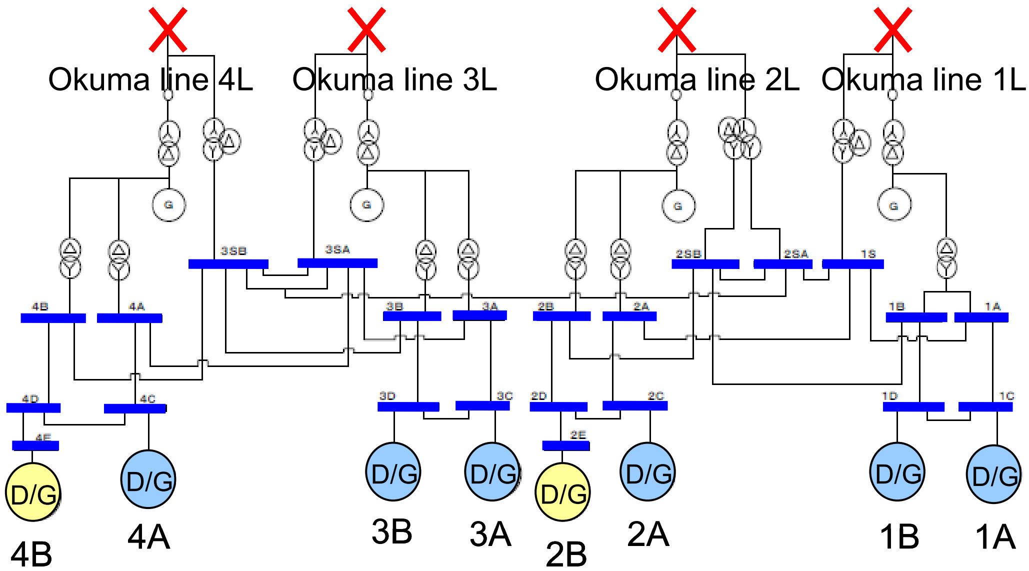


Fukushima Daiichi Unit 6 state of emergency seawater

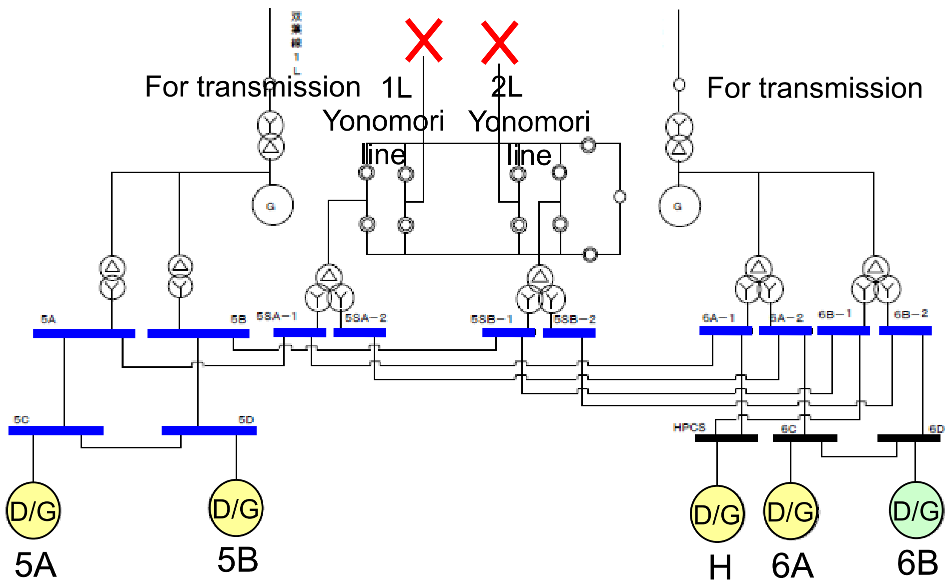
Attachment 7-2

Fukushima Daiichi Nuclear Power Station
State of Damage of Power Systems by Tsunami

Units 1 to 4



Units 5, 6



X :Shutdown due to earthquake

D/G : Main unit submerged by tsunami

D/G : Operable after tsunami

: Power panel suffered water damage or submerged by tsunami

D/G :M/C related equipment submerged by tsunami

(M/C: Metal clad switchgear)

Damage Status at Fukushima Daiichi Nuclear Power Station(After Tsunami)

This table is based on the results of interviews with TEPCO employees who confirmed the damages to site power supply facilities though field patrols and field investigations.

Units 1 to 2

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
Startup transformer	STr(1S)	Transformer yard	Above ground	Unknown	Water damage	STr(2S)	Transformer yard	Above ground	Unknown	Water damage Ancillary items such as insulator damaged
Cable	OF cable (Switchyard～STr(1S))	–	Basement	Unknown	External appearance partially OK	OF cable (Switchyard～STr(2S))	–	Basement	Unknown	Cannot be verified (Note 2)

	Unit 1 Equipment	Location	Floor	Operable?	Conditions	Unit 2 Equipment	Location	Floor	Operable?	Conditions
Emergency Diesel Generator	DG 1A	T/B	B1FL	×	Submerged	DG 2A	T/B	B1FL	×	Submerged
Emergency Diesel Generator	DG 1B	T/B	B1FL	×	Submerged	DG 2B	Common pool	1FL	×	M/C submerged inoperable
Emergency Diesel Generator	–	–	–	–	–	–	–	–	–	–
(M/C) High voltage power panel [Safety]	M/C 1C	T/B	1FL	×	Water damage	M/C 2C	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Safety]	M/C 1D	T/B	1FL	×	Water damage	M/C 2D	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Safety]	–	–	–	–	–	M/C 2E	Common pool	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 1A	T/B	1FL	×	Water damage	M/C 2A	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 1B	T/B	1FL	×	Water damage	M/C 2B	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 1S	T/B	1FL	×	Water damage	M/C 2SA	M/C 2SA bldg.	1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]						M/C 2SB	T/B	B1FL	×	Submerged

Units 3 to 4

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
Startup transformer	STr(3SA)	Transformer yard	Above ground	Unknown	Cannot be verified (Note 1)	Str(3SB)	Transformer yard	Above ground	Unknown	Cannot be verified (Note 1)
Cable	CV cable (Switchyard～Str(3SA))	–	Basement	–	Under work	OF cable (Switchyard～STr(3SB))	–	Basement	Unknown	Cannot be verified (Note 2)

	Unit 3 Equipment	Location	Floor	Operable?	Conditions	Unit 4 Equipment	Location	Floor	Operable?	Conditions
Emergency Diesel Generator	DG 3A	T/B	B1FL	×	Submerged	DG 4A	T/B	B1FL	×	Submerged (Under work)
Emergency Diesel Generator	DG 3B	T/B	B1FL	×	Submerged	DG 4B	Common pool	1FL	×	M/C submerged Inoperable
Emergency Diesel Generator	–	–	–	–	–	–	–	–	–	–
(M/C) High voltage power panel [Safety]	M/C 3C	T/B	B1FL	×	Submerged	M/C 4C	T/B	B1FL	×	Submerged (under inspection)
(M/C) High voltage power panel [Safety]	M/C 3D	T/B	B1FL	×	Submerged	M/C 4D	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Safety]	–	–	–	–	–	M/C 4E	Common pool	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 3A	T/B	B1FL	×	Submerged	M/C 4A	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 3B	T/B	B1FL	×	Submerged	M/C 4B	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 3SA	C/B	B1FL	×	Submerged	–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]						–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]	M/C 3SB	C/B	B1FL	×	Submerged	–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]						–	–	–	–	–

Units 5 to 6

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
Startup transformer	STr(5SA)	Transformer yard	Above ground	○	–	STr (5SB)	Transformer yard	Above ground	○	–
Cable	CV cable (Switchyard～STr(5SA))	–	Basement	○	–	CV cable (Switchyard～STr(5SB))	–	Basement	○	–

	Unit 5 Equipment	Location	Floor	Operable?	Conditions	Unit 6 Equipment	Location	Floor	Operable?	Conditions
Emergency Diesel Generator	DG 5A	T/B	B1FL	×	Related equipment (excitation equipment) submerged	DG 6A	C/S	B1FL	×	Related equipment (SW pump) Water damage
Emergency Diesel Generator	DG 5B	T/B	B1FL	×	Related equipment (excitation equipment) submerged	DG 6B	DG bldg.	1FL	○	–
Emergency Diesel Generator	–	–	–	–	–	HPCSD/G	C/S	B1FL	×	Related equipment (SW pump) Water damage
(M/C) High voltage power panel [Safety]	M/C 5C	T/B	B1FL	×	Submerged	M/C 6C	C/S	B2FL	○	–
(M/C) High voltage power panel [Safety]	M/C 5D	T/B	B1FL	×	Submerged	M/C 6D	C/S	B1FL	○	–
(M/C) High voltage power panel [Safety]	–	–	–	–	–	HPCS DG M/C	C/S	1FL	○	–
(M/C) High voltage power panel [Non-Safety]	M/C 5A	C/B	B1FL	×	Submerged	M/C 6A-1	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]						M/C 6A-2	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 5B	C/B	B1FL	×	Submerged	M/C 6B-1	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]						M/C 6B-2	T/B	B1FL	×	Submerged
(M/C) High voltage power panel [Non-Safety]	M/C 5SA-1	C/B	B1FL	×	Submerged	–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]	M/C 5SA-2	C/B	B1FL	×	Submerged	–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]	M/C 5SB-1	C/B	B1FL	×	Submerged	–	–	–	–	–
(M/C) High voltage power panel [Non-Safety]	M/C 5SB-2	C/B	B1FL	×	Submerged	–	–	–	–	–

Operable: Results determined by TEPCO employees checking equipment conditions in the field
Water damage: Water intrusion watermarks are found
Submerged: Water has accumulated
：Equipment not operable
：Not able to receive power due to inoperability of upstream feed source
：D/G is not damaged by water but is inoperable due to submersion of M/C and other related equipment
T/B ：Turbine Building
C/B ：Control Building
C/S ：Reactor Combination Structure

Note 1: Due to high radiation
Note 2: Assumed that location is submerged

Attachment 7-4 (1/2)

Damage Status at Fukushima Daiichi Nuclear Power Station(After Tsunami)

This table is based on the results of interviews with TEPCO employees who confirmed the damages to site power supply facilities though field patrols and field investigations.

Units 1 to 2

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
(P/C) Power center [Safety]	P/C 1C	C/B	B1FL	×	Submerged	P/C 2C	T/B	1FL	○	Base damaged by water
	P/C 1D	C/B	B1FL	×	Submerged	P/C 2D	T/B	1FL	○	Base damaged by water
	–	–	–	–	–	P/C 2E	Common pool	B1FL	×	Submerged
(P/C) Power center [Non-safety]	P/C 1A	T/B	1FL	×	Water damage	P/C 2A	T/B	1FL	○	Base damaged by water
						P/C 2A-1	T/B	B1FL	×	Submerged
	P/C 1B	T/B	1FL	×	Water damage	P/C 2B	T/B	1FL	○	Base damaged by water
	–	–	–	–	–	–	–	–	–	–
	P/C 1S	T/B	1FL	×	Water damage	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	P/C 2SB	T/B	B1FL	×	Submerged
DC125V	125V DC BUS-1A	C/B	B1FL	×	Submerged	125V DC DIST CTR 2A	C/B	B1FL	×	Submerged
	125V DC BUS-1B	C/B	B1FL	×	Submerged	125V DC DIST CTR 2B	C/B	B1FL	×	Submerged
	–	–	–	–	–	125V DC 2D/G B main bus panel	Common pool	B1FL	×	Submerged

Units 3 to 4

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
(P/C) Power center [Safety]	P/C 3C	T/B	B1FL	×	Submerged	P/C 4C	T/B	1FL	–	Under work
	P/C 3D	T/B	B1FL	×	Submerged	P/C 4D	T/B	1FL	○	–
	–	–	–	–	–	P/C 4E	Common pool	B1FL	×	Submerged
(P/C) Power center [Non-safety]	P/C 3A	T/B	B1FL	×	Submerged	P/C 4A	T/B	1FL	–	Under work
	–	–	–	–	–	–	–	–	–	–
	P/C 3B	T/B	B1FL	×	Submerged	P/C 4B	T/B	1FL	○	–
	–	–	–	–	–	–	–	–	–	–
	P/C 3SA	C/B	B1FL	×	Submerged	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–
	P/C 3SB	C/B	B1FL	×	Submerged	–	–	–	–	–
DC125V	125V DC main bus panel 3A	T/B	MB1FL	○	–	125V DC main bus panel 4A	C/B	B1FL	×	Submerged
	125V DC main bus panel 3B	T/B	MB1FL	○	–	125V DC main bus panel 4B	C/B	B1FL	×	Submerged
	–	–	–	–	–	125V DC 4D/G B main bus panel	Common pool	B1FL	×	Submerged

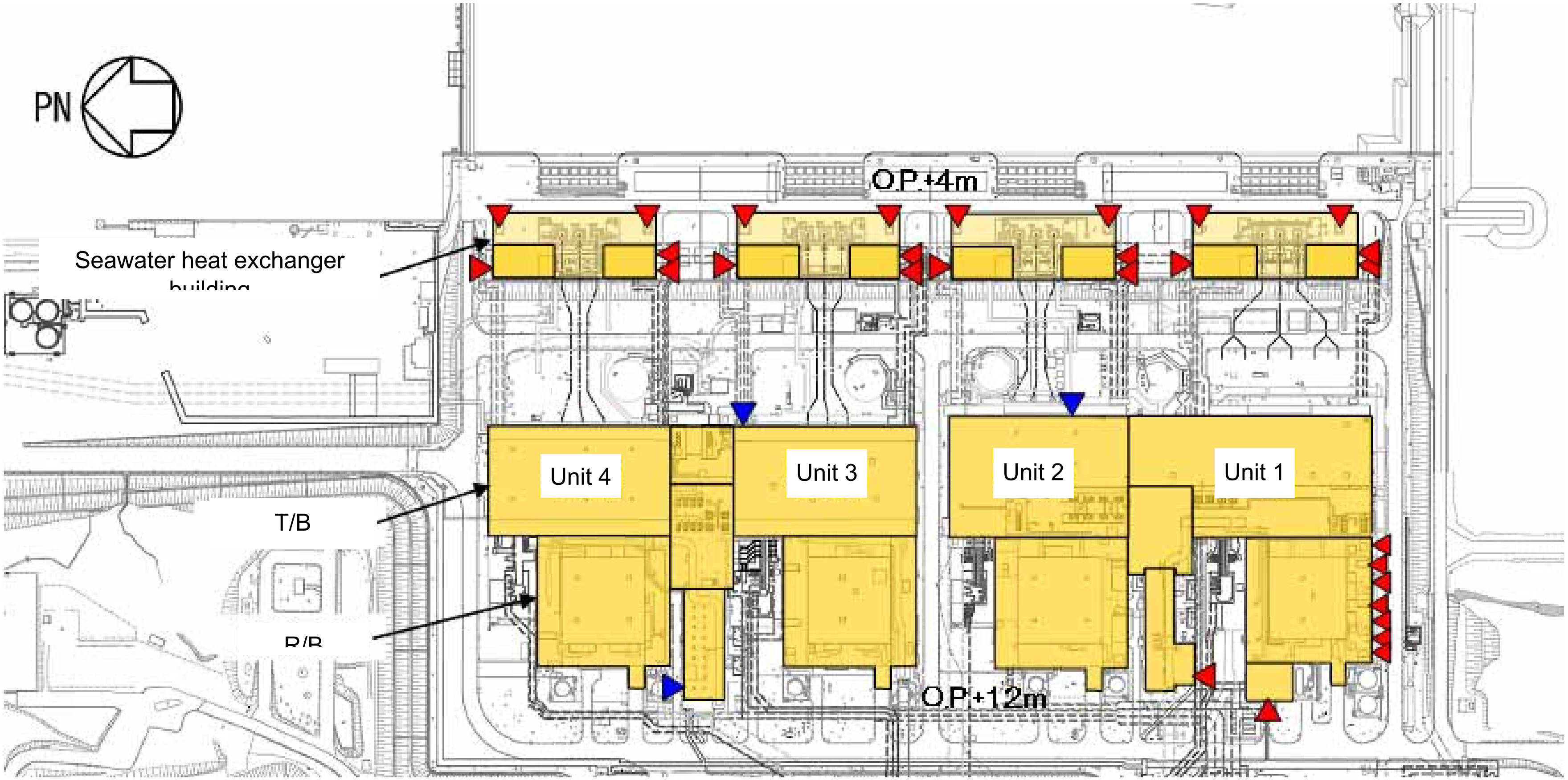
Units 5 to 6

	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
(P/C) Power center [Safety]	P/C 5C	T/B	B1FL	×	Water damage	P/C 6C	C/S	B2FL	○	–
	P/C 5D	T/B	B1FL	×	Water damage	P/C 6D	C/S	B1FL	○	–
	–	–	–	–	–	P/C 6E	DG bldg.	B1FL	○	–
(P/C) Power center [Non-safety]	P/C 5A	C/B	B1FL	×	Water damage	P/C 6A-1	T/B	B1FL	×	Water damage
	P/C 5A-1	T/B	2FL	○	–	P/C 6A-2	T/B	B1FL	×	Water damage
	P/C 5B	C/B	B1FL	×	Water damage	P/C 6B-1	T/B	B1FL	×	Water damage
	P/C 5B-1	T/B	2FL	○	–	P/C 6B-2	T/B	B1FL	×	Water damage
	P/C 5SA	C/B	B1FL	×	Water damage	–	–	–	–	–
	P/C 5SA-1	T/B	B1FL	×	Water damage	–	–	–	–	–
	P/C 5SB	C/B	B1FL	×	Water damage	–	–	–	–	–
DC125V	125V DC main bus panel 5A	T/B	MB1FL	○	–	125V DC PLANT DISTR CENTER 6A	T/B	MB1FL	○	–
	125V DC main bus panel 5B	T/B	MB1FL	○	–	125V DC PLANT DISTR CENTER 6B	T/B	MB1FL	○	–
	–	–	–	–	–	125V DC HPCS DIST CTR	C/S	1FL	○	–

Operable: Results determined by TEPCO employees checking equipment conditions in the field
Water damage: Water intrusion watermarks are found
Submerged: Water has accumulated
(pink) ：Equipment inoperable
(yellow) ：Not able to receive power due to inoperability of M/C feeding power
T/B ：Turbine Building
C/B ：Control Building
C/S ：Reactor Combination Structure

Attachment 7-4 (2/2)

Fukushima Daini Nuclear Power Station
Location of Openings That May Be Water Flow Pathways Into Major Buildings



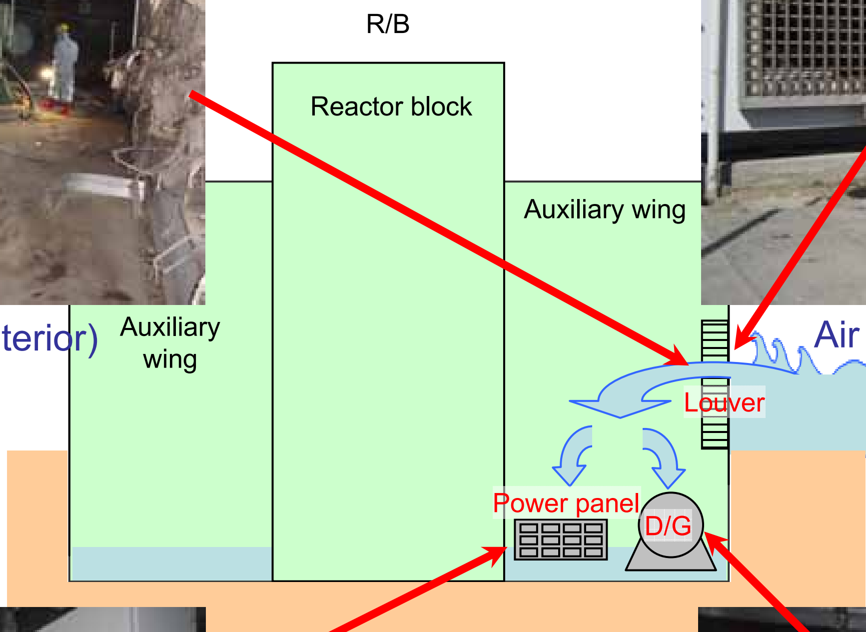
▼ : Above-ground openings assumed to be water flow pathways into major buildings
▼ : Openings connecting to underground trenches/ducts assumed to be water flow pathways into major buildings

Attachment 7-5 (1)

Fukushima Daini Unit 1 EDG Water Damage Conditions

Air supply louver (from interior)

Air supply louver (from exterior)



M/C power panel

EDG

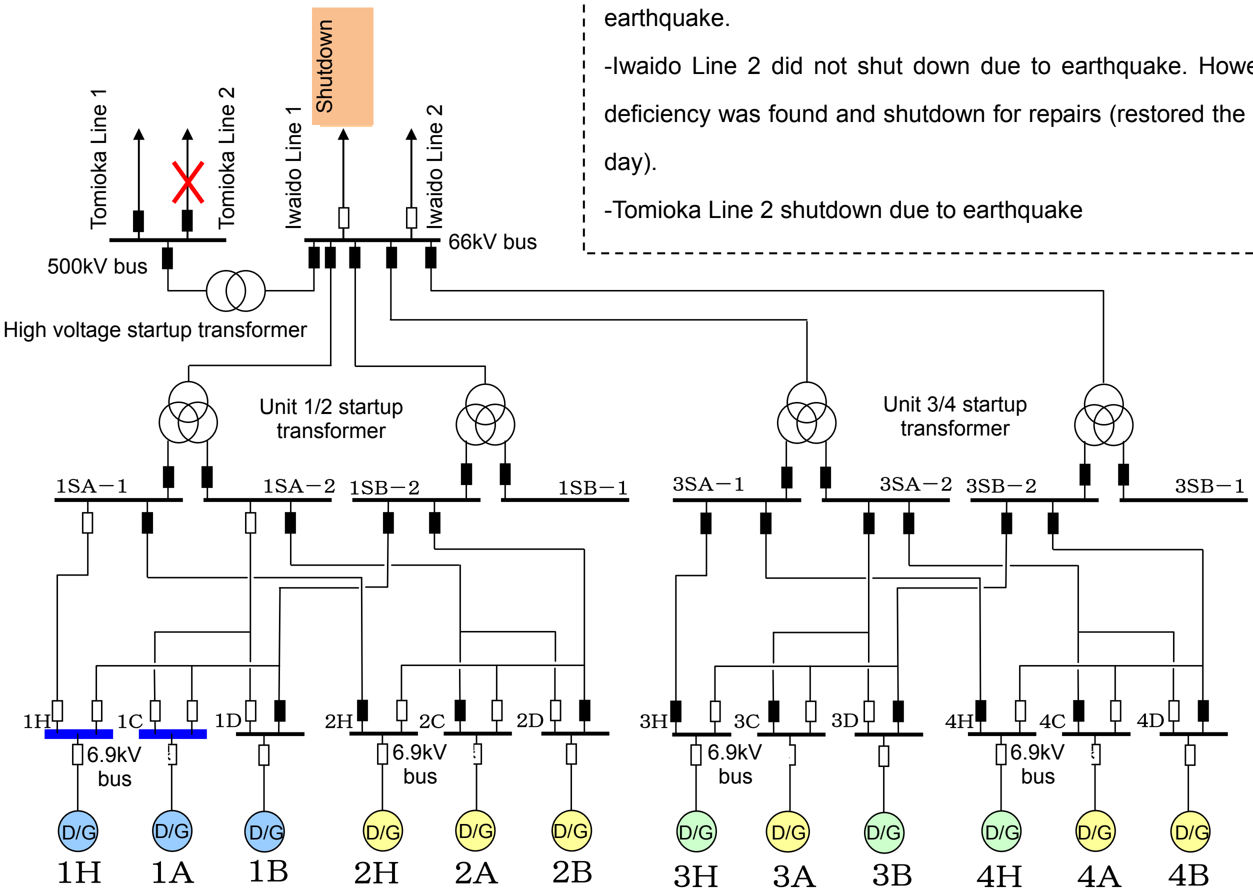
Attachment 7-5 (2)

Fukushima Daini Nuclear Power Station
Power System Damage Conditions Caused by Tsunami

-Iwaido Line 1 was shut down due to inspection before the earthquake.

-Iwaido Line 2 did not shut down due to earthquake. However, deficiency was found and shutdown for repairs (restored the next day).

-Tomioka Line 2 shutdown due to earthquake



X : Shutdown due to earthquake

▬ : Power panel damaged by water or submerged due to tsunami

D/G (blue) : Main unit submerged due to tsunami

D/G (yellow) : M/C or related equipment submerged due to tsunami

D/G (green) : Operable after tsunami

(M/C: Metal clad switchgear)

Damage Status at Fukushima Daiini Nuclear Power Station(After Tsunami)

This table is based on the results of interviews with TEPCO employees who confirmed the damages to site power supply facilities though field patrols and field investigations.

	Units 1 to 2										Units 3 to 4									
	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable	Conditions
Startup transformer	STr(1SA)	Transformer yard	Above ground	○	—	STr(1SB)	Transformer yard	Above ground	○	—	STr(3SA)	Transformer yard	Above ground	○	—	STr(3SB)	Transformer yard	Above ground	○	—
	—	—	—	—	—	—	—	—	—	—	HSTr	Transformer yard	Above ground	○	Oil leak due to damage of oil pipe	—	—	—	—	—
Cable	CV cable (GIS~STr(1SA))	—	Basement	○	—	CV cable (GIS～STr(1SB))	—	Basement	○	—	CV cable (GIS~STr(3SA))	—	Basement	○	—	CV cable (GIS~STr(3SB))	—	Basement	○	—
	—	—	—	—	—	—	—	—	—	—	CV cable (HSTr～GIS)	—	Basement	○	—	—	—	—	—	—
	Unit 1					Unit 2					Unit 3					Unit 4				
	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable	Conditions
DG	DG 1A	C/S	B2FL	×	Submerged	DG 2A	C/S	B2FL	×	Related equipment (SW pump) Water damage	DG 3A	C/S	B2FL	×	Related equipment (SW pump) Water damage	DG 4A	C/S	B2FL	×	Related equipment (SW pump) Water damage
	DG 1B	C/S	B2FL	×	Submerged	DG 2B	C/S	B2FL	×	Related equipment (SW system power) Water damage	DG 3B	C/S	B2FL	○	-	DG 4B	C/S	B2FL	×	Related equipment (SW system power) Water damage
	DG 1H	C/S	B2FL	×	Submerged	DG 2H	C/S	B2FL	×	Related equipment (SW pump) Water damage	DG 3H	C/S	B2FL	○	-	DG 4H	C/S	B2FL	○	—
(M/C) High voltage power panel [Safety]	M/C 1C	C/S	B1FL	×	Submerged	M/C 2C	C/S	B1FL	○	—	M/C 3C	C/S	B1FL	○	—	M/C 4C	C/S	B1FL	○	—
	M/C 1D	C/S	B1FL	○	—	M/C 2D	C/S	B1FL	○	—	M/C 3D	C/S	B1FL	○	—	M/C 4D	C/S	B1FL	○	—
	M/C 1H	C/S	B1FL	×	Submerged	M/C 2H	C/S	B1FL	○	—	M/C 3H	C/S	B1FL	○	—	M/C 4H	C/S	B1FL	○	—
(M/C) High voltage power panel [Non-safety]	M/C 1A-1	C/B	B1F	○	—	M/C 2A-1	C/B	B1FL	○	—	M/C 3A-1	C/B	B2FL	○	—	M/C 4A-1	C/B	B2FL	○	—
	M/C 1A-2	C/B	B1F	○	—	M/C 2A-2	C/B	B1FL	○	—	M/C 3A-2	C/B	B2FL	○	—	M/C 4A-2	C/B	B2FL	○	—
	M/C 1B-1	C/B	B1F	○	—	M/C 2B-1	C/B	B1FL	○	—	M/C 3B-1	C/B	B2FL	○	—	M/C 4B-1	C/B	B2FL	○	—
	M/C 1B-2	C/B	B1F	○	—	M/C 2B-2	C/B	B1FL	○	—	M/C 3B-2	C/B	B2FL	○	—	M/C 4B-2	C/B	B2FL	○	—
	M/C 1SA-1	C/B	B1F	○	—	—	—	—	—	—	M/C 3SA-1	C/B	B2FL	○	—	—	—	—	—	—
	M/C 1SA-2	C/B	B1F	○	—	—	—	—	—	—	M/C 3SA-2	C/B	B2FL	○	—	—	—	—	—	—
	M/C 1SB-1	C/B	B1F	○	—	—	—	—	—	—	M/C 3SB-1	C/B	B2FL	○	—	—	—	—	—	—
	M/C 1SB-2	C/B	B1F	○	—	—	—	—	—	—	M/C 3SB-2	C/B	B2FL	○	—	—	—	—	—	—

Operable: Results determined by TEPCO employees checking equipment conditions in the field
Water damage: Water intrusion watermarks are found
Submerged: Water has accumulated
(pink) : Equipment is not operable
(orange) : D/G is not damaged by water but is inoperable due to submersion of M/C and other related equipment
C/S : Reactor Combination Structure
C/B : Control Building

Attachment 7-7 (1/2)

Damage Status at Fukushima Daiini Nuclear Power Station(After Tsunami)

This table is based on the results of interviews with TEPCO employees who confirmed the damages to site power supply facilities though field patrols and field investigations.

	Units 1 to 2										Units 3 to 4									
	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions	Equipment	Location	Floor	Operable?	Conditions
(P/C) Power center [Safety]	P/C 1C-1	C/S	B1F	×	Submerged	P/C 2C-1	C/S	B1FL	○	–	P/C 3C-1	C/S	B1FL	○	–	P/C 4C-1	C/S	B1FL	○	–
	P/C 1C-2	Hx/B	1FL	×	Submerged	P/C 2C-2	Hx/B	1FL	×	Submerged	P/C 3C-2	Hx/B	1FL	×	Submerged	P/C 4C-2	Hx/B	1FL	×	Submerged
	P/C 1D-1	C/S	B1F	○	–	P/C 2D-1	C/S	B1FL	○	–	P/C 3D-1	C/S	B1FL	○	–	P/C 4D-1	C/S	B1FL	○	–
	P/C 1D-2	Hx/B	1FL	×	Submerged	P/C 2D-2	Hx/B	1FL	×	Submerged	P/C 3D-2	Hx/B	1FL	○	–	P/C 4D-2	Hx/B	1FL	×	Submerged
(P/C) Power center [Non safety]	P/C 1A-1	C/B	1FL	○	–	P/C 2A-1	C/B	1FL	○	–	P/C 3A-1	C/B	1FL	○	–	P/C 4A-1	C/B	1FL	○	–
	P/C 1A-2	C/B	1FL	○	–	P/C 2A-2	C/B	1FL	○	–	P/C 3A-2	C/B	1FL	○	–	P/C 4A-2	C/B	1FL	○	–
	P/C 1B-1	C/B	1FL	○	–	P/C 2B-1	C/B	1FL	○	–	P/C 3B-1	C/B	1FL	○	–	P/C 4B-1	C/B	1FL	○	–
	P/C 1B-2	C/B	1FL	○	–	P/C 2B-2	C/B	1FL	○	–	P/C 3B-2	C/B	1FL	○	–	P/C 4B-2	C/B	1FL	○	–
	P/C 1SA	C/B	1FL	○	–	–	–	–	–	–	P/C 3SA	C/B	B2FL	○	–	–	–	–	–	–
	P/C 1SB	C/B	1FL	○	–	–	–	–	–	–	P/C 3SB	C/B	B2FL	○	–	–	–	–	–	–
DC 125V	DC125V Main bus panel A	C/B	1FL	○	–	DC125V Main bus panel A	C/B	2FL	○	–	DC125V Main bus panel A	C/B	1FL	○	–	DC125V Main bus panel A	C/B	1FL	○	–
	DC125V Main bus panel B	C/B	1FL	○	–	DC125V Main bus panel B	C/B	2FL	○	–	DC125V Main bus panel B	C/B	1FL	○	–	DC125V Main bus panel B	C/B	1FL	○	–
	DC125V HPCS Main bus panel	C/S	B2FL	×	Submerged	DC125V HPCS Main bus panel	C/S	B2FL	○	–	DC125V HPCS Main bus panel	C/S	B2FL	○	–	DC125V HPCS Main bus panel	C/S	B2FL	○	–
DC 250V	DC250V Main bus panel	C/S	1FL	○	–	DC250V Main bus panel	C/S	1FL	○	–	DC250V Main bus panel	C/S	B2FL	○	–	DC250V Main bus panel	C/S	B2FL	○	–

Operable: Results determined by TEPCO employees checking equipment conditions in the field
Water damage: Water intrusion watermarks are found
Submerged: Water has accumulated
(pink shading) : Equipment is not operable
C/S : Reactor Combination Structure
C/B : Control Building
Hx/B : Seawater Heat Exchanger Building

Attachment 7-7 (2/2)

Fukushima Daiichi Unit 1 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	CS(A)	R/B basement (O.P. -1230)	A	○	○ Note 1	X	Power and seawater systems (CCSW) lost following tsunami
		CS(C)	R/B basement (O.P. -1230)	A	○	○ Note 1	X	Power and seawater systems (CCSW) lost following tsunami
		CCS(A)	R/B basement (O.P. -1230)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Power and seawater systems (CCSW) lost following tsunami
		CCS(B)	R/B basement (O.P. -1230)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Power and seawater systems (CCSW) lost following tsunami
		CCSW(A)	Outside (O.P. 4000)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Unit flooded with seawater and power lost during tsunami
		CCSW(B)	Outside (O.P. 4000)	A	○	○ Note 1	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Unit flooded with seawater and power lost during tsunami
		CS(B)	R/B basement (O.P. -1230)	A	○	○ Note 1	X	Power and seawater systems (CCSW) lost following tsunami
		CS(D)	R/B basement (O.P. -1230)	A	○	◎	X	Power and seawater systems (CCSW) lost following tsunami
		CCS(C)	R/B basement (O.P. -1230)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Power and seawater systems (CCSW) lost following tsunami
		CCS(D)	R/B basement (O.P. -1230)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Power and seawater systems (CCSW) lost following tsunami
		CCSW(C)	Outside (O.P. 4000)	A	○	◎	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Unit flooded with seawater and power lost during tsunami
		CCSW(D)	Outside (O.P. 4000)	A	○	○ Note 1	X	Operation of manual startup (S/C cooling) confirmed prior to tsunami Unit flooded with seawater and power lost during tsunami
		HPCI	R/B basement (O.P. -1230)	A	○	◎	X	Power lost after tsunami (auxiliary oil pump)
		IC(A)	R/B 4th Floor (O.P. 31000)	A	○	◎	(Unknown)	Operation confirmed by automatic startup (RPV high pressure) prior to tsunami Valve status after tsunami could not be confirmed due to loss of power
		IC(B)	R/B 4th Floor (O.P. 31000)	A	○	◎	(Unknown)	Operation confirmed by automatic startup (RPV high pressure) prior to tsunami Valve status after tsunami could not be confirmed due to loss of power
	Reactor injection	MUWC	T/B basement (O.P. 3200)	B	◎	◎	X	Power lost after tsunami

	SFP Cooling	SFP cooling (FPC system)	R/B 3rd floor (O.P. 25900)	B	◎	△ Note 1	X	Power lost after earthquake. Seawater systems (SW) lost after tsunami
		SFP cooling (SHC system)	R/B 1st floor (O.P. 10200)	A	○	○ Note 1	X	Power lost after tsunami. Seawater systems (SW) lost after tsunami
Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and that negative pressure was maintained after the reactor scram until the tsunami. Thereafter, the building was damaged by the hydrogen explosion.
		Reactor Containment Vessel		A	◎ (functional)	◎ (functional)	X	There is no evidence that suggests that the PCV was damaged prior to tsunami arrival.

(Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby

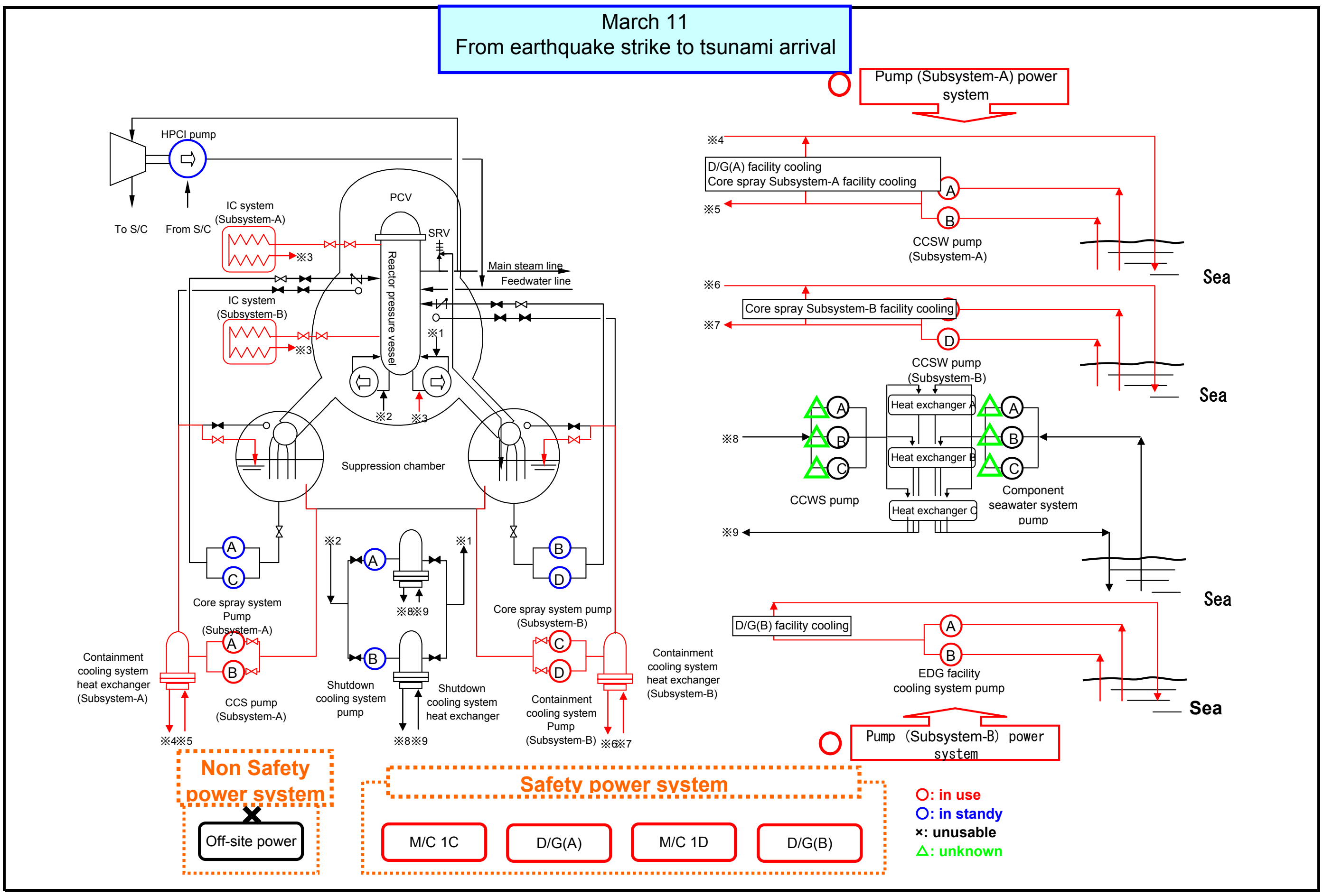
Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.

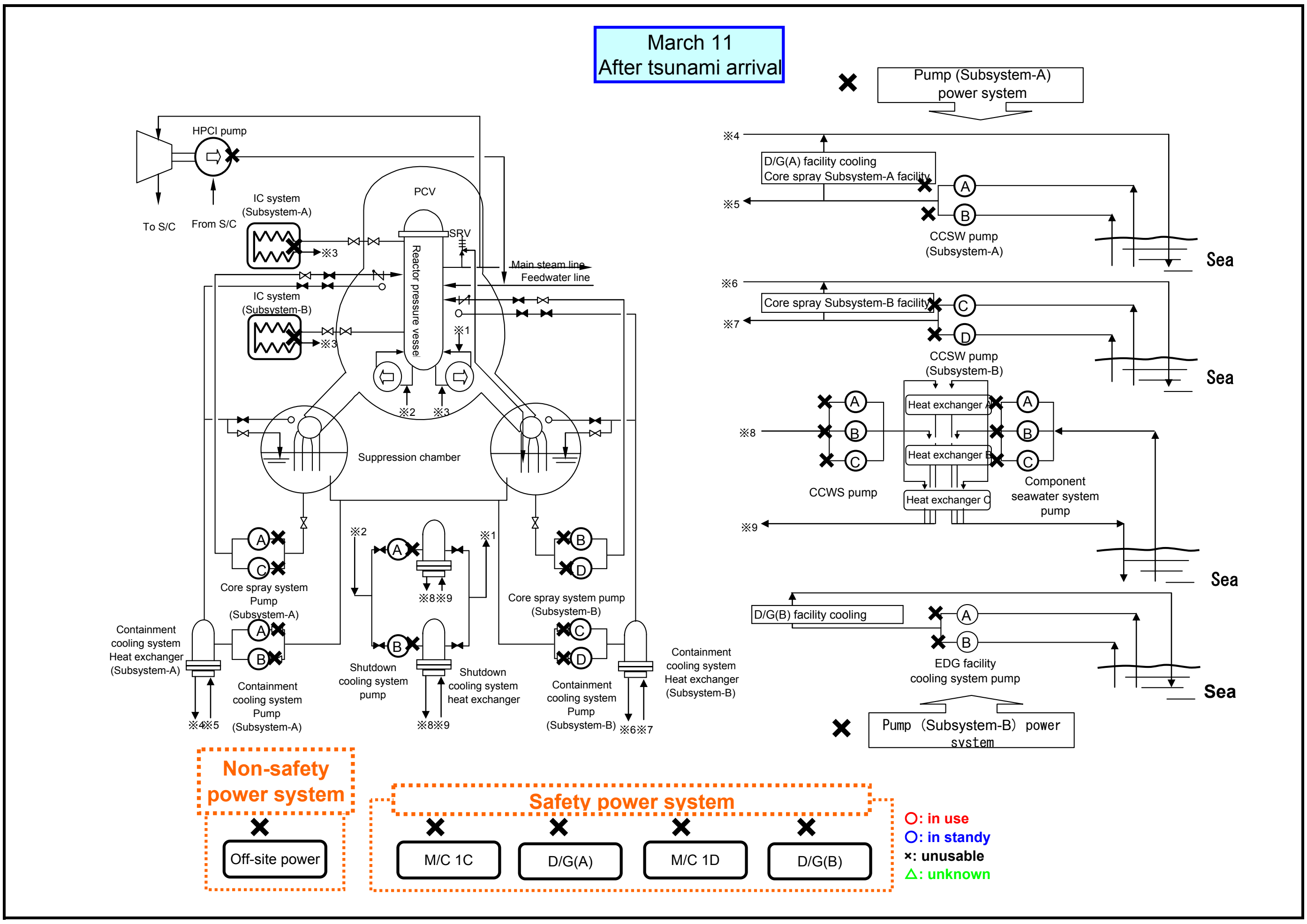
Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.

For these reasons it is presumed that function was maintained.

*JEAC4601-2008 “Technical Code for Seismic Design for Nuclear Power Plants”

Fukushima Daiichi Unit 1 System schematic





Fukushima Daiichi Unit 2 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	RHR(A)	R/B basement (O.P. -1030)	A	○	◎	X	Operation confirmed by manual startup (S/C cooling) prior to tsunami Power and seawater system (RHRS A/C) lost after tsunami
		RHR(B)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHR(C)	R/B basement (O.P. -1030)	A	○	◎	X	Operation confirmed by manual startup (S/C cooling) prior to tsunami Power and seawater system (RHRS A/C) lost after tsunami
		RHR(D)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHRS(A)	Outside (O.P. 4000)	A	○	◎	X	Operation confirmed by manual startup (S/C cooling) prior to tsunami Equipment flooded and lost power during tsunami
		RHRS(B)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		RHRS(C)	Outside (O.P. 4000)	A	○	◎	X	Operation confirmed by manual startup (S/C cooling) prior to tsunami Equipment flooded and lost power during tsunami
		RHRS(D)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		CS(A)	R/B basement (O.P. -1000)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		CS(B)	R/B basement (O.P. -1000)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		HPCI	R/B basement (O.P. -2060)	A	○	○ Note 1	X	Power lost after tsunami (auxiliary oil pump)
	Reactor injection	RCIC	R/B basement (O.P. -2060)	A	○	◎	◎→X	Manually started after earthquake. Operation following tsunami was confirmed but the equipment stopped shortly after. (cause unknown)
		MUWC	T/B basement (O.P. 1900)	B	◎	◎	X	Power lost after tsunami
	SFP cooling	SFP cooling (FPC system)	R/B 3rd floor (O.P. 26900)	B	◎	△ Note 1	X	Power lost after earthquake. Seawater systems (SW) lost after tsunami
		SFP cooling (RHR system)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system lost after tsunami

Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and that negative pressure was maintained after the reactor scram until the tsunami. After the tsunami the blowout panels were opened.
		Reactor Containment Vessel		A	◎ (functional)	◎ (functional)	X	There is no evidence that suggests that the PCV was damaged prior to arrival of the tsunami

(Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby

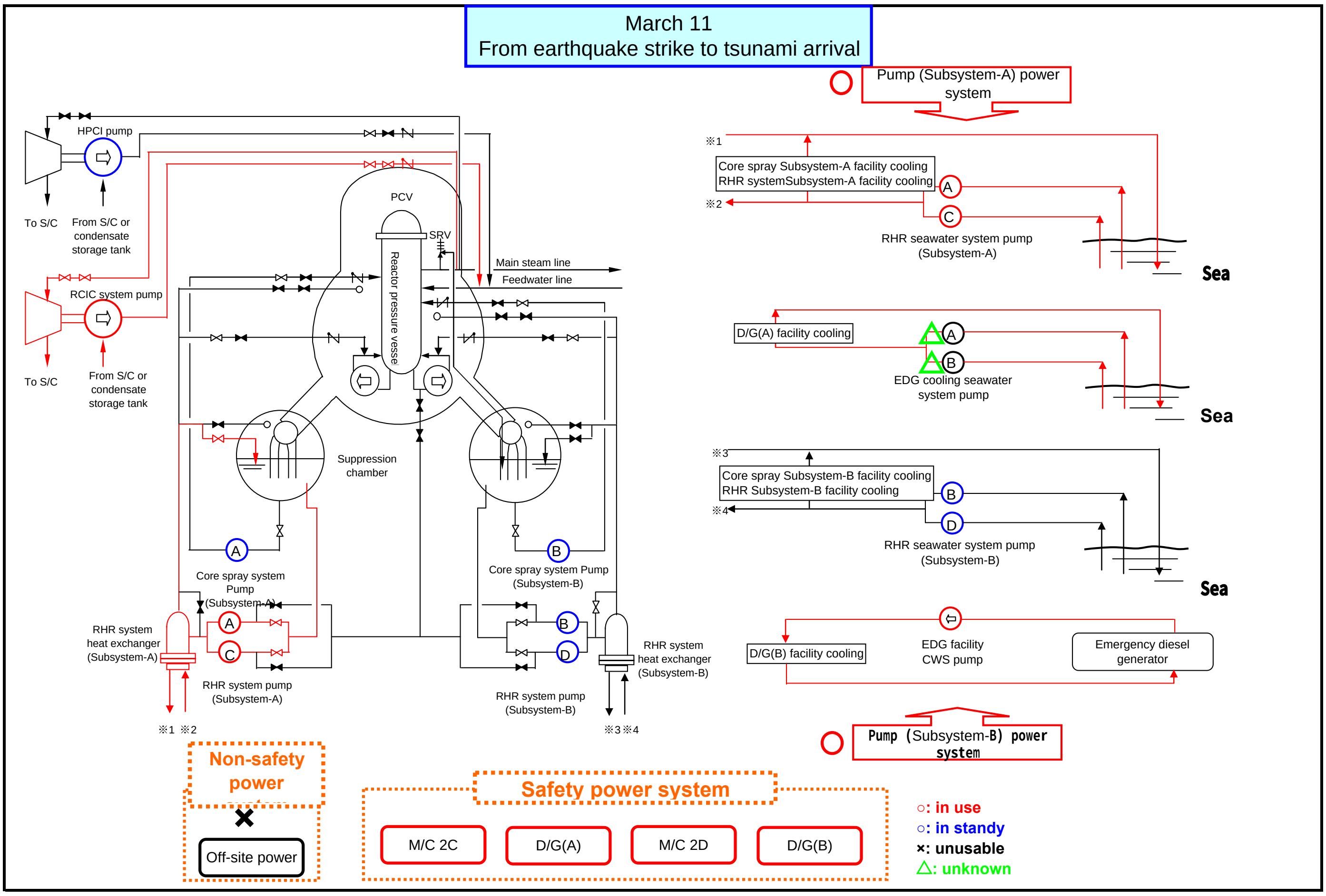
Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.

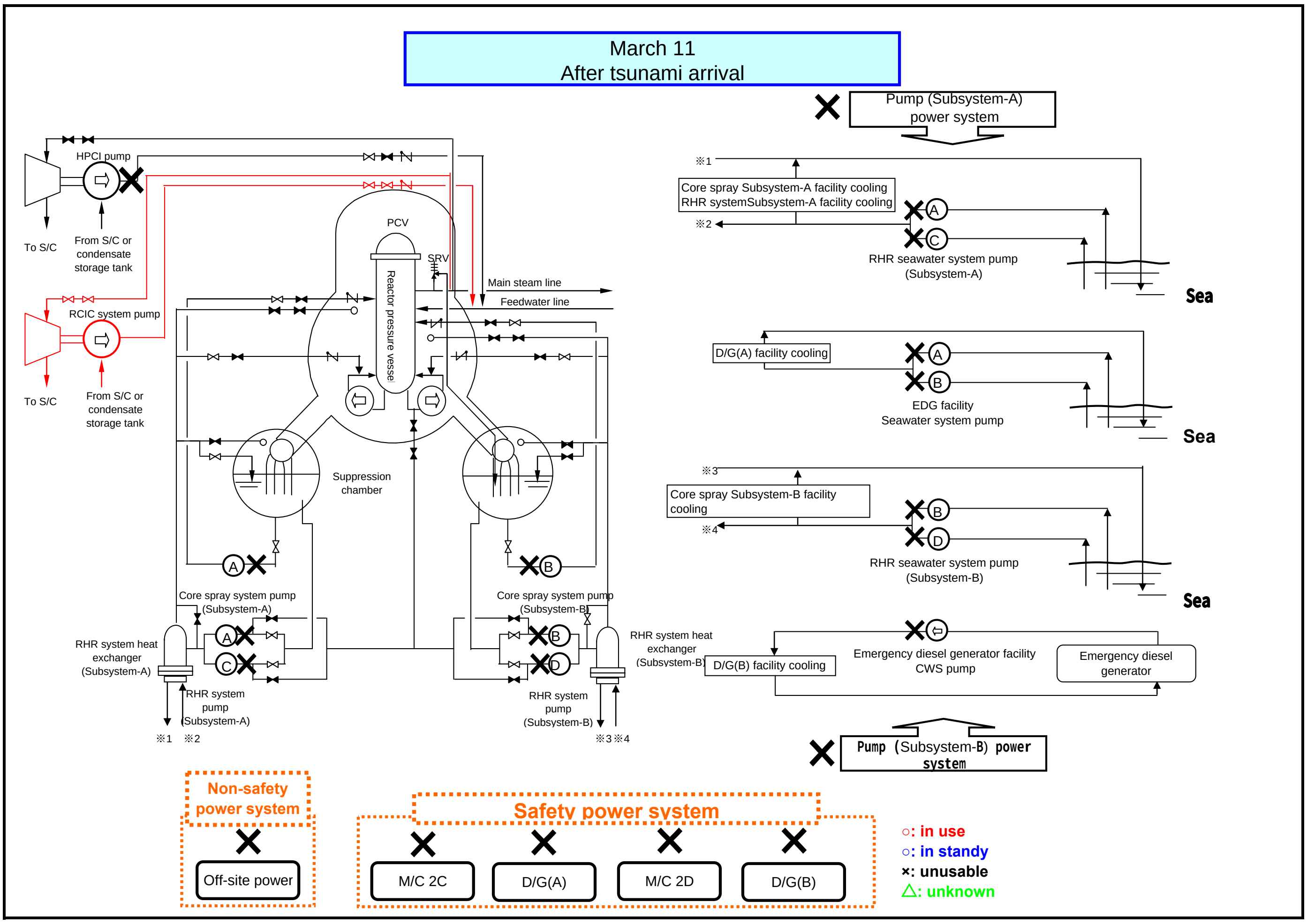
Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.

For these reasons it is presumed that function was maintained.

*JEAC4601-2008 “Technical Code for Seismic Design for Nuclear Power Plants”

Fukushima Daiichi Unit 2 System schematic





Fukushima Daiichi Unit 3 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	RHR(A)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		RHR(B)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHR(C)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		RHR(D)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHRS(A)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		RHRS(B)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		RHRS(C)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		RHRS(D)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		CS(A)	R/B basement (O.P. -1000)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		CS(B)	R/B basement (O.P. -1000)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		HPCI	R/B basement (O.P. -2060)	A	○	○	◎→X	Following the tsunami the HPCI automatically started up when reactor water level dropped. It was manually shut down due to decreased reactor pressure. Thereafter, the unit could not be restarted due to AC power loss.
	Reactor injection	RCIC	R/B basement (O.P. -2060)	A	○	○	◎→X	Manually started following tsunami but the unit automatically shut down short after. Thereafter it was unable to be restarted (cause unknown)
		MUWC	T/B basement (O.P. 2420)	B	◎	◎	X	Power lost after tsunami
	SFP Cooling	SFP cooling (FPC system)	R/B 3rd floor (O.P. 26900)	B	◎	△ Note 1	X	Power lost after earthquake. Seawater systems (SW) lost after tsunami
		SFP cooling (RHR system)	R/B basement (O.P. -1030)	A	○	○ Note 1	X	Power and seawater system lost after tsunami

Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and the negative pressure was maintained from the time following the reactor scram until the tsunami. Thereafter it was damaged by the hydrogen explosion.
		Reactor Containment Vessel		A	◎ (functional)	◎ (functional)	X	There is no evidence that suggests that the PCV was damaged prior to arrival of the tsunami

(Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby

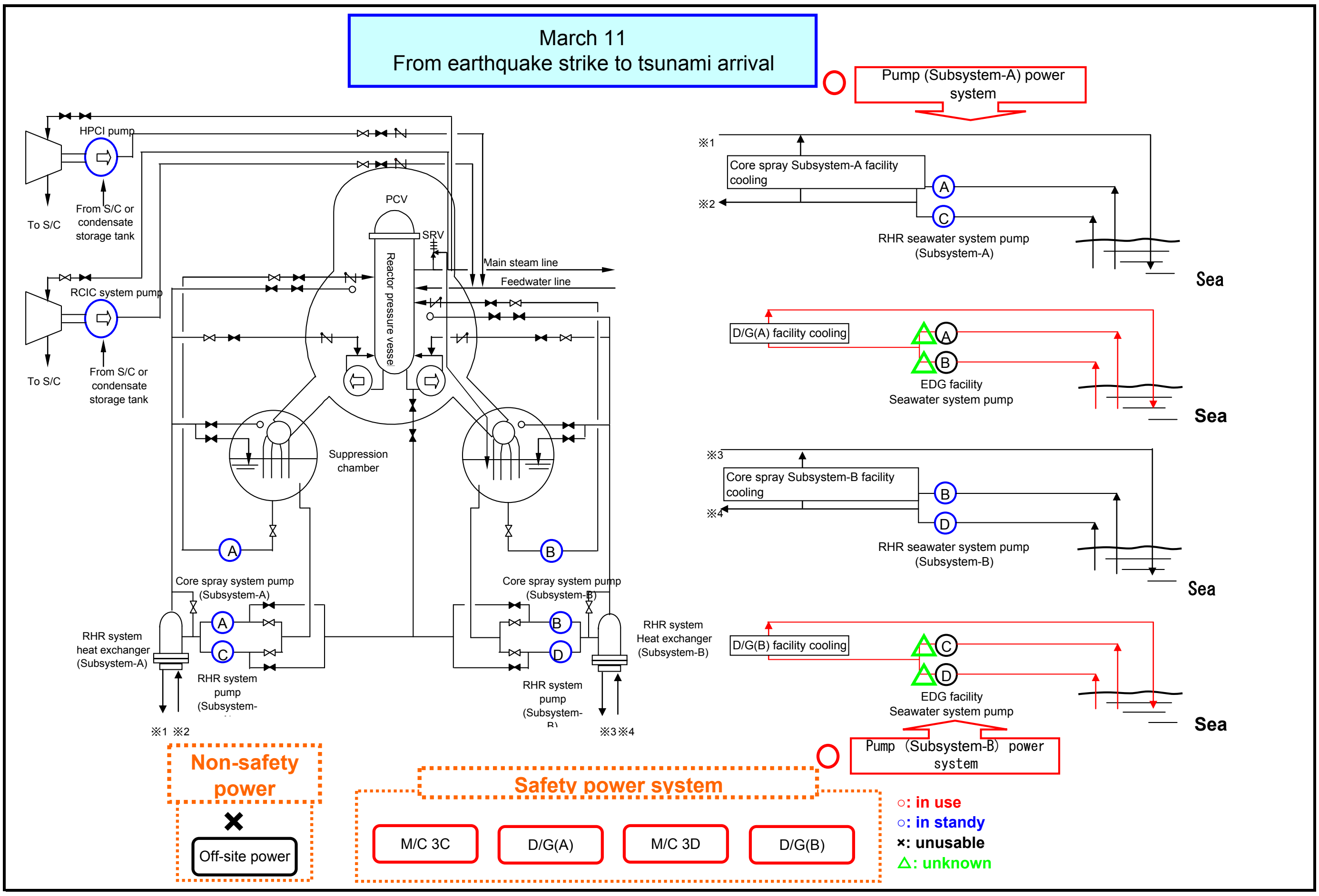
Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.

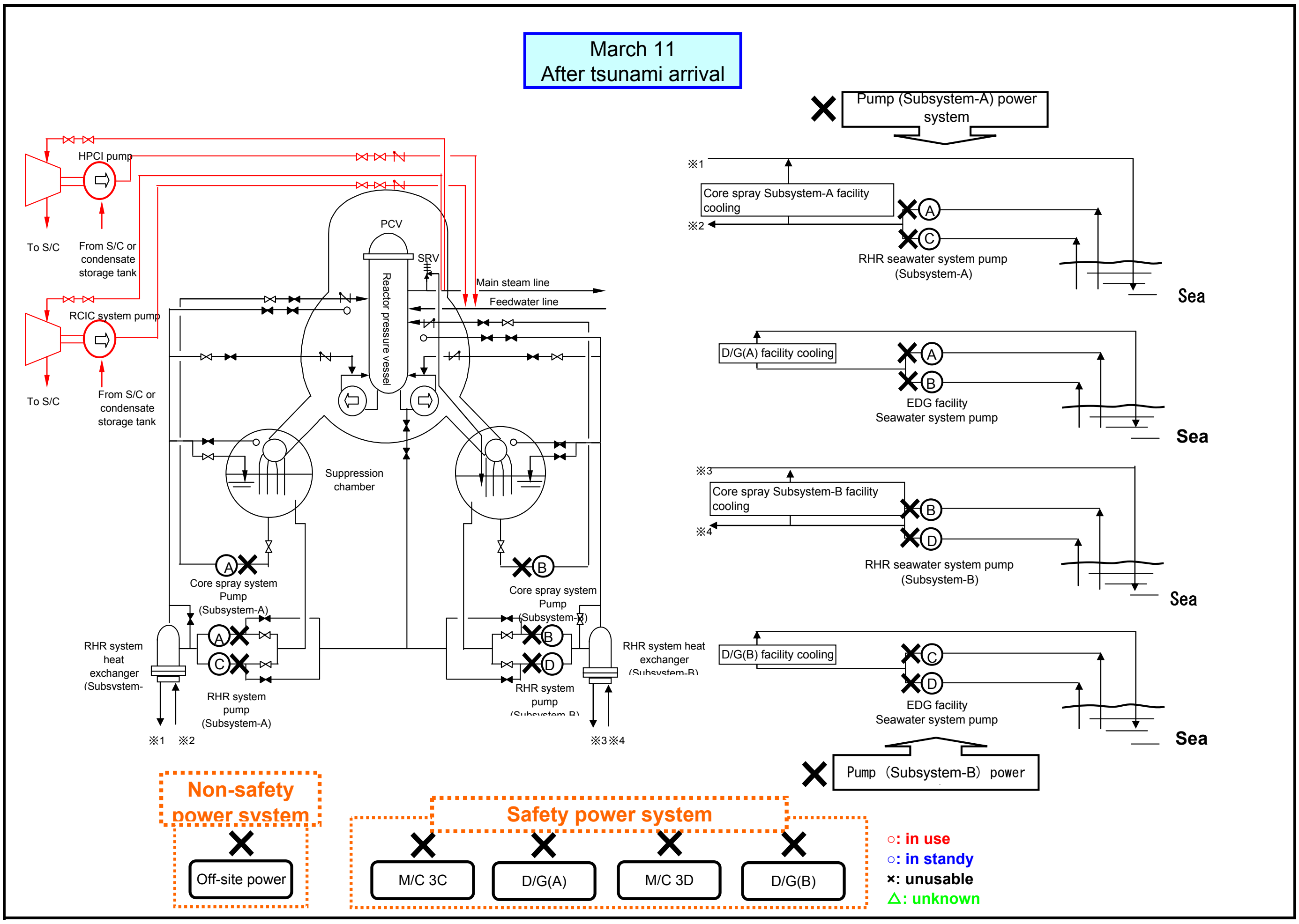
Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.

For these reasons it is presumed that function was maintained.

*JEAC4601-2008 "Technical Code for Seismic Design for Nuclear Power Plants"

Fukushima Daiichi Unit 3 System schematic





Fukushima Daiichi Unit 4 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	RHR(A)	R/B basement (O.P. -1110)	A	—	—	—	
		RHR(B)	R/B basement (O.P. -1110)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHR(C)	R/B basement (O.P. -1110)	A	—	—	—	
		RHR(D)	R/B basement (O.P. -1110)	A	◎ (SFP cooling)	○ Note 1	X	Shut down due to power loss during earthquake (Note 2) Power and seawater system (RHRS B/D) lost after tsunami
		RHRS(A)	Outside (O.P. 4000)	A	—	—	—	
		RHRS(B)	Outside (O.P. 4000)	A	◎ (SFP cooling)	○ Note 1	X	Shut down due to power loss during earthquake (Note 2) Unit flooded with seawater and power lost during tsunami.
		RHRS(C)	Outside (O.P. 4000)	A	—	—	X	
		RHRS(D)	Outside (O.P. 4000)	A	◎ (SFP cooling)	○ Note 1	X	Shut down due to power loss during earthquake (Note 2) Unit flooded with seawater and power lost during tsunami.
		CS(A)	R/B basement (O.P. -1110)	A	—	—	—	
		CS(B)	R/B basement (O.P. -1110)	A	—	—	—	
		HPCI	R/B basement (O.P. -2060)	A	—	—	—	
	Reactor injection	RCIC	R/B basement (O.P. -2060)	A	—	—	—	
		MUWC	T/B basement (O.P. 1900)	B	◎	◎	X	Power lost after tsunami
	SFP Cooling	SFP cooling (FPC system)	R/B 3rd floor (O.P. 26900)	B	◎	△ Note 1	X	One unit was undergoing inspection and one unit was in operation prior to the earthquake. Off-site power was interrupted following the earthquake.
		SFP cooling (RHR system)	R/B basement (O.P. -1110)	A	◎	○ Note 1	X	Shut down due to power loss during earthquake (Note 2) Power and seawater system (RHRS B/D) lost after tsunami

Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and the negative pressure was maintained from the time following the reactor scram until the tsunami. Thereafter it was damaged by the hydrogen explosion.
		Reactor Containment Vessel						Open for outage

((Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby
—: Shut down for outage (function not needed)

Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.

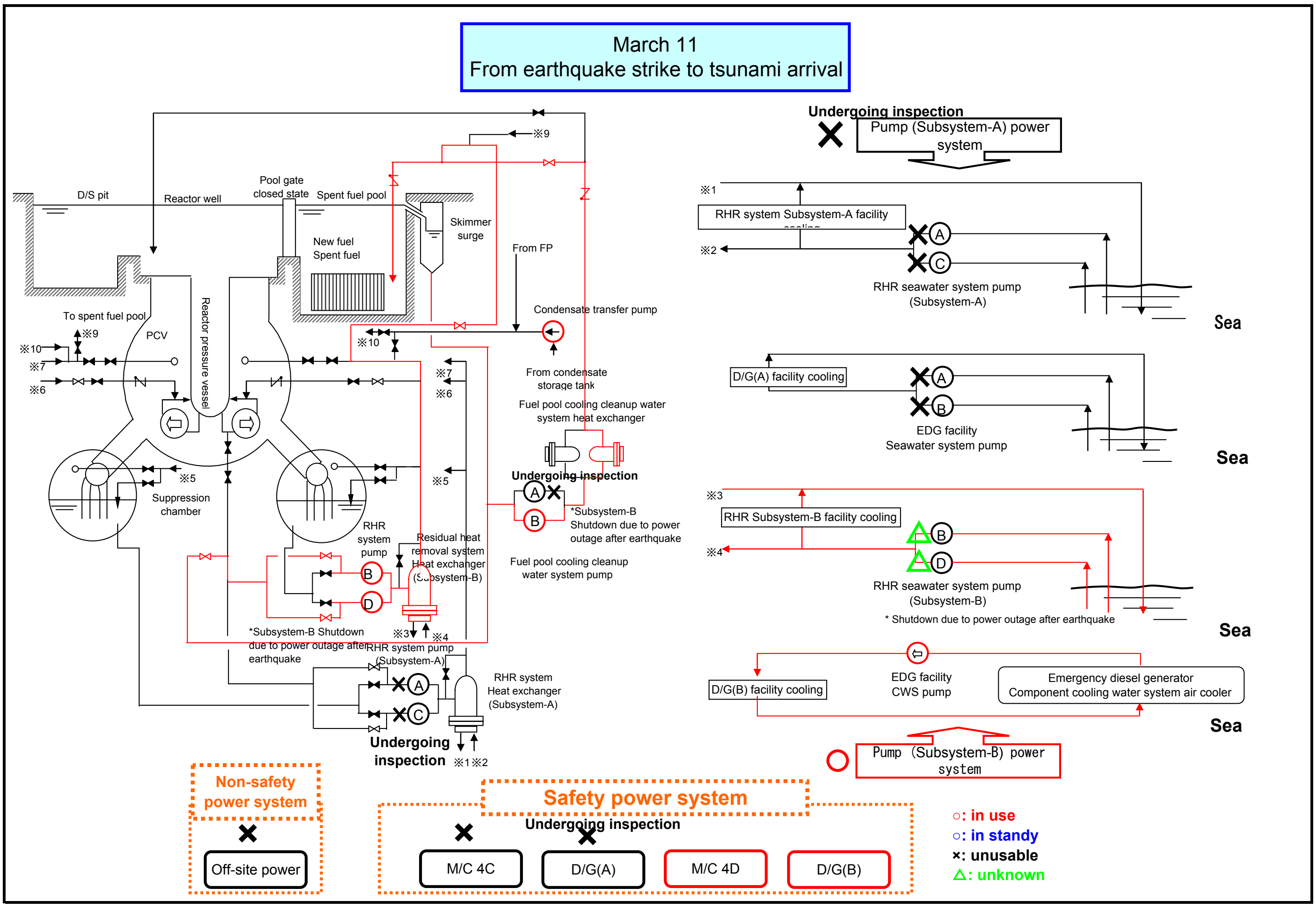
Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.

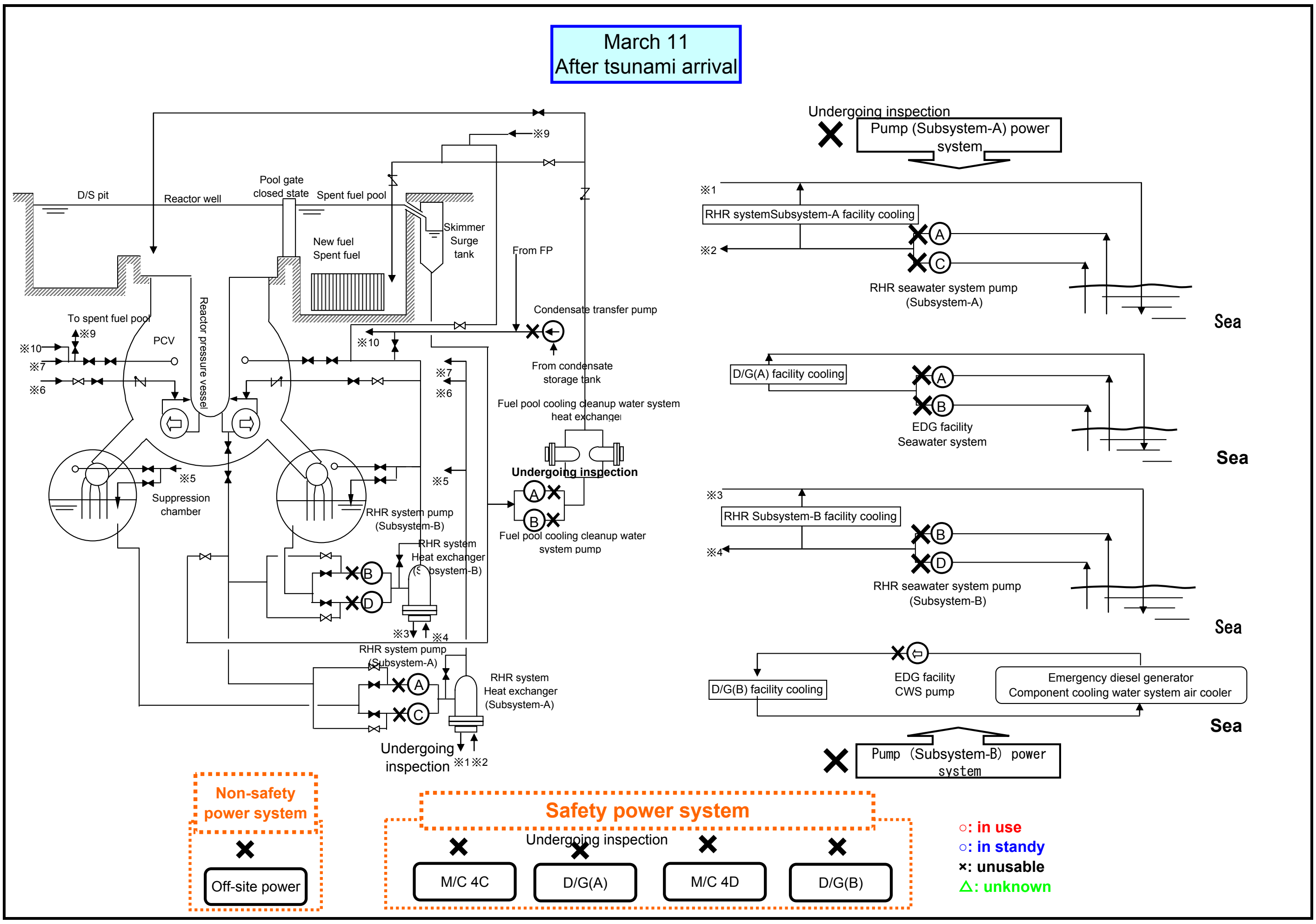
For these reasons it is presumed that function was maintained.

*JEAC4601-2008 "Technical Code for Seismic Design for Nuclear Power Plants"

Note 2: Restarting the residual heat removal system after power was being supplied by the emergency diesel generators was not implemented prior to arrival of the tsunami because the SFP water level was full (near overflowing) prior to the earthquake and the SFP water temperature was around 27 degree-C, therefore during the early stages of the event not restarting the unit was not expected to hinder fuel cooling.

Fukushima Daiichi Unit 4 System schematic





Fukushima Daiichi Unit 5 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	RHR(A)	R/B basement (O.P. 940)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		RHR(B)	R/B basement (O.P. 940)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHR(C)	R/B basement (O.P. 940)	A	○	○	X→◎ Note 2	Power and seawater system (RHRS A/C) lost after tsunami. A temporary RHRS submerged pump was installed and operated after March 19 (SHC/emergency heat load mode alternate operation)
		RHR(D)	R/B basement (O.P. 940)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		RHRS(A)	Outside (O.P. 4000)	A	○	○ Note 1	X Note 2	The unit was flooded with seawater and lost power after the tsunami. On March 18 a temporary submerged pump was installed and operated on March 19. (One temporary submerged pump started up by RHRS A/C)
		RHRS(B)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost after tsunami
		RHRS(C)	Outside (O.P. 4000)	A	○	○ Note 1	X Note 2	The unit was flooded with seawater and lost power after the tsunami. On March 18 a temporary submerged pump was installed and operated on March 19. (One temporary submerged pump started up by RHRS A/C)
		RHRS(D)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost during tsunami
		CS(A)	R/B basement (O.P. 940)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		CS(B)	R/B basement (O.P. 940)	A	○	○ Note 1	X	Power and seawater system (RHRS B/D) lost after tsunami
		HPCI	R/B basement (O.P. 940)	A	—	—	—	Shut down for outage
	Reactor Injection	RCIC	R/B basement (O.P. 940)	A	—	—	—	Shut down for outage
		MUWC	T/B basement (O.P 4900)	B	◎	◎	X→◎ Note 2	In operation after earthquake. Power lost after tsunami. Operated using temporary power.
	SFP Cooling	SFP cooling (FPC system)	R/B 3rd floor (O.P. 32,700)	B	◎	△ Note 1	X	Off-site power was interrupted after earthquake. Seawater system (SW) lost after tsunami.
		SFP cooling (RHR system)	R/B basement (O.P. 940)	A	○	○	X→◎ Note 2	Power and seawater system lost after tsunami. A temporary RHRS submerged pump was installed and operated from March 19 by RHR (C) (SHC/emergency heat load mode alternate operation)

Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and the negative pressure was maintained from the time following the reactor scram until the tsunami. Holes were drilled in the roof on March 18 after the tsunami (hydrogen accumulation prevention: preventative maintenance)
		Reactor Containment Vessel		A	—	—	—	Open for outage

(Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby

—: Shut down for outage (function not needed)

Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.

Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.

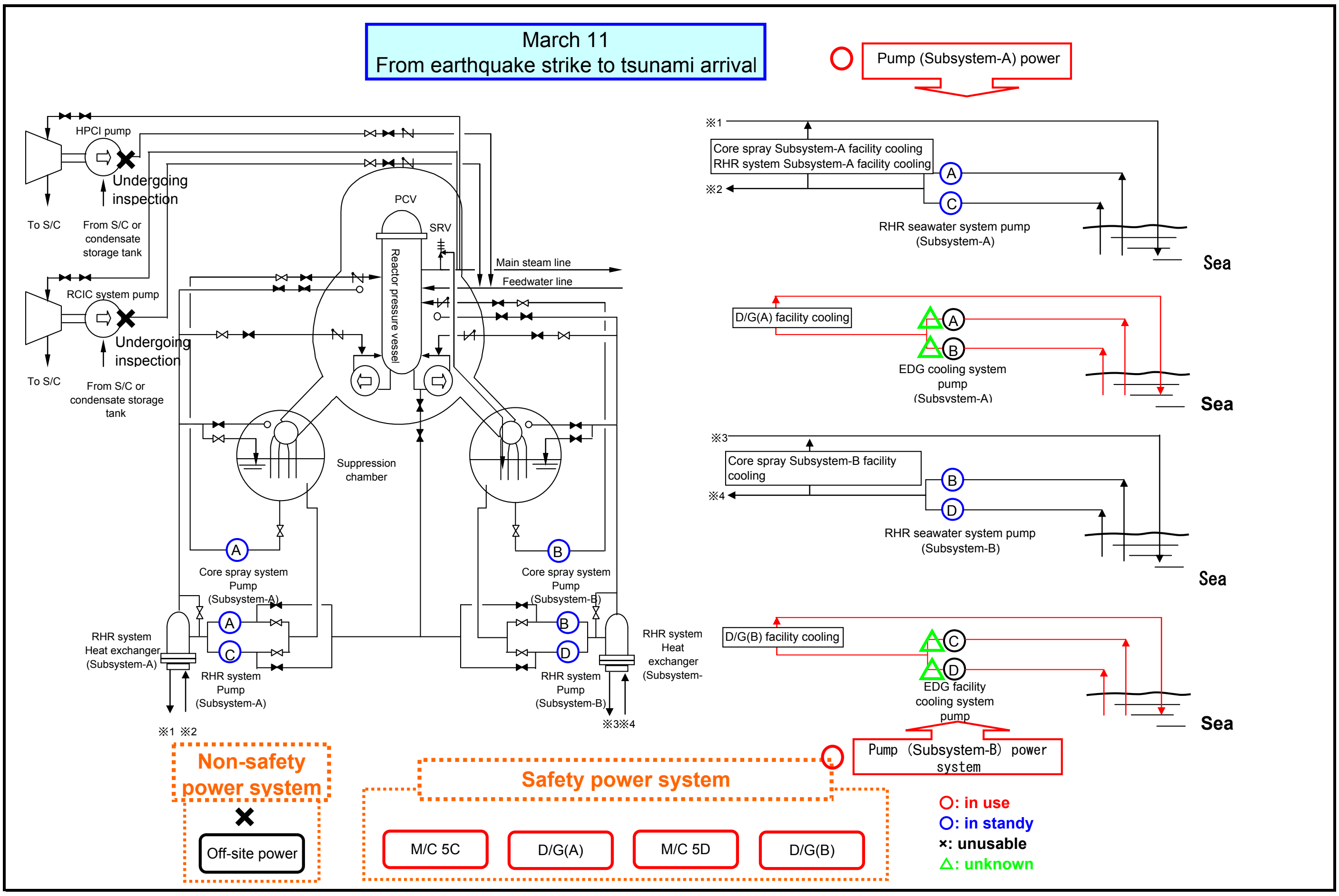
For these reasons it is presumed that function was maintained.

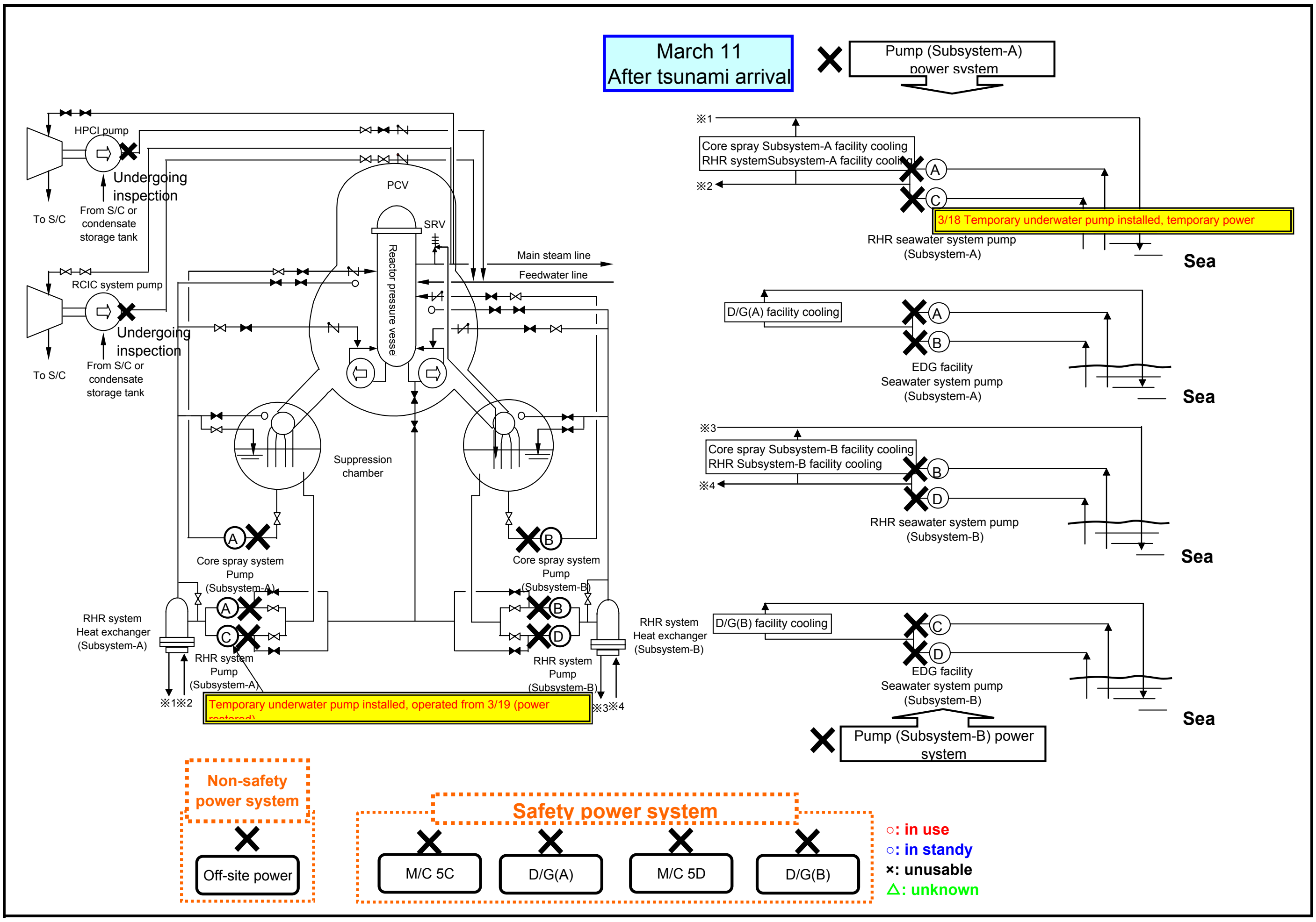
*JEAC4601-2008 "Technical Code for Seismic Design for Nuclear Power Plants"

Note 2: After the tsunami one or both of the power and seawater systems were lost and system function was lost temporarily, but thereafter function was restored by temporary equipment.

Note 3: Status under cold shut down (March 20, 2011)

Fukushima Daiichi Unit 5 System schematic





Fukushima Daiichi Unit 6 Emergency Core Cooling Systems (including equipments) List
(Pre- & post-earthquake, post-tsunami)

			Location	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	After the arrival of the tsunami	Notes
Cooling down	ECCS	RHR(A)	R/B Basement 2nd floor (O.P. 1000)	A	○	○ Note 1	X	Seawater system (RHRS A/C) lost after tsunami
		RHR(B)	R/B Basement 2nd floor (O.P. 1000)	A	◎ (SHC operation)	○	X→◎ Note 3	Shut down due to power loss during earthquake (Note 2) Seawater system (RHRS B/D) lost after tsunami. RHRS temporary submerged pump installed and operated starting on March 19 (SHC/emergency heat load mode alternate operation)
		RHR(C)	R/B Basement 2nd floor (O.P. 1000)	A	○	○ Note 1	X→○ Note 3	Seawater system (RHRS B/B) lost after tsunami. Could be operated by installation of temporary submerged pump.
		RHRS(A)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost after tsunami
		RHRS(B)	Outside (O.P. 4000)	A	◎ (SHC operation)	○ Note 1	X Note 3	Shut down due to power loss during earthquake (Note 2) Unit flooded with seawater and power lost during tsunami. A temporary RHRS submerged pump was installed on March 19 and operated on the same day (Two temporary submerged pumps started up by RHRS B/D)
		RHRS(C)	Outside (O.P. 4000)	A	○	○ Note 1	X	Unit flooded with seawater and power lost after tsunami
		RHRS(D)	Outside (O.P. 4000)	A	◎ (SHC operation)	○ Note 1	X Note 3	Shut down due to power loss during earthquake (Note 2) Unit flooded with seawater and power lost during tsunami. A temporary RHRS submerged was installed on March 19 and operated on the same day (Two temporary submerged pumps started up by RHRS B/D)
		LPCS	R/B Basement 2nd floor (O.P. 1000)	A	○	○ Note 1	X	Power and seawater system (RHRS A/C) lost after tsunami
		HPCS	R/B Basement 2nd floor (O.P. 1000)	A	○	○ Note 1	X	Seawater system (D/G (H) SW) lost after tsunami.
	Reactor injection	RCIC	R/B Basement 2nd floor (O.P. 1000)	A	—	—	—	Shut down for outage
		MUWC	T/B basement (O.P. 3400)	B	◎	◎	◎	D/G B system started and MUWC (B) operated by receiving power from power source D system

	SFP Cooling	SFP cooling (FPC system)	R/B 4th floor (O.P. 34,000)	B	◎	△ Note 1	X	Power lost after earthquake. Seawater systems (SW) lost after tsunami
		SFP cooling (RHR system)	R/B Basement 2nd floor (O.P. 1000)	A	○	○	X→◎ Note 3	Shut down due to power loss during earthquake (Note 2) Seawater system (RHRS B/D) lost after tsunami. A temporary RHRS submerged pump was installed and operated from March 19. (SHC/emergency heat load mode alternate operation)
Confining inside	Reactor containment facilities	Reactor Building		A	◎ (functional)	◎ (functional)	X	It is presumed that the SGTS was in operation and the negative pressure was maintained from the time following the reactor scram. Holes were drilled in the roof on March 18 after the tsunami (hydrogen accumulation prevention: preventative maintenance)
		Reactor Containment Vessel		A	—	—	—	Open for outage

(Key) ◎: In Operation ○: Standby △:Shutdown due to loss of normal power supply X: Loss of function or excluded from standby
—: Shut down for outage (function not needed)

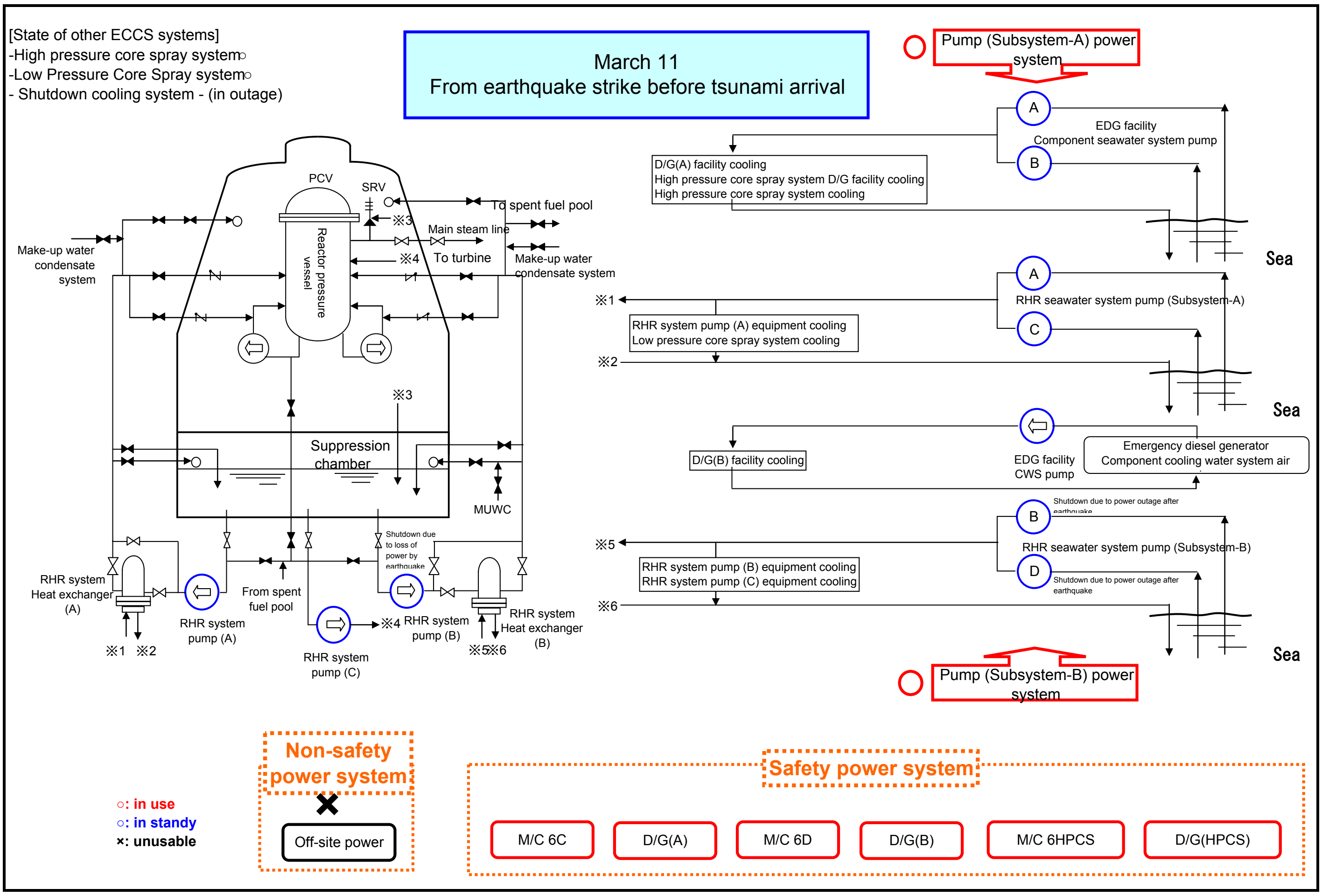
Note 1: At Unit 5, which experienced relatively large vibration during this earthquake, the residual heat removal system was operated on March 19, 2011 following the earthquake and walk-down by shift members revealed no major damage to systems or equipments.
Furthermore, the maximum acceleration recorded in the basement of the reactor building where these equipments are located is well below the maximum acceleration for which it has been confirmed that equipments can maintain function*.
For these reasons it is presumed that function was maintained.
*JEAC4601-2008 "Technical Code for Seismic Design for Nuclear Power Plants"

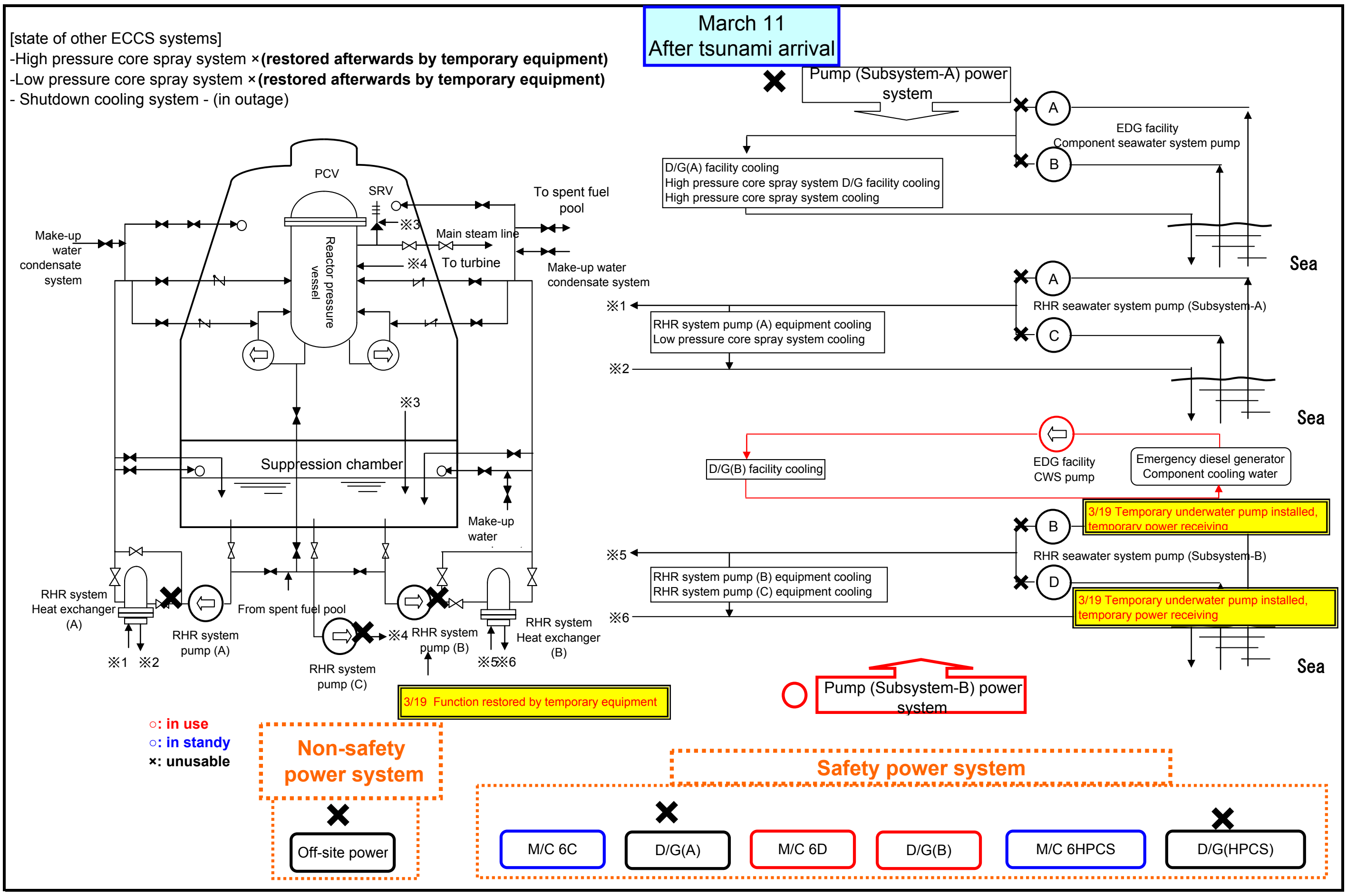
Note 2: Cooling of the reactor while shut down and pool cooling using power supplied by emergency diesel generators was not implemented prior to arrival of the tsunami because reactor was already in cold shut down prior to the earthquake, the SFP water level was full (near overflowing) prior to the earthquake, and the SFP water temperature was around 25 degree-C, so during the early stages of the event not cooling the reactor or the pool was not expected to hinder fuel cooling.

Note 3: After the tsunami one or both of the power and seawater systems were lost and system function was lost temporarily, but thereafter function was restored by temporary equipment.

Note 4: Status until cold shut down (March 20, 2011)

Fukushima Daiichi Unit 6 System schematic



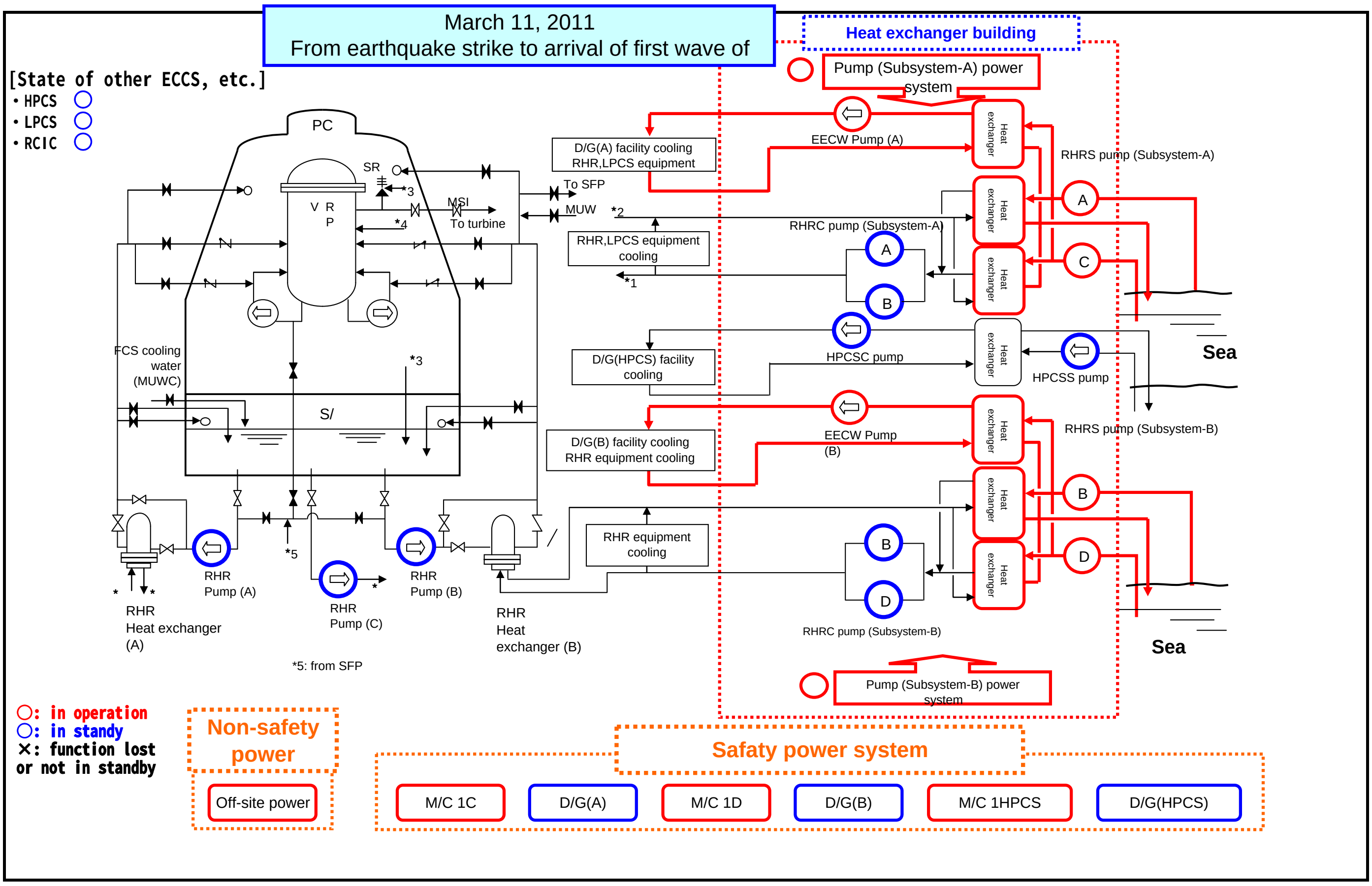


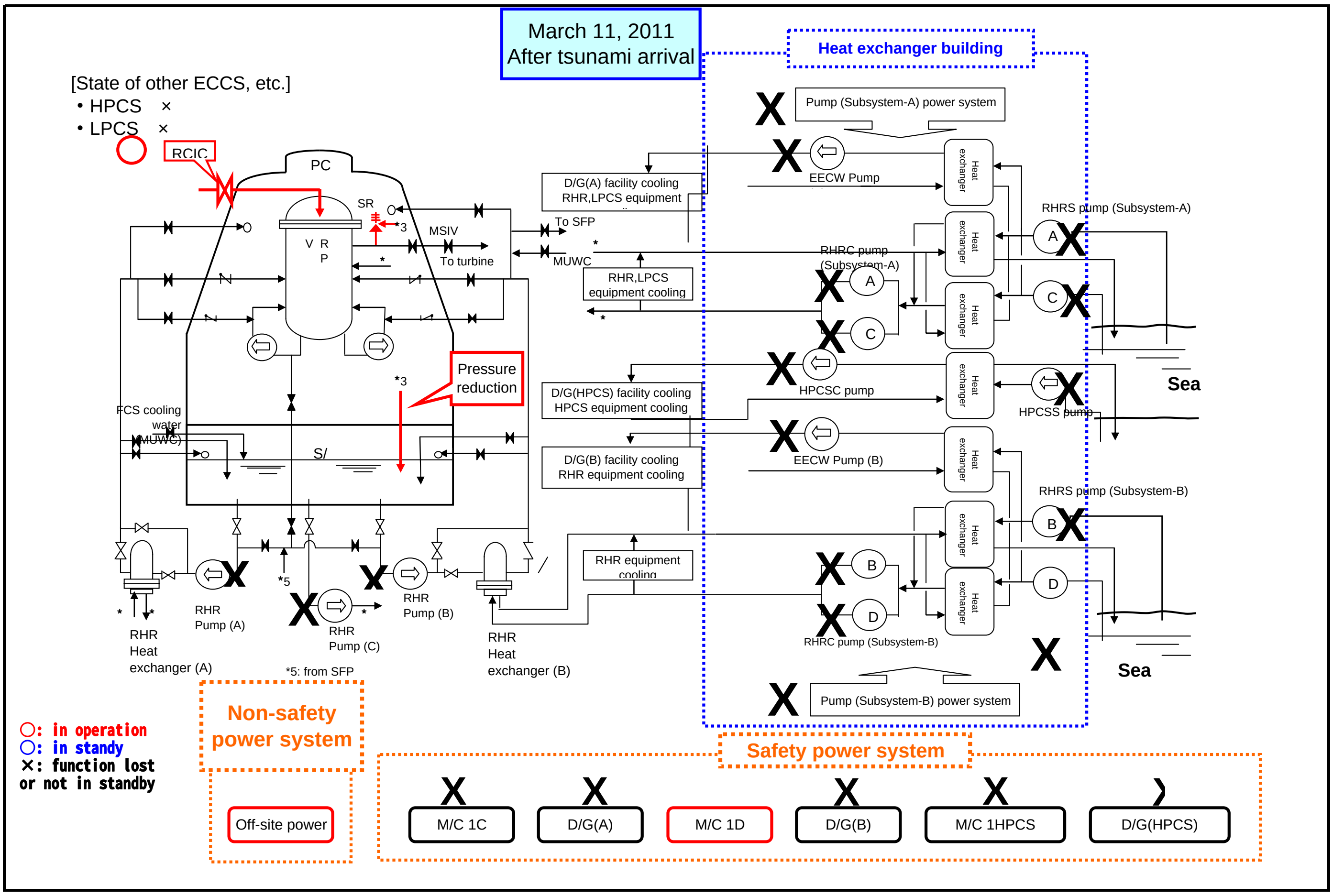
Fukushima Daini Unit 1 Emergency Core Cooling Systems (including components) List (Pre- & post-earthquake, post-tsunami)

			Location (units: mm)	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	From tsunami arrival up to cold shutdown	Status from cold shutdown to present (March 1, 2012)	Comments
Cooling down	ECCS & others	RHR(A)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Power damaged by water by tsunami; unavailable due to inoperability of RHRS, RHRC, EECW; no damage to pumps After restoration of RHRS, RHRC, EECW, started up on November 17, 2011
		LPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	×	Power damaged by water by tsunami; unavailable due to inoperability of RHRS, RHRC, EECW. No damage to pumps.
		RHRC(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on November 9, 2011.
		RHRC(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, temporarily placed at Unit 3 T/B 2nd Floor.
		RHRS(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on November 11, 2011.
		RHRS(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	×	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, temporarily placed at Unit 1 seawater heat exchanger bldg. 2nd Floor.
		EECW(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on November 4, 2011.
		RHR(B)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→◎	◎	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on March 14, 2011.
		RHR(C)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→○	×	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, standby from march 14, 2011. Removed power to feed to RHR(A) due to start up of RHR(A).
		RHRC(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	◎	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Startup on September 26, 2011.
		RHRC(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×→◎	×	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After laying temporary cables, feeding power, and replacing motor, started up on march 13, 2011. After repairing motor, installed on Unit 1 seawater heat exchanger bldg. 1st Floor.
		RHRS(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×→◎	×	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. After laying temporary cables and feeding power, started up on March 13, 2011. After repairing motor, temporarily placed on Unit 1 seawater heat exchanger bldg. 2nd Floor.
		RHRS(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	◎	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. After repairing motor, feed power through temporary cables. Started up on January 12, 2012.
		EECW(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×→◎	◎	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. Feed power through high voltage power supply car and by laying temporary cables. After replacing with alternate motor, started up on March 14, 2011. After repairing motor, laid temporary cables to supply power. Started up on November 26, 2011.
		HPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	×	Unavailable due to inoperability of HPCSS, HPCSC due to water damage to power supply caused by tsunami No damage to pumps
		HPCSC	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, temporarily placed on Unit 3 T/B 2F.
		HPCSS	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. After repairing motor, temporarily placed on Unit 3 T/B 2F.
	Reactor injection	RCIC	R/B Reactor Wing B2F (O.P.0000)	A	○	○	◎→○	×	Started up after the tsunami, but was out of service due to drop in reactor pressure on March 12, 2011.
		MUWC (alternate injection)	T/B B1F (O.P.2400)	B	○	○	○→◎→○	○	Operated on March 12, 2011, standby on March 14, 2011.
	SFP cooling	FPC	R/B Reactor Wing 4F (O.P.33000)	B	◎	×	×	◎	Unavailable due to trip caused by the earthquake and inoperability of RCW due to tsunami, started injection with FPMUW pump and pool circulation with FPC pump on March 14, 2011. After restoration of RCW, started up (B) on July 17, 2011, (A) is under restoration.
		RHR	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→◎	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. After restoration of RHRS, RHRC, EECW, started up on March 16, 2011 (FPC auxiliary cooling mode)
Confining inside	Reactor containment facilities	R/B Reactor Wing		A	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	After reactor automatic scram, SGTS started up, negative pressure was maintained in R/B Reactor Wing, no signs of damage were found.
		PCV		As	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	No signs in PCV pressure indicated damage.

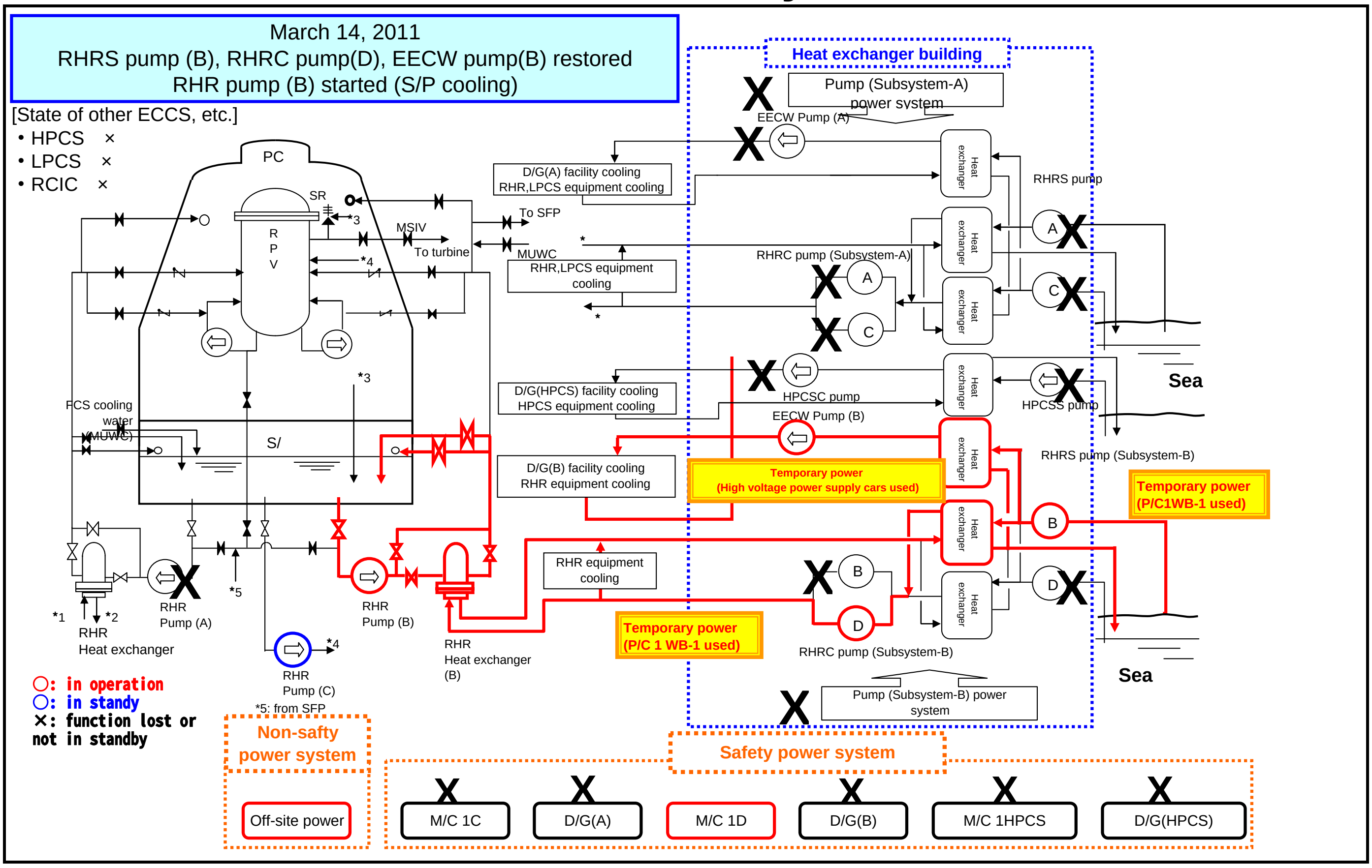
(Key) ◎: In Operation ○: Standby X: Loss of function or excluded from standby

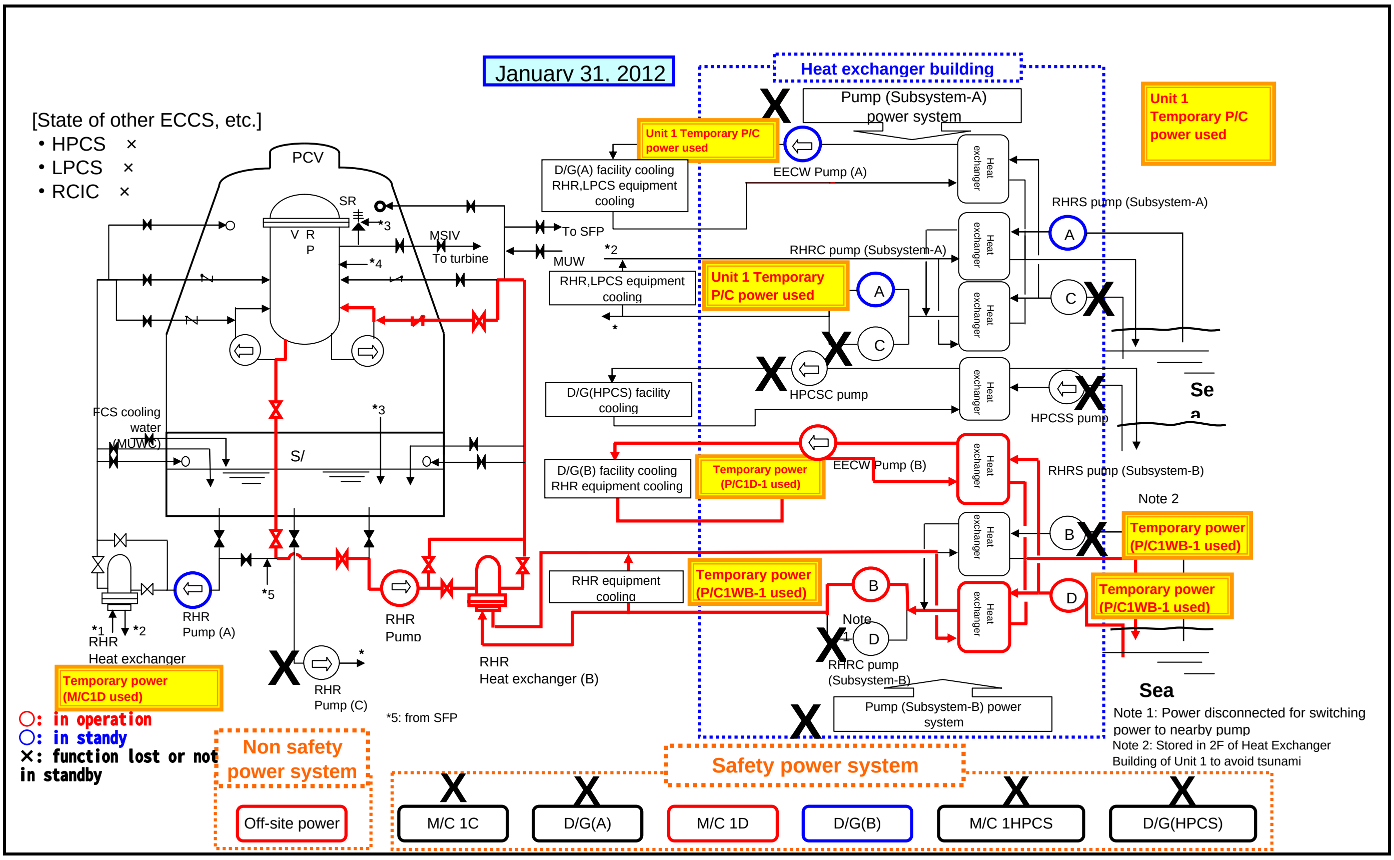
Fukushima Daini Unit 1 System schematic

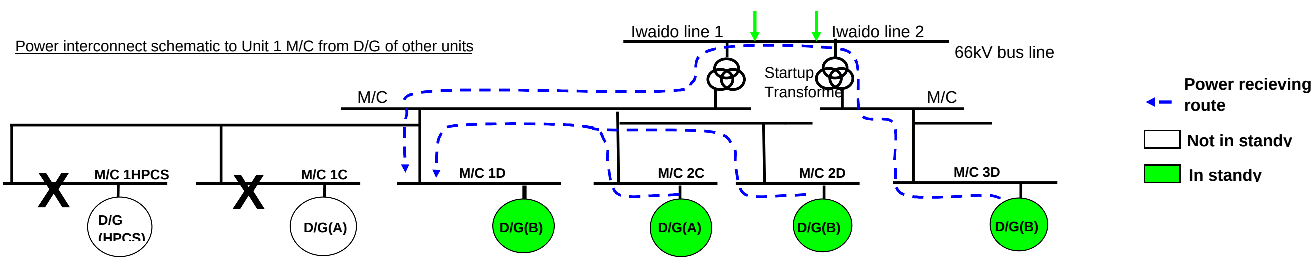




Fukushima Daini Unit 1 System schematic





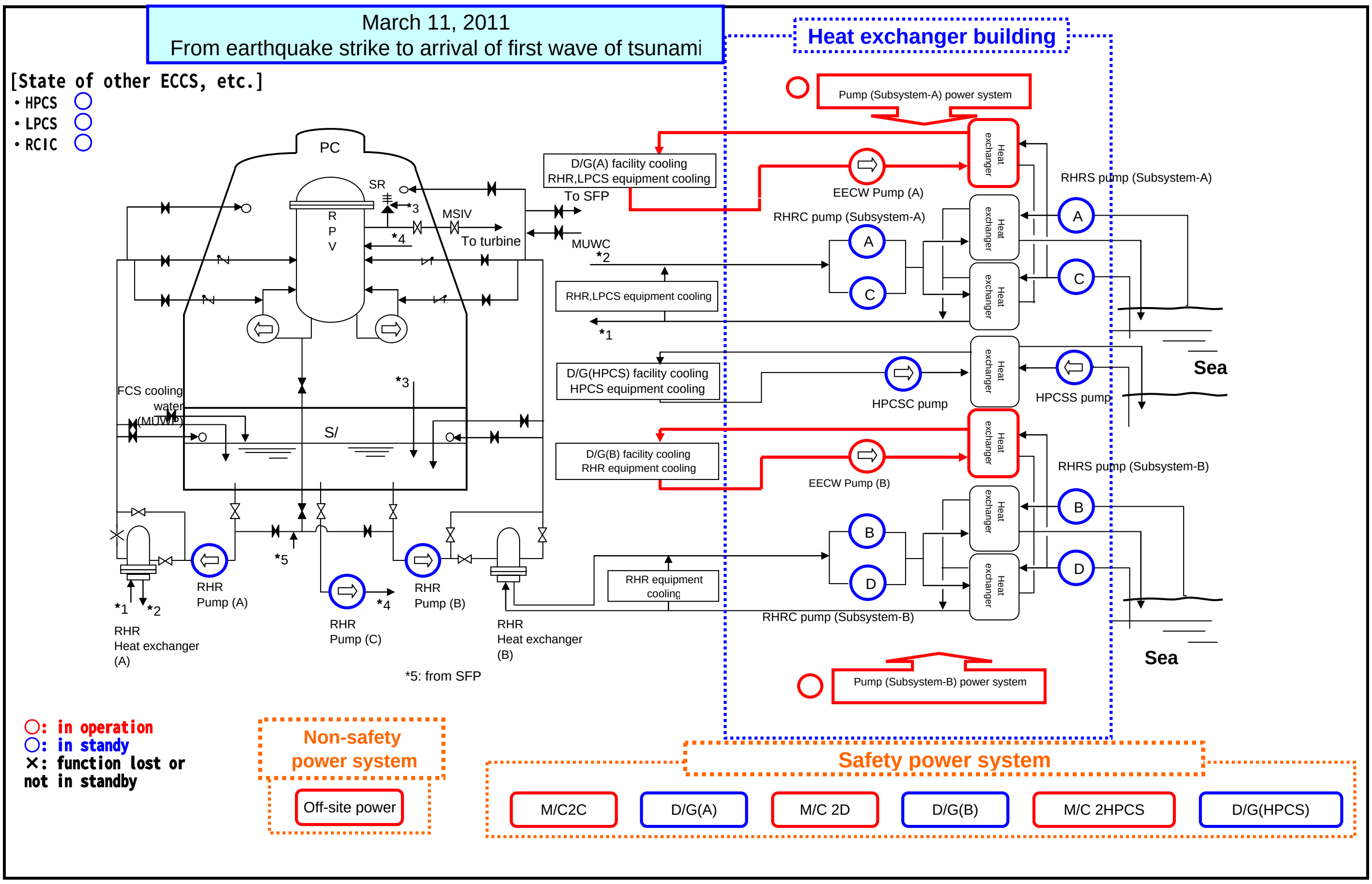


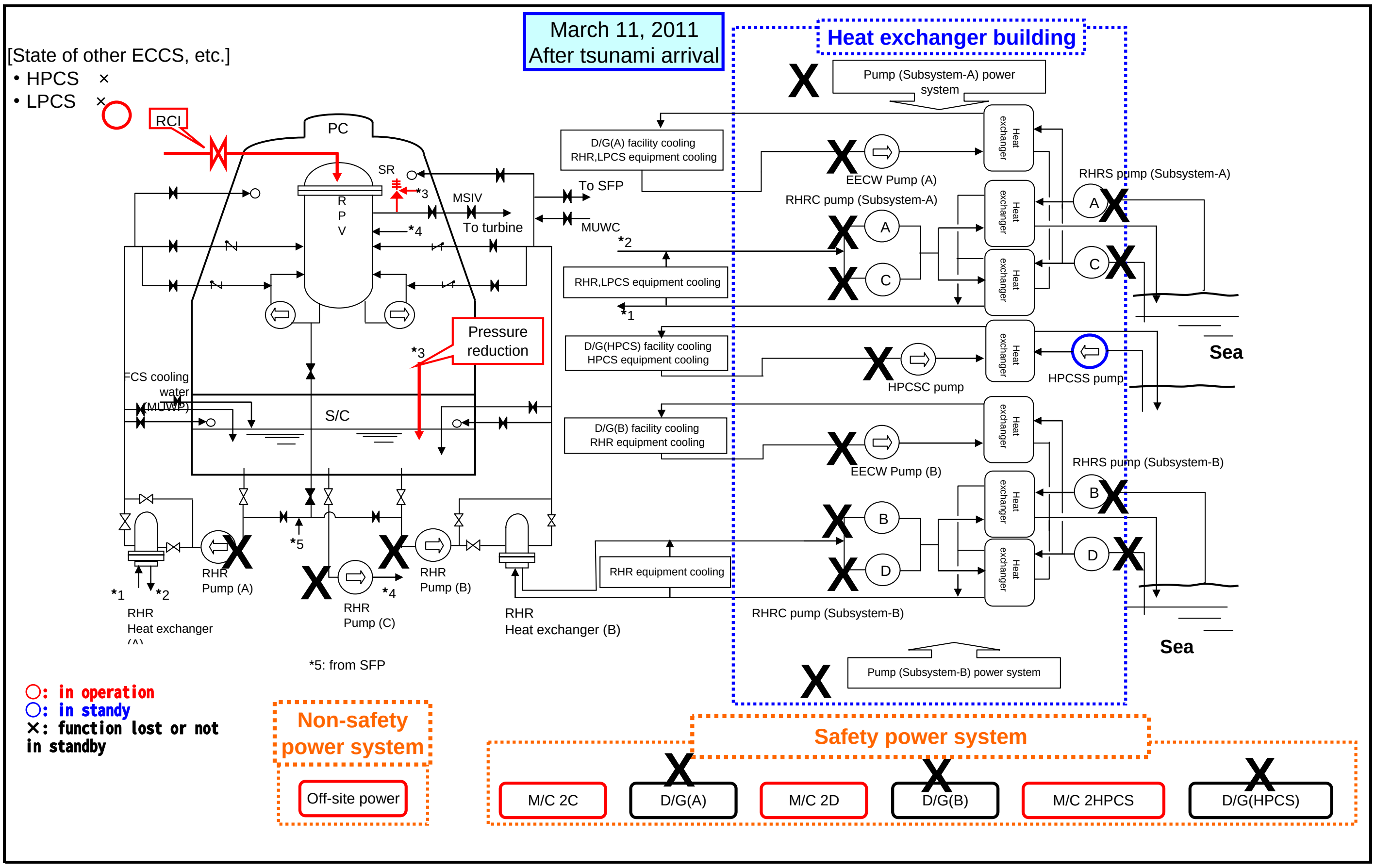
Fukushima Daini Unit 2 Emergency Core Cooling Systems (including components) List

			Location (units: mm)	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	From tsunami arrival up to cold shutdown	Status from cold shutdown to present (March 1, 2012)	Comments
Cooling down	ECCS & others	RHR(A)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on August 6, 2011.
		LPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on August 9, 2011.
		RHRC(A)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	○	×	○	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Laid temporary cables and fed power, started up on August 6, 2011.
		RHRC(C)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	○	×	×	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Laid temporary cables and fed power, started up on August 6, 2011.
		RHRS(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 6, 2011.
		RHRS(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, temporarily placed on Unit 2 seawater heat exchanger bldg. 2F.
		EECW(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 3, 2011.
		RHR(B)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→◎	◎	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on March 14, 2011.
		RHR(C)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→○	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, on standby on March 14, 2011.
		RHRC(B)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	○	×→◎	×	Unavailable due to water damage to power supply caused by tsunami No damage to pumps Laid temporary cables and fed power, started up on March 14, 2011. Covered and placed on Unit 2 seawater heat exchanger bldg. 2F
		RHRC(D)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	○	×	◎	Unavailable due to water damage to power supply caused by tsunami. +K19No damage to pumps. Laid temporary cables and fed power, started up on July 8.
		RHRS(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×→◎	×	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Laid temporary cables and fed power, started up on March 14, 2011. Motor has been repaired. Stored at factory (temporarily placed in spare parts warehouse on February 1, 2012).
		RHRS(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	◎	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on October 12, 2011.
		EECW(B)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	◎	×→◎	◎	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Laid temporary cables and fed power, started up on March 14, 2011.
		HPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	×	Unavailable due to inoperability of HPCSC due to tsunami. No damage to pumps. August 30, 2011: unavailable due to inoperability of HPCSS.
		HPCSC	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Unavailable due to water damage to motor caused by tsunami. No damage to pumps. After replacing motor with spare, started up on April 2, 2011. August 30, 2011: unavailable due to inoperability of HPCSS.
		HPCSS	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	○	×	August 30, 2011: motor failure.
	Reactor injection	RCIC	R/B Reactor Wing B2F (O.P.0000)	A	○	○	◎→○	×	Started up after tsunami, out of service on March 12, 2011 due to drop in reactor pressure.
		MUWC (alternate injection)	T/B B1F (O.P.2400)	B	○	○	○→◎→○	○	Operated on March 12, 2011, standby on March 14.
	SFP cooling	FPC	R/B Reactor Wing 4F (O.P.31800)	B	◎	×	×	◎	Unavailable due to trip by earthquake and inoperability of RCW due to tsunami. After restoration of RCW, startup (A) on July 18, 2011, startup of (B) on July 19, 2011.
		RHR	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→◎	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. After restoration of RHRS, RHRC, EECW, started up on March 16, 2011 (FPC auxiliary cooling mode).
Confining inside	Reactor containment facilities	R/B Reactor Wing		A	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	After reactor automatic shutdown, SGTS started up, negative pressure was maintained in R/B Reactor Wing, no signs of damage were found.
		PCV		As	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	No signs in PCV pressure indicated damage.

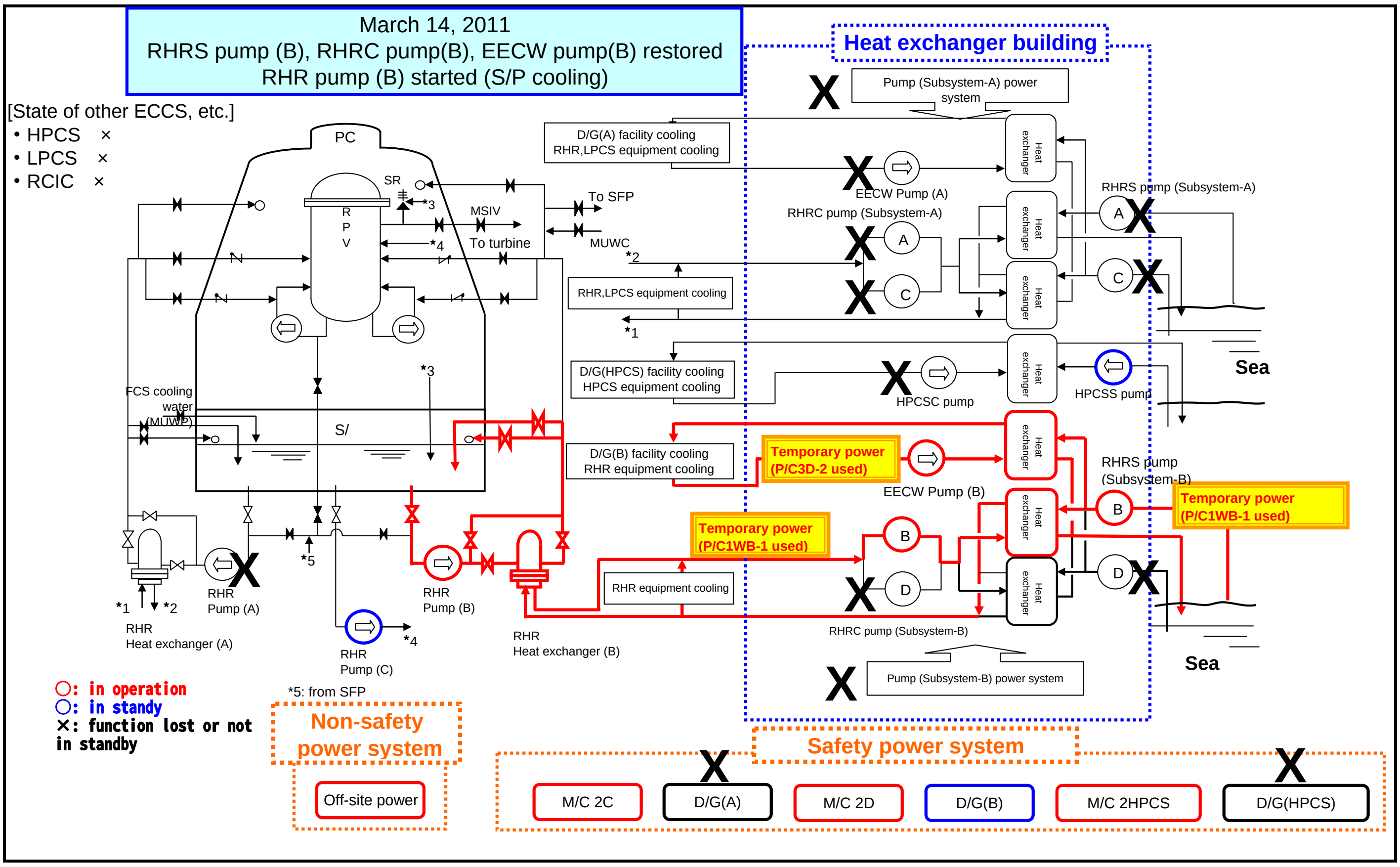
(Key) ◎: In Operation ○: Standby X: Loss of function or excluded from standby

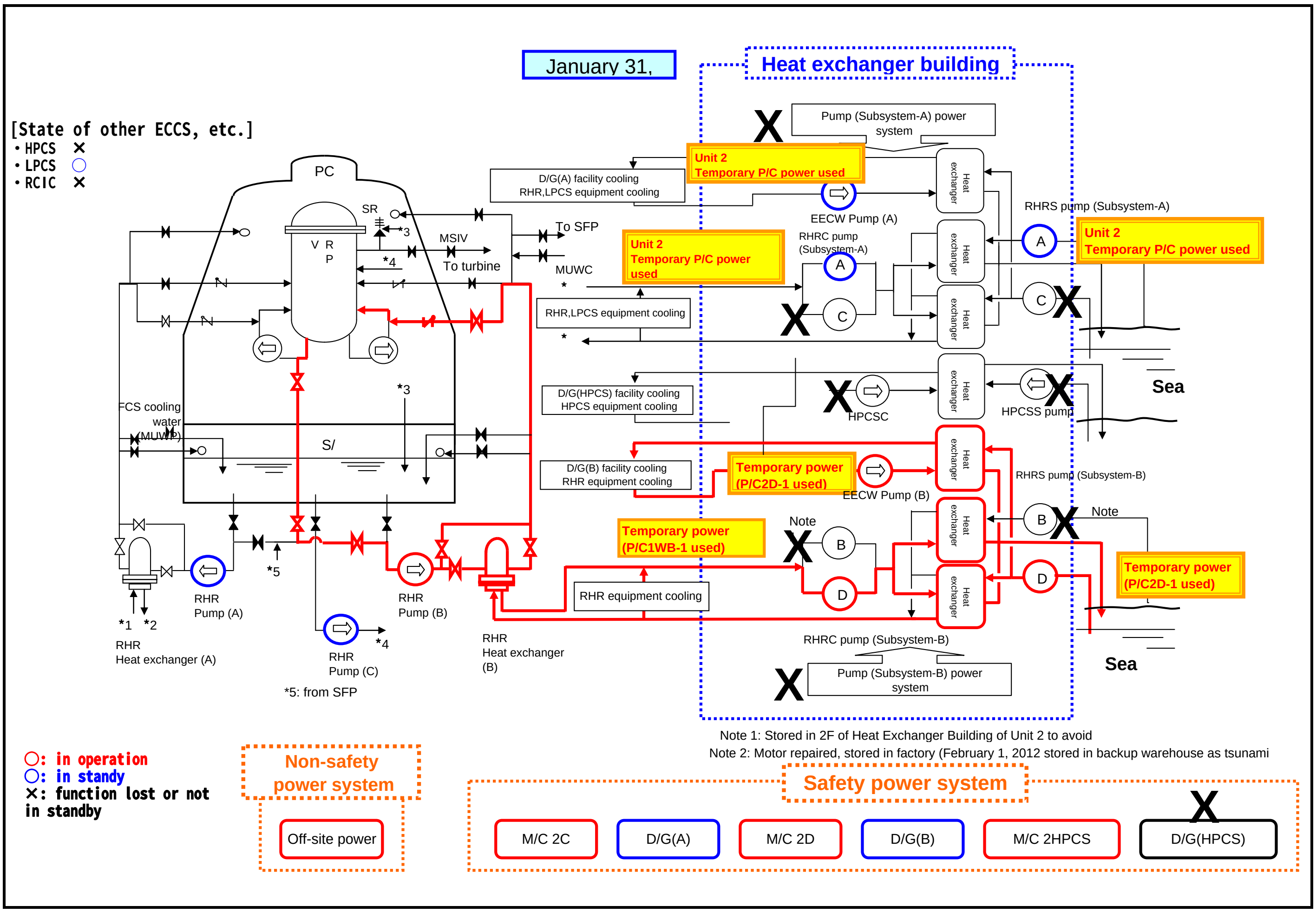
Fukushima Daini Unit 2 System schematic





Fukushima Daini Unit 2 System schematic





Note 1: Stored in 2F of Heat Exchanger Building of Unit 2 to avoid

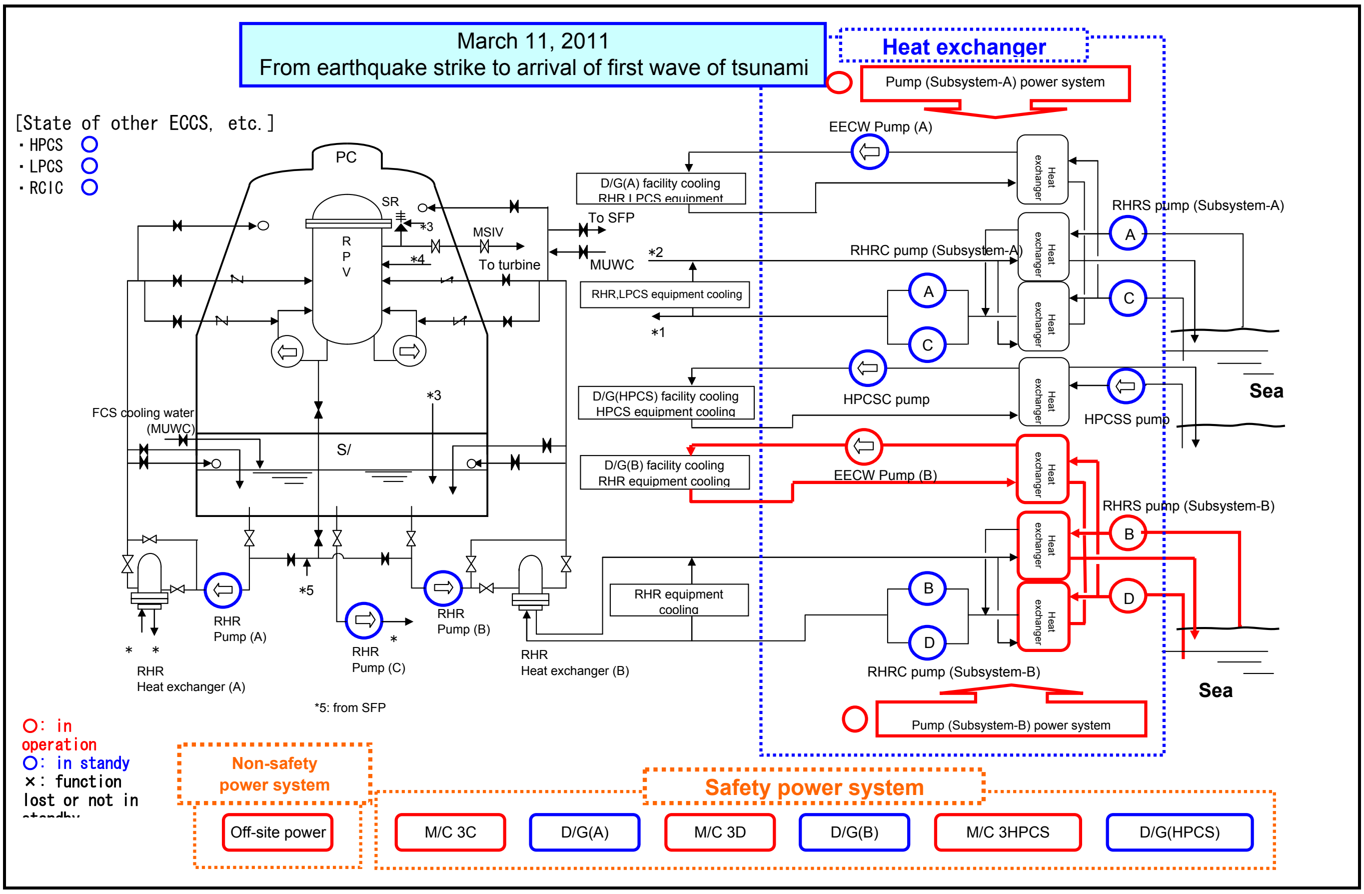
Note 2: Motor repaired, stored in factory (February 1, 2012 stored in backup warehouse as tsunami

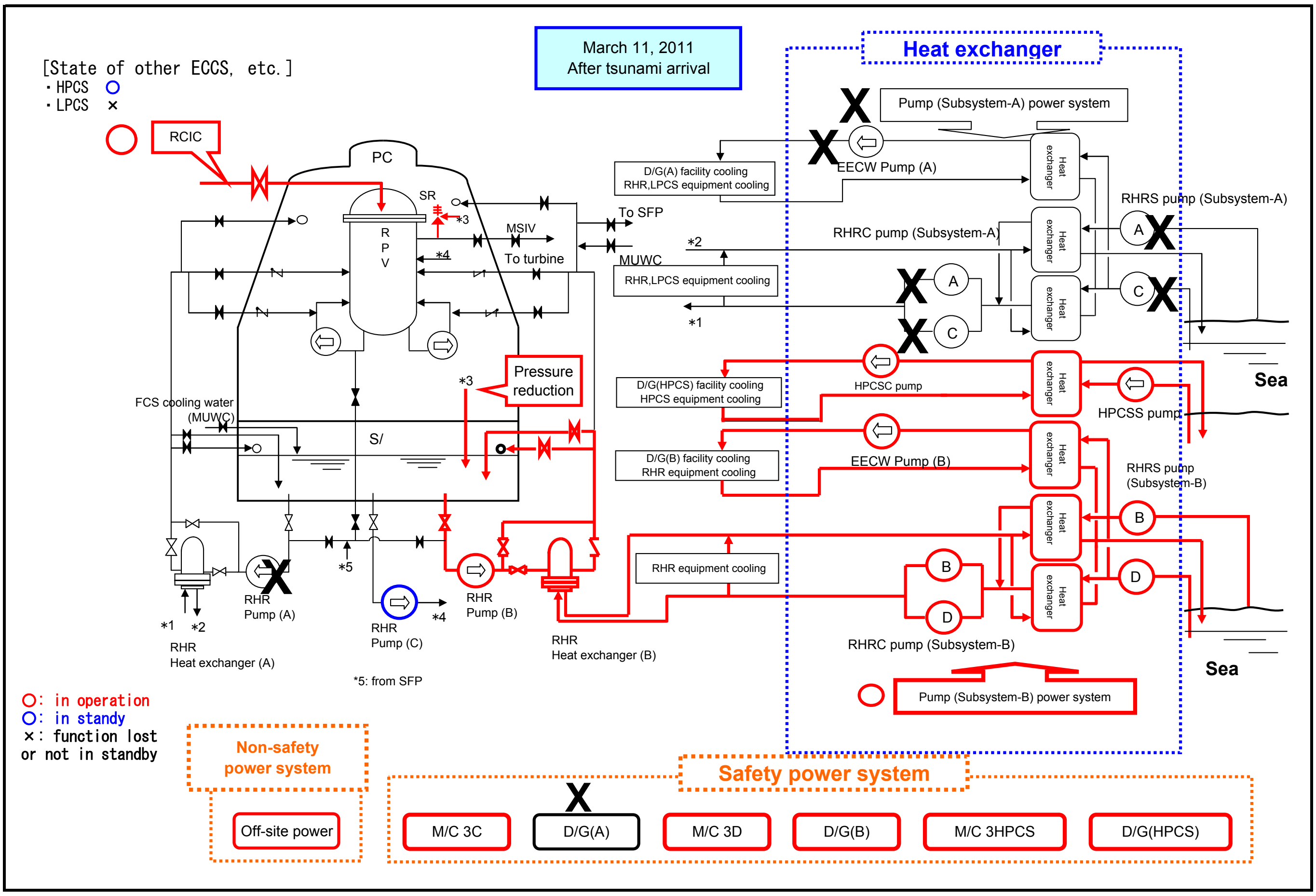
Fukushima Daini Unit 3 Emergency Core Cooling Systems (including components) List (Pre- & post-earthquake, post-tsunami)

			Location (units: mm)	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	From tsunami arrival up to cold shutdown	Status from cold shutdown to present (March 1, 2012)	Comments
Cooling down	ECCS & others	RHR(A)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on August 30, 2011.
		LPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on September 1, 2011.
		RHRC(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 26, 2011.
		RHRC(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on September 9, 2011.
		RHRS(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 30, 2011.
		RHRS(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on September 14, 2011.
		EECW(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 23, 2011.
		RHR(B)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	◎	◎	Started up on March 11, 2011 (S/C cooling mode). Switched to shutdown cooling mode March 12, 2011.
		RHR(C)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	○	○	
		RHRC(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	◎	Started up on March 11, 2011.
		RHRC(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	×	Started up on March 11, 2011. Temporarily placed on Unit 3 T/B 2F.
		RHRS(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	◎	◎	Started up on March 11, 2011.
		RHRS(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	◎	×	Started up on March 11, 2011. Temporarily placed on Unit 3 seawater heat exchanger bldg. 2F.
		EECW(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	◎	◎	Started up on March 11, 2011.
		HPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	○	○	
		HPCSC	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	○	
		HPCSS	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	○	
	Reactor injection	RCIC	R/B Reactor Wing B2F (O.P.0000)	A	○	○	◎→○	×	Started up after tsunami, went out-of-service on March 11, 2011 due to drop in reactor pressure.
		MUWC (alternate injection)	T/B B2F (O.P.-2000)	B	○	○	○→◎→○	○	Operated on March 11, 2011, standby on March 12, 2011.
	SFP cooling	FPC	R/B Reactor Wing 4F (O.P.31800)	B	◎	×	×→◎	◎	Unavailable due to trip by earthquake and inoperability of RCW due to tsunami. Started up on March 15, 2011 (Cooling water for FPC heat exchanger was RHRC). After restoration of RCW, switched cooling water to RCW on June 13, 2011.
		RHR	R/B Reactor Wing B2F (O.P.0000)	A	○	○	○	○	
Confining inside	Reactor containment facilities	R/B Reactor Wing		A	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	After reactor automatic shutdown, SGTS started up, negative pressure was maintained in R/B Reactor Wing, no signs of damage were found.
		PCV		As	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	No signs in PCV pressure indicated damage.

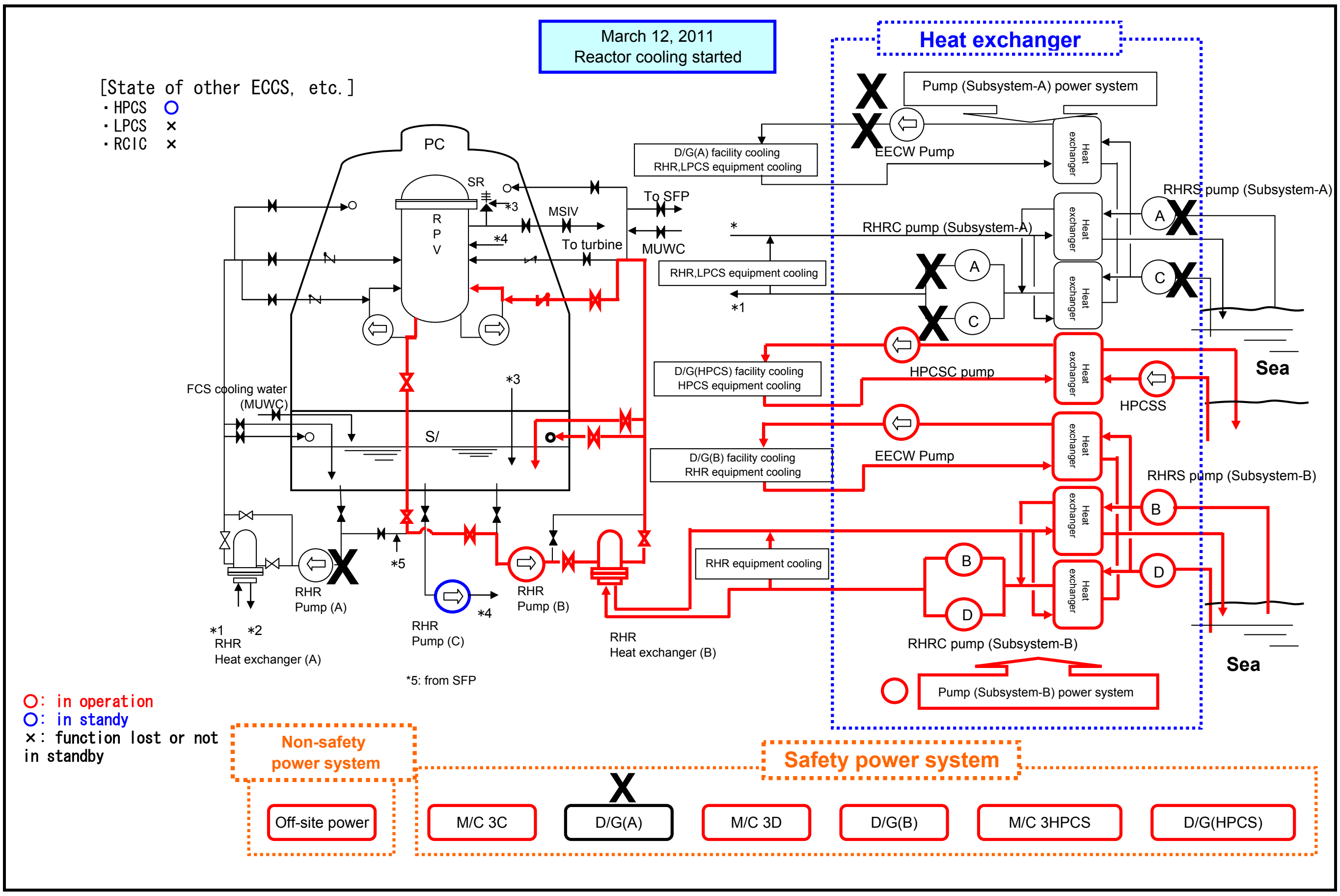
(Key) ◎: In Operation ○: Standby X: Loss of function or excluded from standby

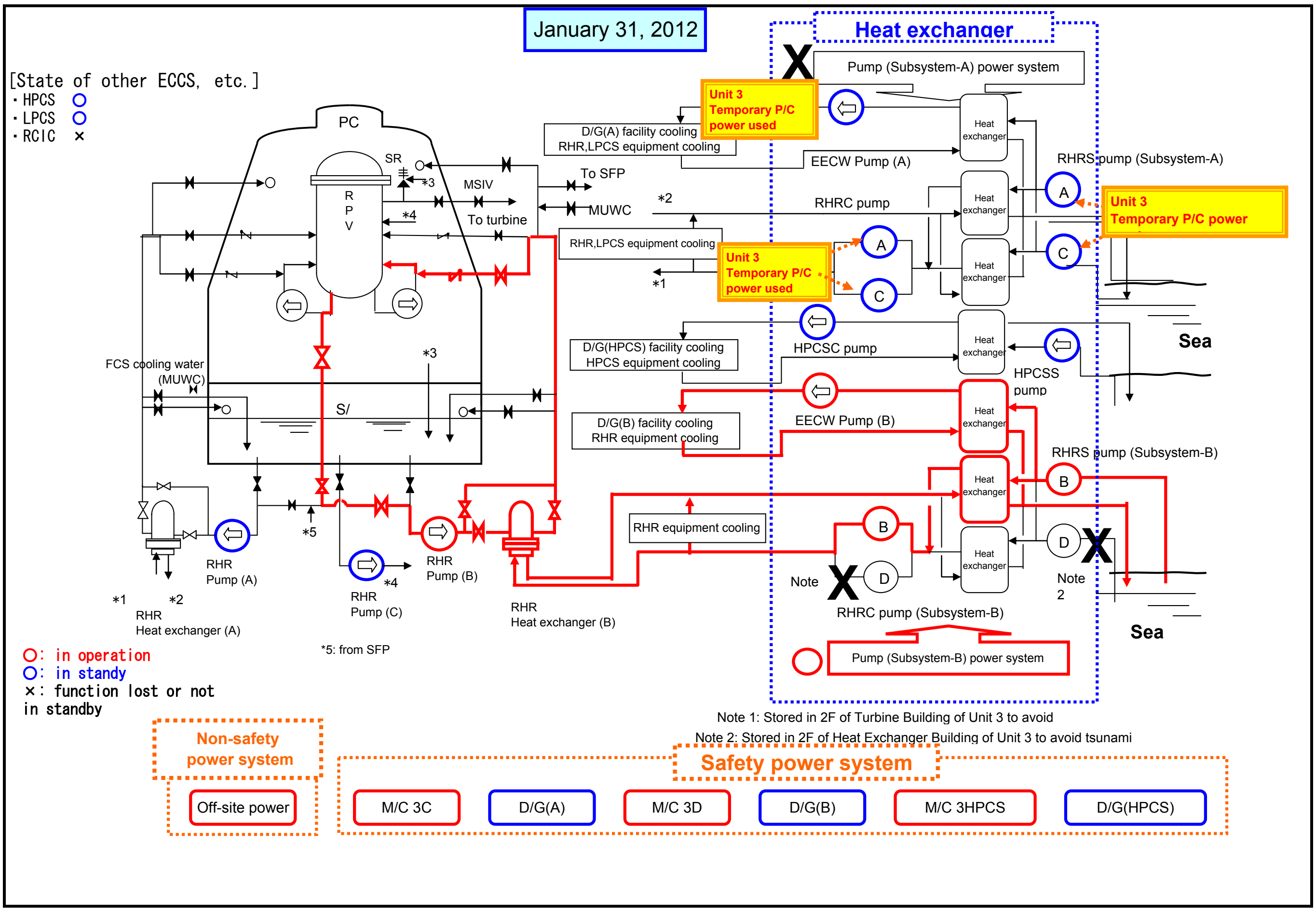
Fukushima Daini Unit 3 System schematic





Fukushima Daini Unit 3 System schematic



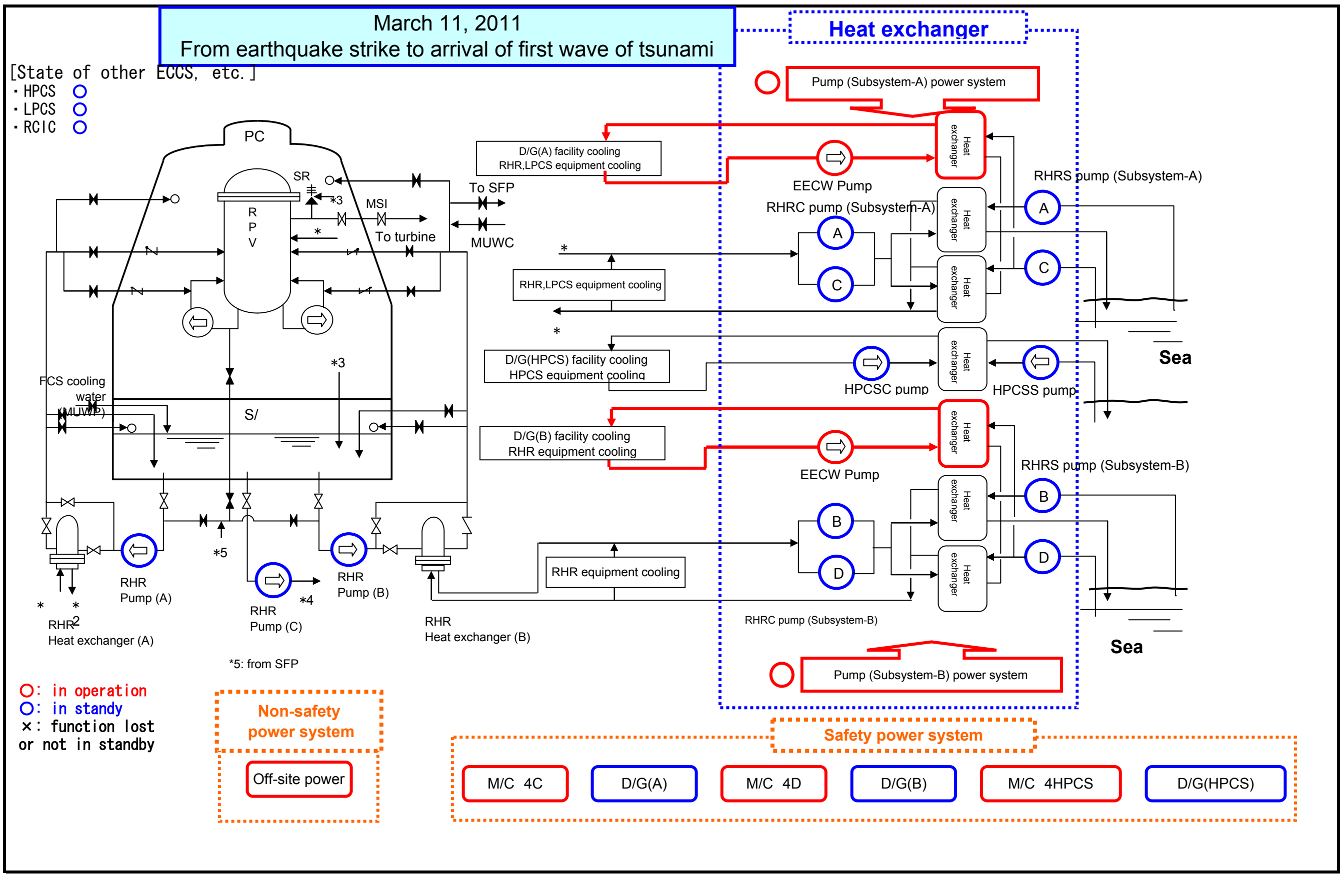


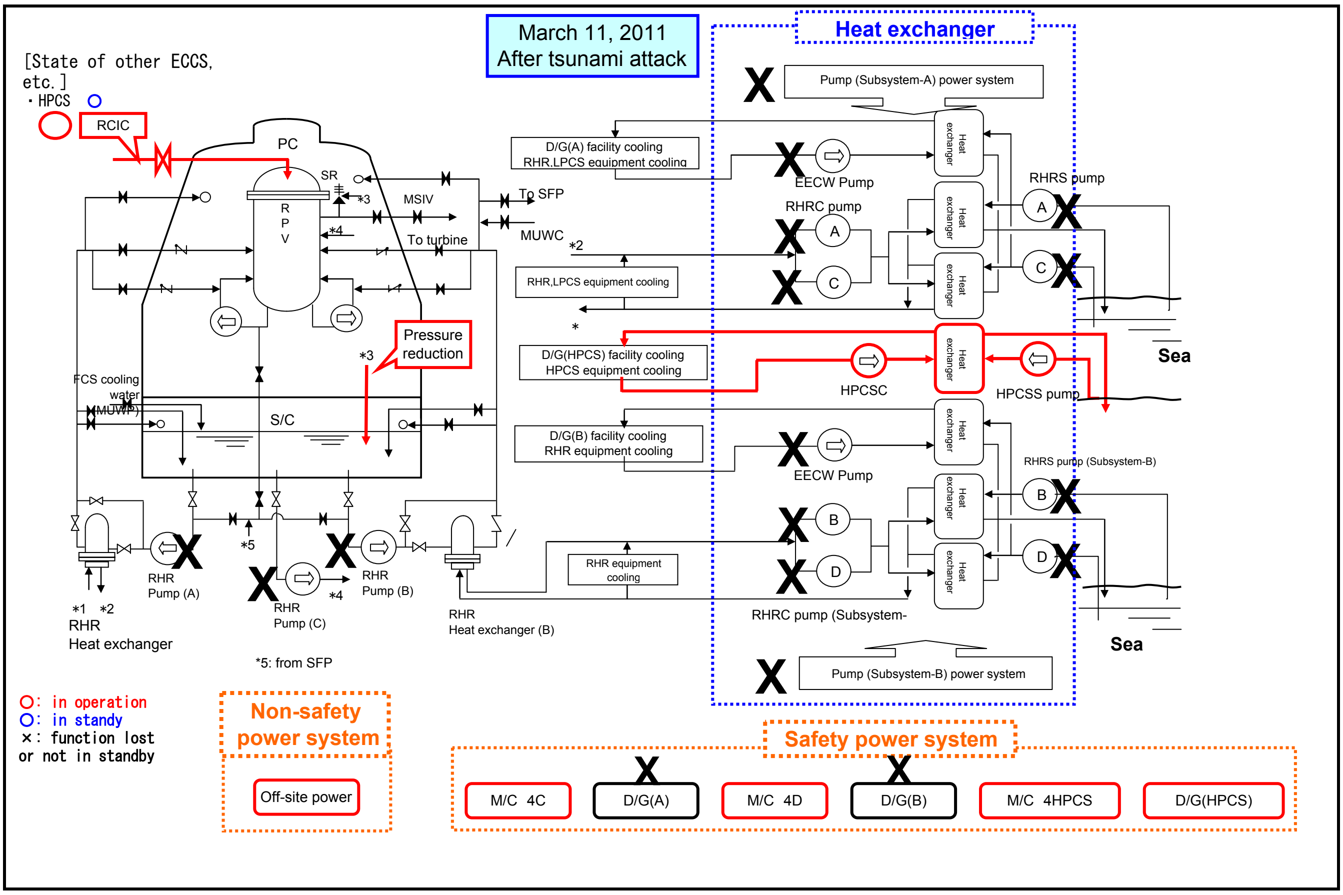
Fukushima Daini Unit 4 Emergency Core Cooling Systems (including components) List
(Pre- & post-earthquake, post-tsunami)

			Location (units: mm)	Seismic class	At time of reactor automatic scram	From reactor automatic scram up to first tsunami wave	From tsunami arrival up to cold shutdown	Status from cold shutdown to present (March 1, 2012)	Comments
Cooling down	ECCS & others	RHR(A)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on August 2, 2011.
		LPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on August 4, 2011.
		RHRC(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on July 25, 2011.
		RHRC(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Power supply and motors unavailable due to water damage by tsunami. After repairing motor, temporarily placed on Unit 4 T/B 2F.
		RHRS(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on August 2, 2011.
		RHRS(C)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	×	Power supply and motors unavailable due to water damage by tsunami. After repairing motor, temporarily placed on Unit 4 seawater heat exchanger building 2F.
		EECW(A)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	◎	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to supply power. Started up on July 21, 2011.
		RHR(B)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→◎	◎	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, started up on March 14, 2011.
		RHR(C)	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→○	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. No damage to pumps. After restoration of RHRS, RHRC, EECW, on standby- on March 14, 2011.
		RHRC(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×→◎	◎	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. Laid temporary cables and fed power, after replacing with spare motor, started up on March 14, 2011. After repairing motor, started up on July 7, 2011.
		RHRC(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	○	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. Laid temporary cables and fed power, replaced with spare motor and started up on June 29, 2011. After repairing motor, started up on September 29, 2011.
		RHRS(B)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×	◎	Power supply and motors unavailable due to water damage by tsunami. No damage to pumps. After repairing motor, laid temporary cables to feed power and started up on September 21, 2011.
		RHRS(D)	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	×→◎	×	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Laid temporary cables and fed power, started up on March 14, 2011. After repairing motor, stored at factory (temporarily placed in spare parts warehouse on February 1, 2012).
		EECW(B)	Seawater heat exchanger bldg. 2F (O.P.11200)	A	○	◎	×→◎	◎	Unavailable due to water damage to power supply caused by tsunami. No damage to pumps. Feed power through high voltage power supply car and by laying temporary cables, started up on March 14, 2011. Feed power by laying temporary cables.
		HPCS	R/B Reactor Wing B2F (O.P.0000)	A	○	○	○→◎→○	○	Water injection into core as appropriate from March 12, 2011. Standby on March 14, 2011.
		HPCSC	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	○	
		HPCSS	Seawater heat exchanger bldg. 1F (O.P.4200)	A	○	○	◎	○	
	Reactor injection	RCIC	R/B Reactor Wing B2F (O.P.0000)	A	○	○	◎→○	×	Started up after tsunami, went out-of-service on March 12, 2011 due to drop in reactor pressure.
		MUWC (alternate injection)	T/B B2F (O.P.-2000)	B	○	○	○→◎→○	○	Started up on March 12, 2011, standby on March 12, 2011.
	SFP cooling	FPC	R/B Reactor Wing 4F (O.P.31800)	B	◎	×	×→◎→○→◎	◎	Unavailable due to trip by earthquake and inoperability of RCW due to tsunami. Started up on March 15, 2011 (Cooling water for FPC heat exchanger was RHRC). Standby on March 16, 2011. After restoration of RCW, started up on June 5, 2011.
		RHR	R/B Reactor Wing B2F (O.P.0000)	A	○	○	×→○→◎→○	○	Unavailable due to inoperability of RHRS, RHRC, EECW due to tsunami. After restoration of RHRS, RHRC, EECW, started up on March 16, 2011 (FPC auxiliary cooling mode), standby on June 5, 2011.
Confining inside	Reactor containment facilities	R/B Reactor Wing		A	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	After reactor automatic shutdown, SGTS started up, negative pressure was maintained in R/B Reactor Wing, no signs of damage were found.
		PCV		As	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	◎ (Functioning)	No signs in PCV pressure indicated damage.

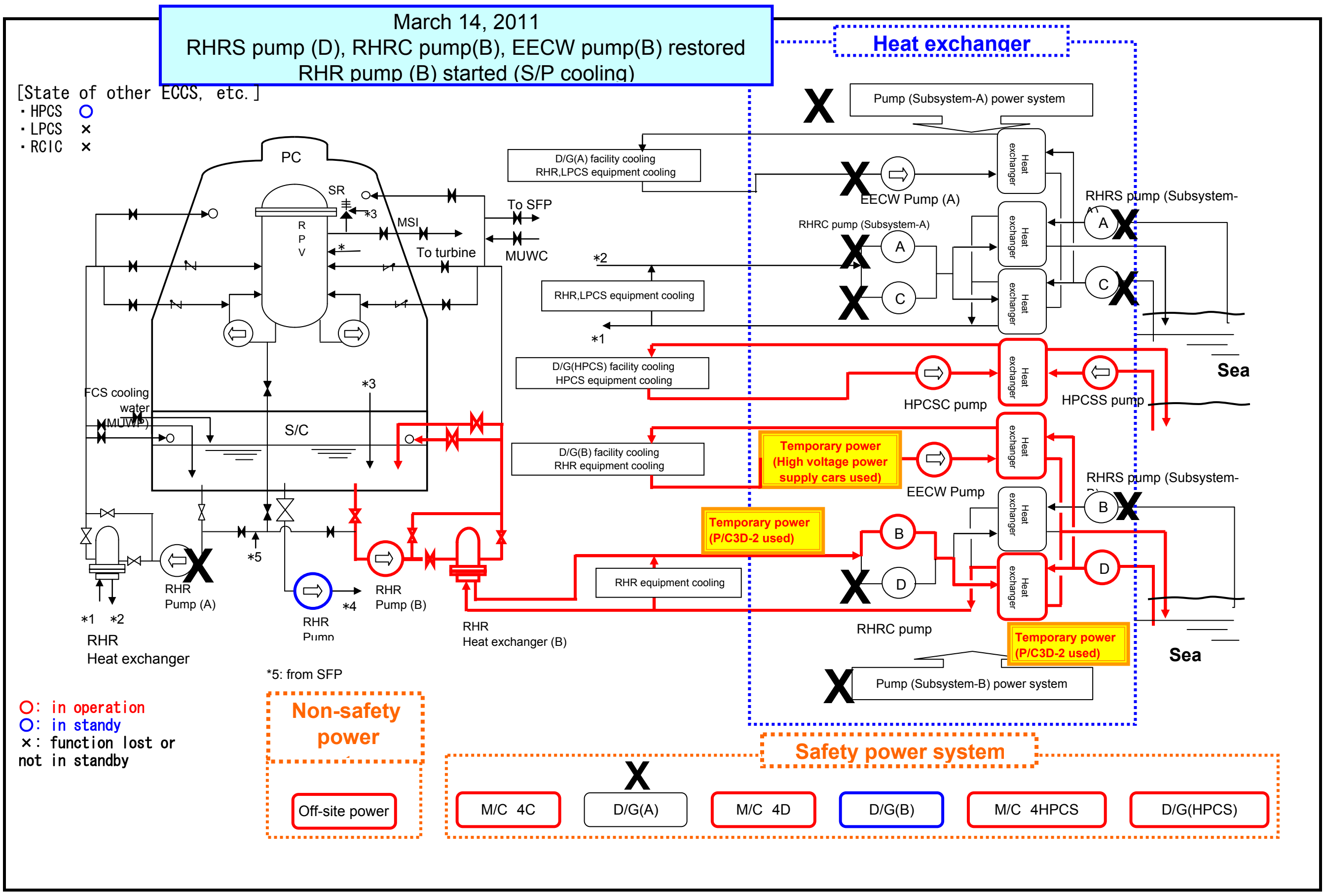
(Key) ◎: In Operation ○: Standby X: Loss of function or excluded from standby

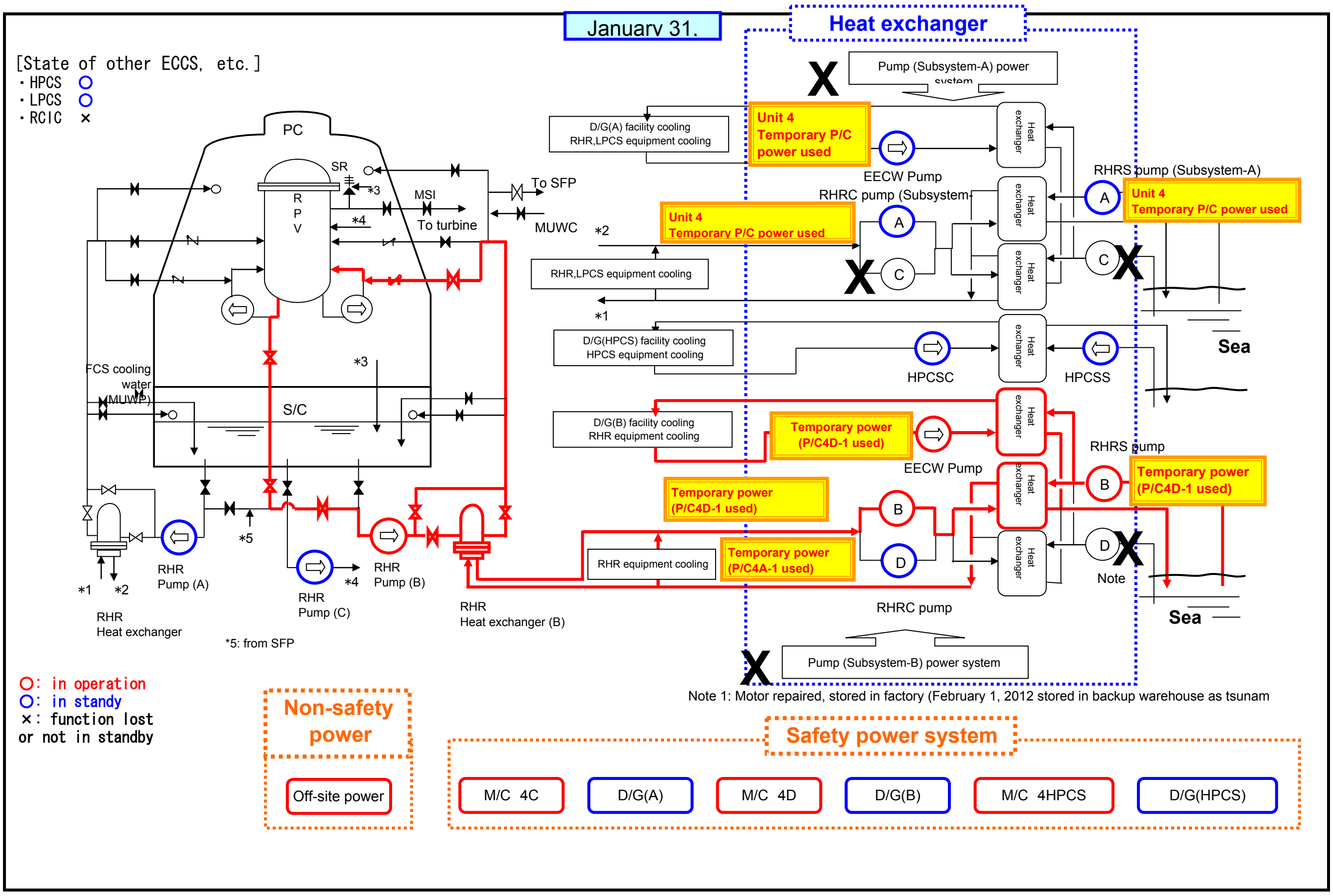
Fukushima Daini Unit 4 System schematic





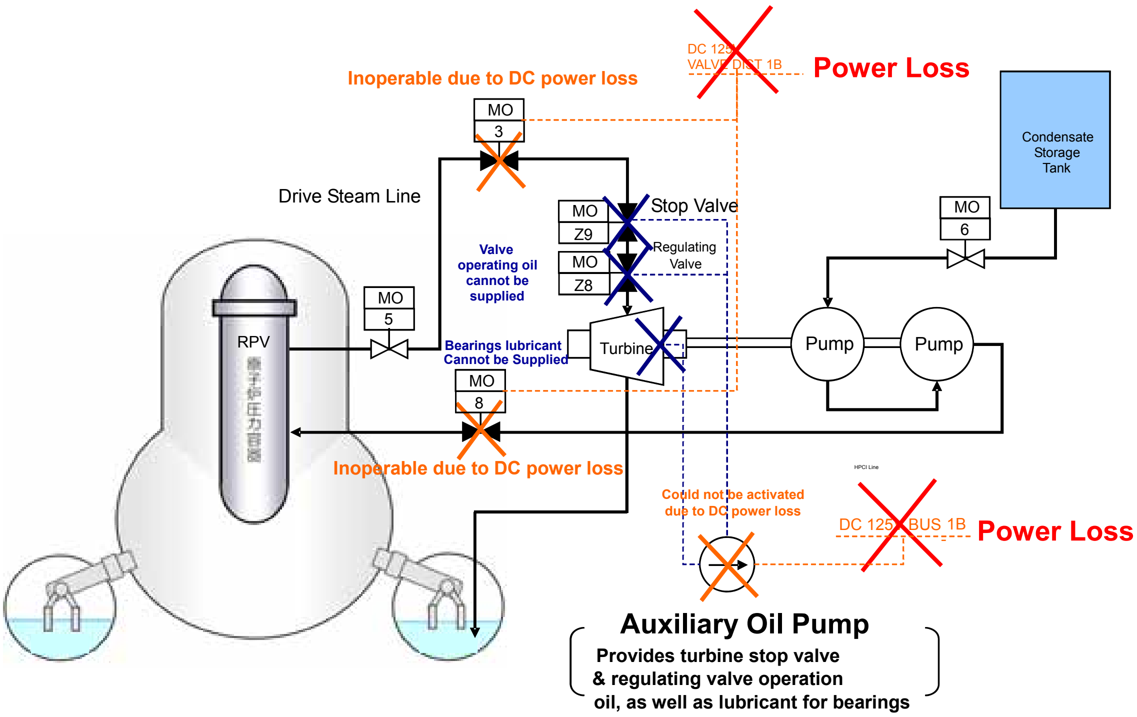
Fukushima Daini Unit 4 System schematic





Fukushima Daiichi Unit 1 HPCI

When the HPCI is activated, the auxiliary oil pump normally activates first. This supplies operating oil to the turbine stop valve and regulating valve, allowing HPCI turbine activation. However, the auxiliary oil pump could not be activated due to DC power loss, resulting in HPCI inoperability.



HPCI equipments status

Flow of Activation

HPCI Automatic Activation Signal

→ ~~Auxiliary Oil Pump Activation~~ →Turbine Stop Valve [MO -2301-Z9], Regulating Valve [MO-2301-Z8] unable to opened.

→ Barometric Condenser Vacuum Pump Activation

→ HPCI Steam supply Isolation Valve Opening (Inside[MO -2301-4],Outside [MO-2301-5])

→ HPCI Turbine Intake Valve (MO-2301-3) Opening

→ Valve for Suction from Condensate Storage Tank [MO -2301-6] Opening

→ Injection Valve [MO-2301-8] Opening

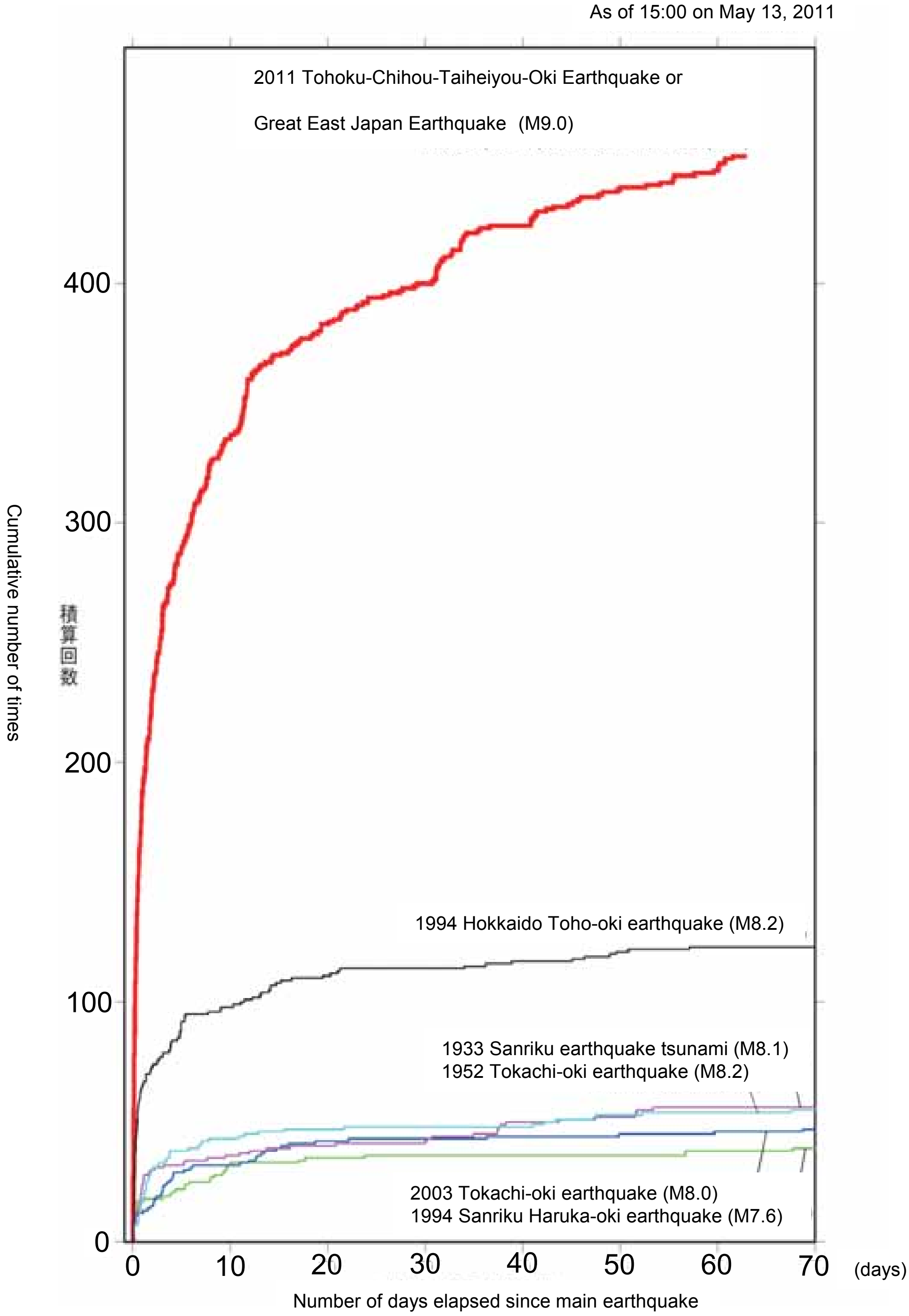
→ Minimum Flow Rate Bypass Valve [MO-2301-14] Opening

→ Coolant Valve [MO-2301-240] Opening

→ Test Bypass Valve [MO-2301-15, MO-2301-10] Closing

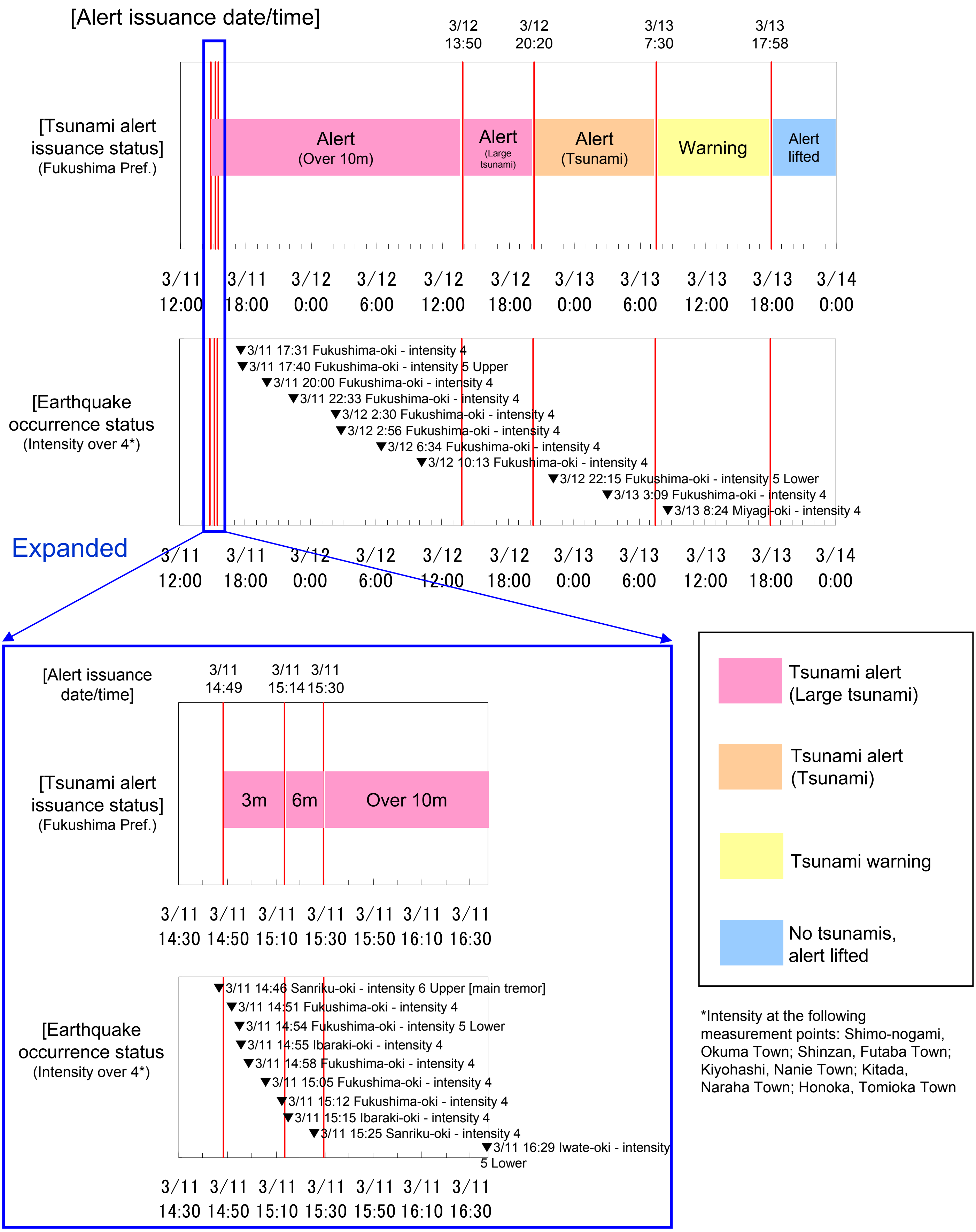
Flow of HPCI activation

Aftershock occurrence status
(Comparison of number of aftershocks for major sea area earthquakes (over M5.0))



Source: Materials issued by the JMA (May 13, 2011)

Aftershock occurrence status
(Tsunami alert issuance records (Fukushima Pref.))



Created based on 16th JMA meteorological work performance evaluation panel materials (May 31,2011)

Aftershock occurrence status

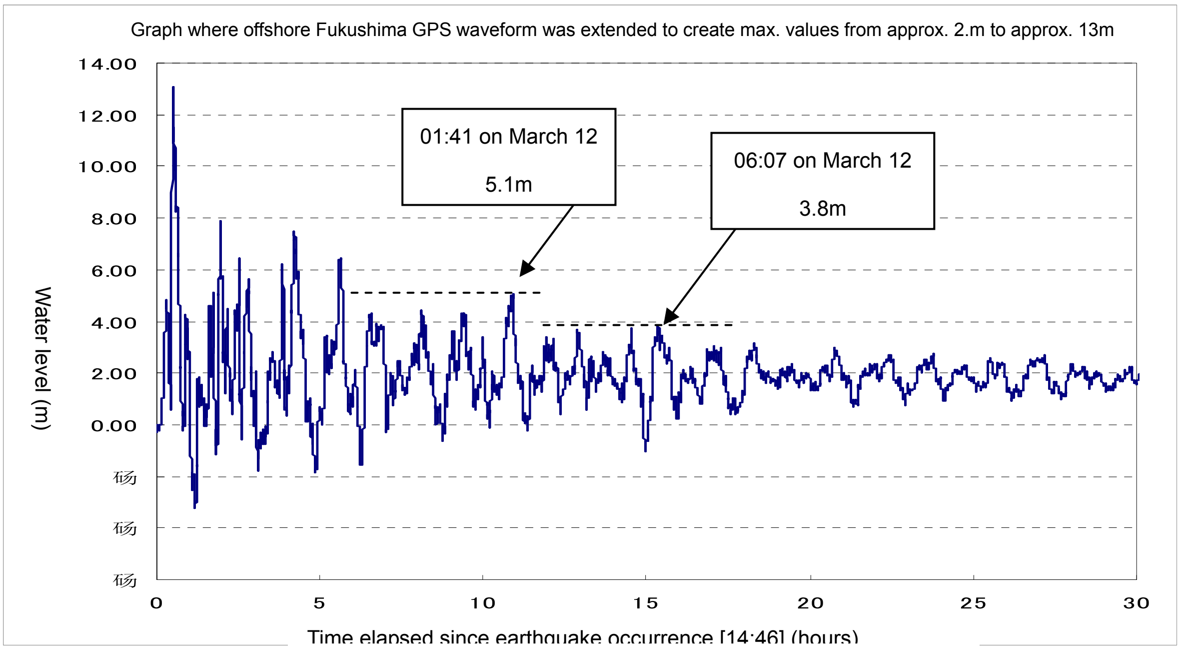
(Basic evaluation of continual tsunamis at Fukushima Daiichi Nuclear Power Station)

Due to the scale of this earthquake, the waveforms recorded by the offshore Fukushima GPS wave height gauge showed continued vibrations by tsunami for an extended period of time. Since the offshore Fukushima GPS wave height gauge is set within the deeper sections of the offshore area, the absolute value of its measured values are low. However, this is greatly magnified in the shallower coastal areas. A basic evaluation of continual tsunamis at Fukushima Daiichi NPS was performed based on offshore Fukushima GPS records.

[Considerations]

- Max. tsunami height according to offshore Fukushima GPS records was approx. 2.6m (actual measured value)
- Max. tsunami height at Fukushima Daiichi NPS tidal station was approx. 13.1m (recreated calculation)
- Basic evaluation used ratio between 2.6m and 13m (5 times the value) to understand trends

[Results]



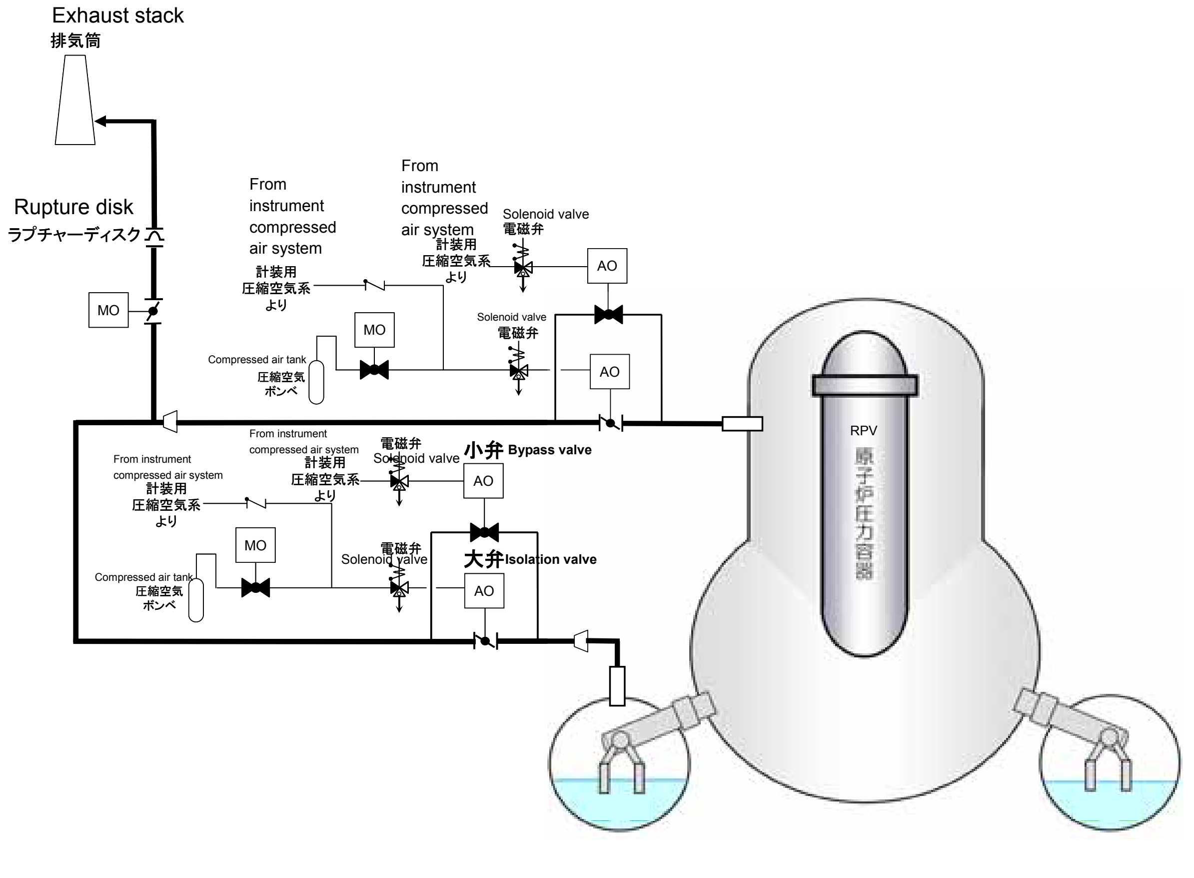
○ Peaks exceeding 4m prior to "5.1m at 01:41 on March 12" can be seen via basic evaluation

○ Peaks approaching 4m can be seen prior to "3.8m at 06:07 on March 12"

Thus it can be seen that the risk of tsunami flooding for the seaside O.P.+4m area continued in the time period until the early hours of March 12, or the day after earthquake occurrence. Note that the "tsunami alert (large tsunami): waves over 10m" issued by the JMA for the Fukushima Pref. coastline remained in effect until 13:50 on March 12 (approx. 23 hours after earthquake occurrence), when it was switched to "tsunami alert (large tsunami)."

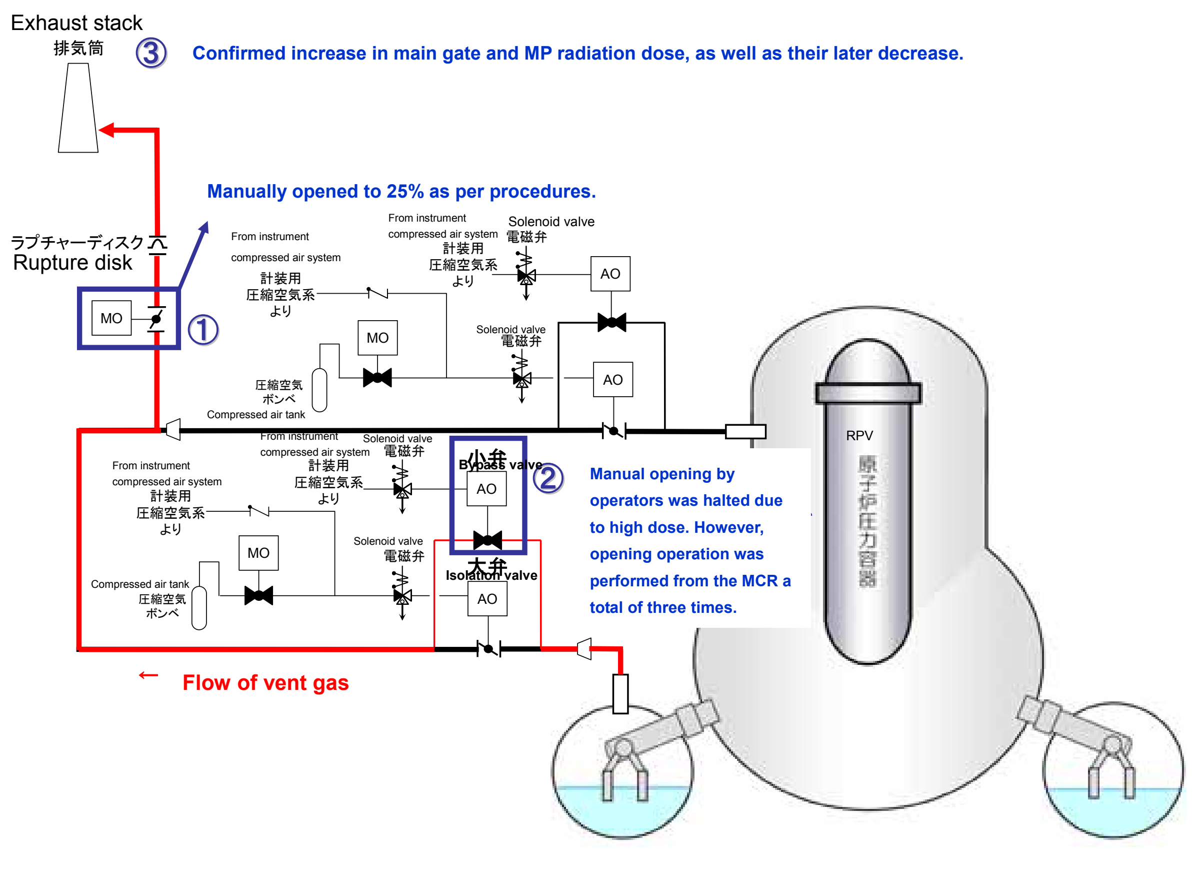
Fukushima Daiichi Unit 1 reactor PCV venting

Before the earthquake on March 11



Rupture disk activation pressure: 448kPa gage

Bypass valve use at 10:40 on March 12



Rupture disk activation pressure: 448kPa gage

[PCV vent valve (MO valve) and S/C vent valve (AO valve) bypass valve opening]

① 09:15 on March 12

PCV vent valve (MO valve) was opened to 25% as per procedures.

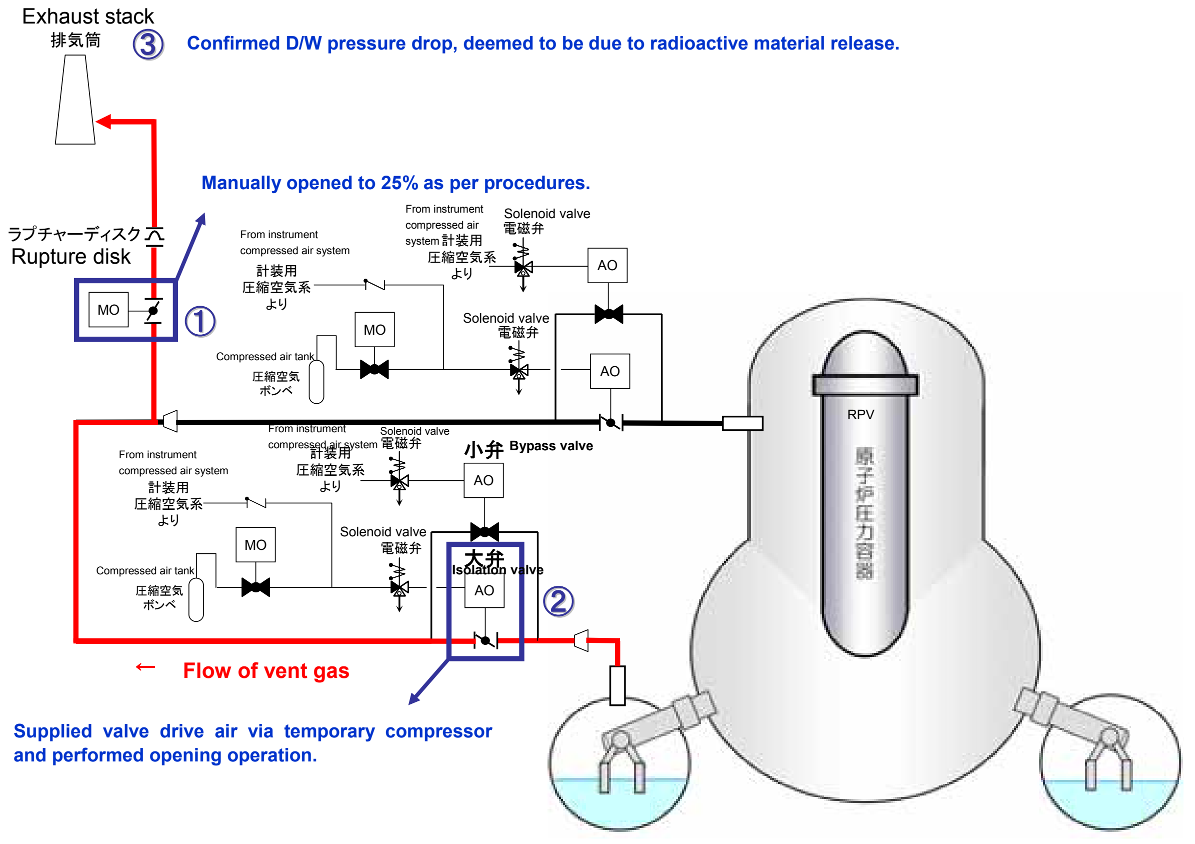
② 10:17 (1st time), 10:23 (2nd time), 10:24 (3rd time) on March 12

From the MCR, the S/C vent valve (AO valve) bypass valve solenoid valve was excited using small generator as a power source, and opening operation was performed. Could not confirm whether opening actually took place.

③ 10:40 on March 12

Since radiation levels near the station main gate and nearby monitoring posts were rising, the station ERC considered it highly likely that radioactive materials had been released due to venting. However, since radiation levels dropped at 11:15, it was confirmed that venting was not sufficiently effective.

Isolation valve use at 14:30 on March 12



Rupture disk activation pressure: 448kPa gage

[S/C vent valve (AO valve) isolation valve opening]

(1) 09:15 on March 12

PCV vent valve (MO valve) was opened to 25% as per procedures.

(2) Around 14:00 on March 12

Temporary compressor connected to IA system and pressurization performed in order to operate S/C vent valve (AO valve) isolation valve.

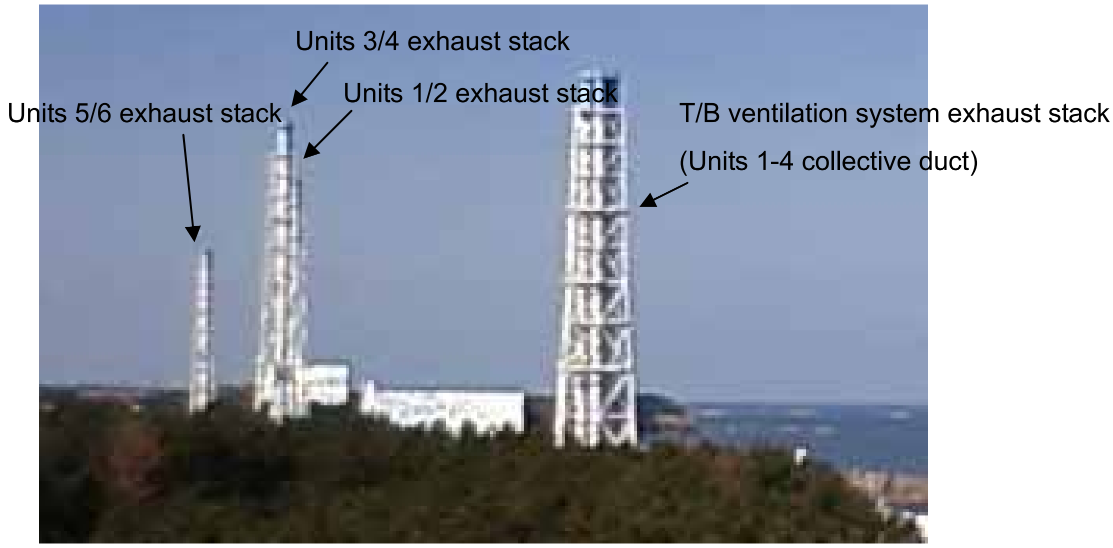
(3) 14:30 on March 12

Confirmed drop in D/W pressure, deemed to be caused by “release of radioactive materials” via venting.

(D/W pressure: 750kPa [abs] → 580kPa [abs] (14:50))

Fukushima Daiichi Unit 1 reactor PCV venting exhaust according to photos from the Fukuichi Live Camera

■Taken at 14:00 on March 12

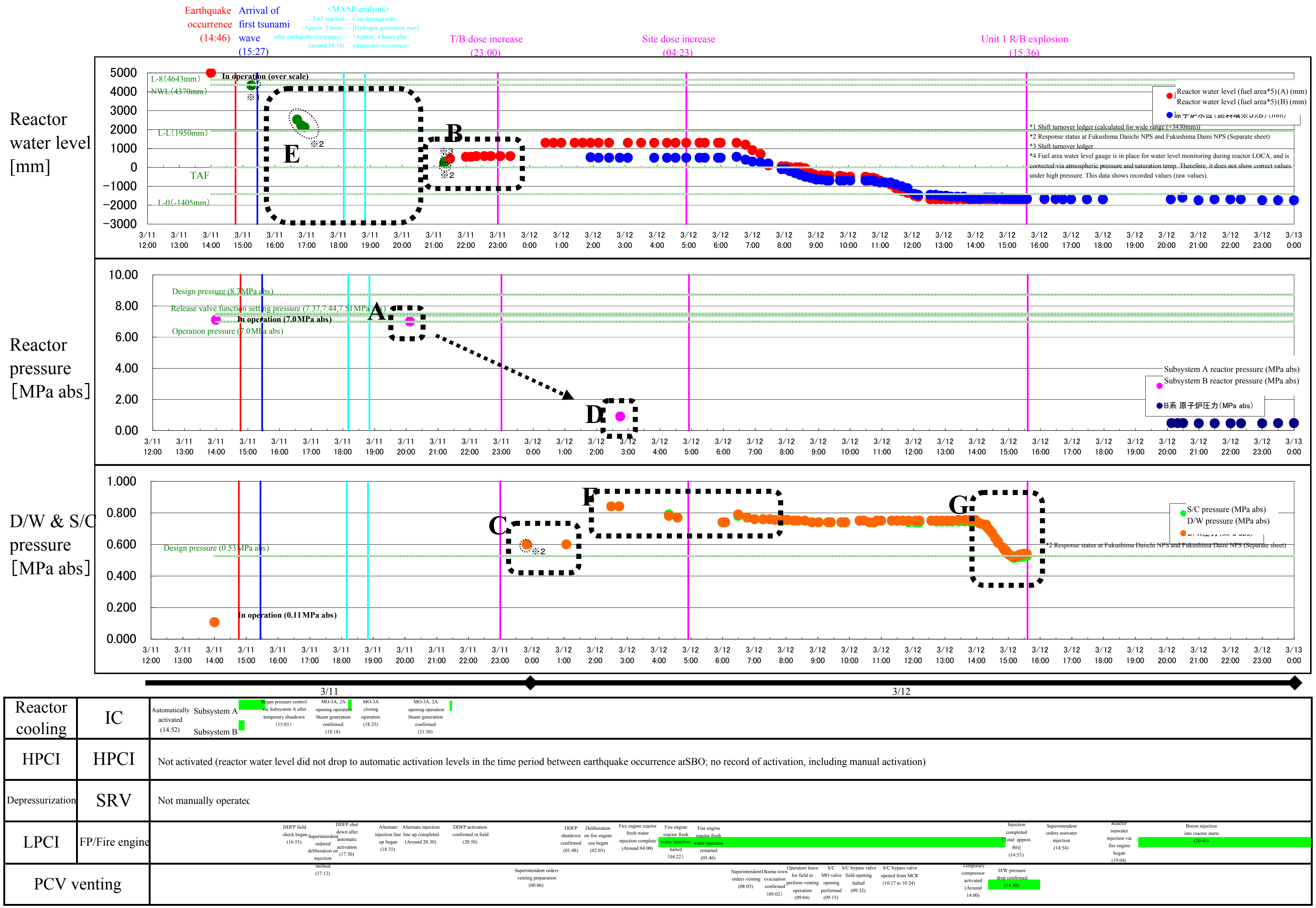


Around 14:00 – temporarily installed compressor connected for pressurization to allow S/C vent valve (AO valve) isolation valve operation
14:30 - D/W pressure drop confirmed

■Taken at 15:00 on March 12

Steam-like mass seen toward mountain side of Units 1/2 exhaust stack
(Not seen in photos taken after 16:00)

Fukushima Daiichi Unit 1 Plant Parameters Transient



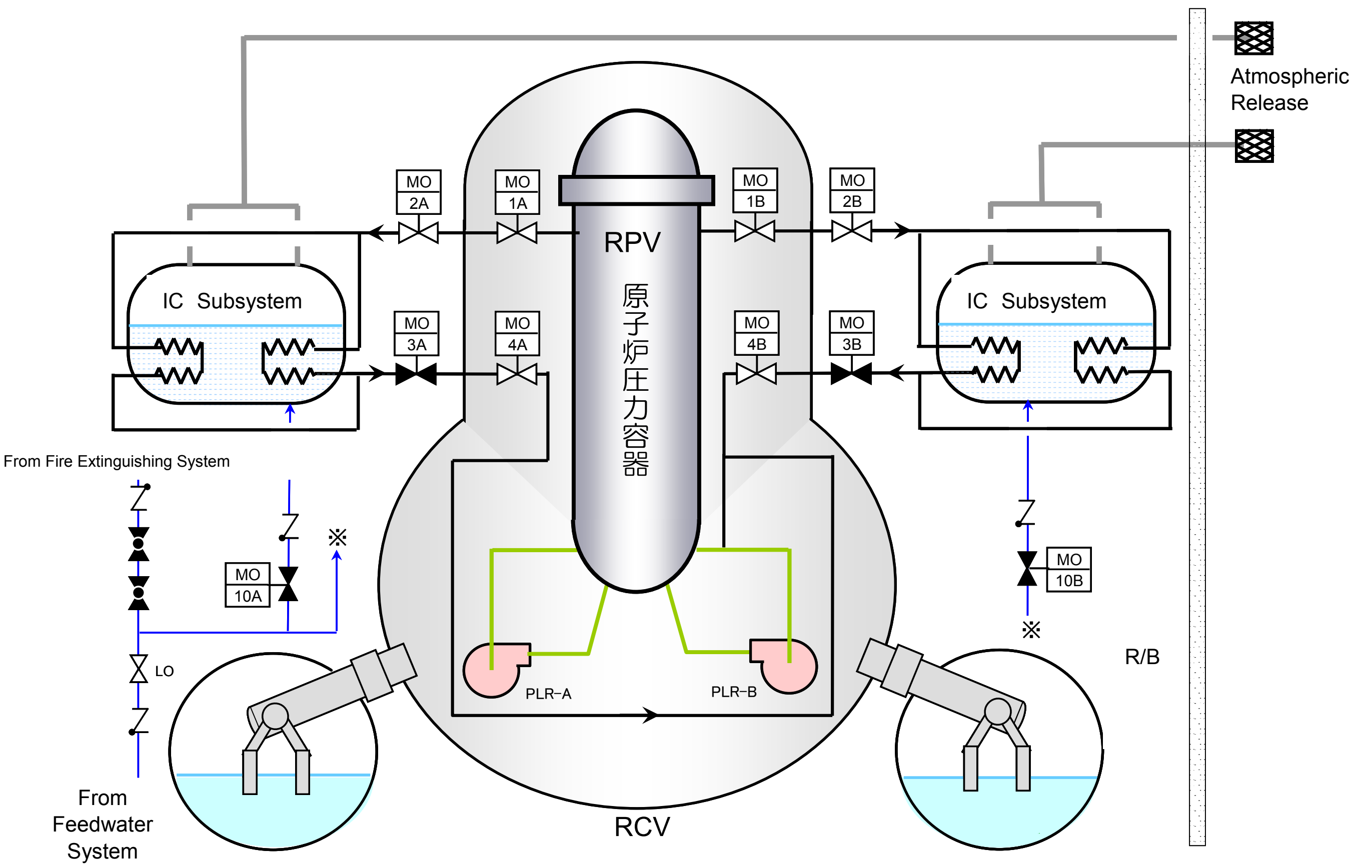
About the Isolation Condenser System (IC)

There are four isolation valves per the Isolation Condenser system (IC), which are opened/closed to perform startup/shutdown operation and restrict radioactive material release / prevent release of reactor water via isolation when IC pipes rupture. Since these valves are driven by motors, loss of power means they can no longer operate due to loss of power for the drive motors as well. Although MO valve inoperability due to loss of power should be avoided, there are design considerations to ensure IC system startup (heat removal function) and isolation function reliability are not immediately affected in this case.

1. Securing reliability of startup/isolation function in IC design

(1) IC system structure

The IC system structure is shown in the figure below. The IC directs reactor steam to the IC, where it is cooled via heat transfer with IC shell side water, before it returns to the reactor via the return pipe. Thus is the IC structured to be a closed loop. IC shell side water temperature rises via this heat transfer, and the resulting steam is released outside the building. Two isolation valves (MO valves) are installed (one inside the PCV and one outside the PCV) on the steam supply and return pipes. The valve inside the PCV is driven by AC, while the one outside is driven by DC. Power is provided via separate system for Subsystems A/B; which are powered by separate emergency power (AC) and DC power sources.



IC system structure

IC (Subsystem A) power structure			IC (Subsystem B) power structure		
Isolation valve	**Installation location**	**Power source**	**Isolation valve**	**Installation location**	**Power source**
Valve 1A	Inside	AC power (MCC-1D)	**Valve 1B**	Inside	AC power (MCC-1C)
Valve 2A	Outside	DC power (125V-1A)	**Valve 2B**	Outside	DC power (125V-1B)
Valve 3A	Outside	DC power (125V-1A)	**Valve 3B**	Outside	DC power (125V-1B)
Valve 4A	Inside	AC power (MCC-1D)	**Valve 4B**	Inside	AC power (MCC-1C)

As stated earlier, there are four isolation valves per system. When in standby, the return pipe outside valve is closed, and the other three are all open.

In case of IC pipe rupturing, the isolation valves are designed to interlock and close when rupture is detected via IC flowrate abnormality.

The above-mentioned system concept is adopted by most nuclear power stations with IC both domestically and abroad. It is not one used solely by Fukushima Daiichi Unit 1. The design of this type of system allows operation function (heat removal) and isolation function to be maintained if one of the equipment malfunctions, as explained below.

(2) Reliability in startup from standby

The IC is not an equipment set as part of ECCS. However, in order to function as a backup facility, it possesses high reliability in startup from standby. Policy 9 of the ”Regulatory Guide for Reviewing Safety Design of Light Water Nuclear Power Reactor Facilities (hereinafter referred to as “Policy”),” requires “design ensuring system safety function even if a single component of system malfunctions in addition to off-site power loss” for equipment possessing vital safety functions.

Specifically, at Fukushima Daiichi Unit 1:

○ IC has design considerations in place for situations where a single component of the system experiences fail, alongside prepared emergency power (emergency DG) or batteries usable during SBO (DC power).

○ Since IC MO valves open/close via electric motors, valves cannot be operated if drive equipment experiences failure or drive power is lost. Therefore, isolation valves outside the PCV (valves 3A, 3B) remain open on standby and the minimum number of isolation valves per system which must be operated during standup (one per system, valves 3A & 3B) are used when IC is in standby.

○ Isolation valves which perform opening/closing during operation (valves 3A, 3B) use highly reliable DC power as drive power. The DC power used is from a separate system (Subsystems A/B) to ensure reliability.

The above allows IC operation when AC power is lost. Even in the event of failure for a single system (e.g. DC power), one of the two IC systems will remain operable. IC possesses high cooling function, meaning only one of the systems need to be activated to secure decay heat removal function.

(3) Isolation function reliability in standby/operational states

Since the IC is a system which penetrates the reactor PCV for circulation between the inside of the reactor and the IC body, two isolation valves are placed (one inside the PCV and one outside the PCV) on any pipe which penetrates the PCV in order to prevent reactor coolant leakage outside the PCV if IC pipes rupture. Policy 30 requires that “reactor PCV isolation valves connected to major piping be designed to automatically and definitely close for accidents requiring isolation function.”

Specifically, at Fukushima Daiichi Unit 1:

- ○ In case IC pipes rupture during standby, two isolation valves are placed (one inside the PCV and one outside the PCV) on any pipe which penetrates the PCV in order to prevent reactor water leakage outside the PCV. The drive power and rupture detection (control logic circuit) for these valves are supplied by emergency power or DC power.
- ○ All IC isolation valves are designed to automatically close via interlocking if IC pipe rupture is detected. To avoid loss of “automatic closing function” due to inability to perform rupture detection due to abnormalities (e.g. control logic circuit power source (DC power) shutdown), isolation via interlocking control is triggered when logic circuit power is lost.
- ○ In cases where isolation is necessary, the power source system is structured to ensure successful isolation via closing of one of the valves (either inside or outside) on pipes penetrating the PCV. This ensures isolation, even if a single valve fails to operate due to malfunction of a single component (e.g. valve drive equipment, drive power). Specifically, the isolation valves on the inside and outside of the PCV are each driven by a separate power source (inside: AC power, outside: DC power). This design ensures isolation function will be maintained even if a single component (e.g. valve drive equipment, drive power) malfunctions.
- ○ Even if isolation via interlocking is performed when DC power for one of the systems is lost, the IC for the other system can be activated, thus securing IC system RHR function.

The above ensures isolation function reliability in case of single component malfunction. It also ensures function will not be lost due to single component malfunction, from the standpoint of securing RHR function after interlocking.

2. Summary

(1) The Fukushima Daiichi Unit 1 IC system is designed to ensure startup from standby, even in the case of a single component malfunctions. Its design also ensures isolation from standby/operational states, even in the case of a single component malfunctions.

(2) Even if isolation interlocking occurs due to DC power loss, as long as it is a single component malfunction, one of the two IC systems can be started up to secure decay heat removal function.

(3) The above proves that the Fukushima Daiichi Unit 1 IC facility possesses safety function from the standpoint of reliability, and fulfills the requirements for reliability requested in the Policy.

(4) However, IC function was impaired in this accident, to the point where IC could not be operated. This was due to loss of both AC and DC power (each power source possess two systems), a severe accident which greatly exceeded design prerequisites.

Fukushima Daiichi Unit 1 Isolation Condenser System (IC) system structure

1. Drain pipe connection method

The drain pipes for Fukushima Daiichi Unit 1 Isolation Condenser System (IC) Subsystems A/B (condenser reactor return pipe) are both connected to the Subsystem B of PLR system, which then return to the reactor.

However, on the reactor establishing permit application, IC Subsystem A is connected to the PLR Subsystem A, while the IC Subsystem B is connected to the PLR Subsystem B.

To adjust for this difference (reason for design change), relevant documents (reactor establishing permit application, construction permit application) were inspected and relevant parties interviewed. However, the reason for changes to IC drain pipe connection method could not be confirmed.

The speculated reasons for design change are considered below.

(1) Placement of IC within buildings

Fig. 1 shows the IC placement listed on the Fukushima Daiichi Unit 1 reactor establishing permit application. Two IC are placed on the same side of the reactor at Fukushima Daiichi Unit 1.

Meanwhile, the PLR Subsystems A/B are set diagonally from each other on each side of the reactor. The IC drain pipe was most likely connected to the near side PLR system to reduce pipe pressure load and primary coolant pressure boundary.

(2) PLR system pipe leak potential reduction

Along with IC system pipes, reactor shutdown cooling system (hereinafter referred to as “SHC system”) pipes are connected to PLR system pump suction pipes.

Since increasing the number of connections to PLR system pipes raises leak potential, SHC system pipes are thought to have been connected to the PLR A pump suction pipe, while IC Subsystems A/B are believed to have been joined before being connected to the PLR B pump suction pipe.

Success/failure of IC system startup is dependent upon isolation valve (active equipment) operation. Therefore, reliability is ensured by giving Subsystems A/B independent valve structure in case valves for one of the systems fail to operate.

Drain pipes (static equipment) have very low possibility of rupturing, but would lead to reactor LOCA due to reactor coolant leakage if rupture occurs. However, since the Emergency Core Cooling System would activate in this case, IC system functions are not expected.

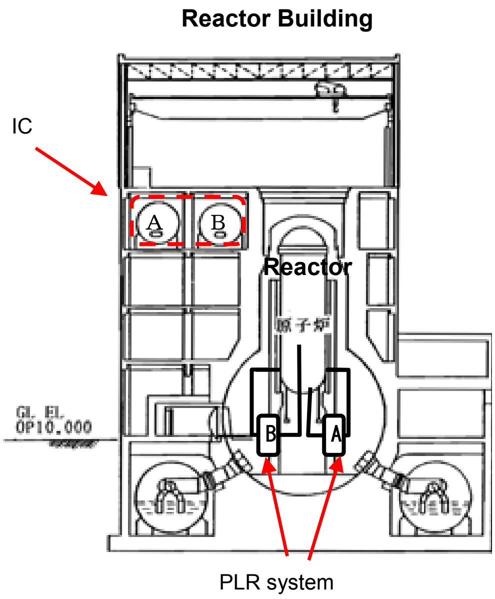


Fig. 1 Fukushima Daiichi Unit 1 IC placement (overview)

2. Reasons why changes to drain pipe connection method were not reflected

As of 1991, in accordance with documents issued by the Agency for Natural Resources and Energy (formerly of the MITT) (hereinafter referred to as the Agency), an investigation was conducted on areas where actual facility conditions were not reflected in the reactor establishing permit application body reference fig. and attached documents 8 due to changes (in specific designs) after the submission of reactor establishing permit application. However, changes in drain pipe connection methods were overlooked at this time, and also during reactor installation change approval application in 1993 (the first for Fukushima Daiichi). Thus did they remain unaltered to this day.

It should be noted that the Agency sees no problem legally with differences between the contents of establishing permit application attached document and actual facility conditions.

The details are covered below in chronological order.

(1) October 1991

The Agency requested a written explanation regarding the specific areas of difference between document (reactor establishing permit application body and reference fig., attached documents 8) contents and actual facility conditions upon comparison of the two.

(2) Around October to December 1991

Differences between the contents of reactor establishing permit application body/reference fig., attached documents 8 and construction permit application contents for all TEPCO stations were compared, and areas differing from actual conditions (hereinafter referred to as "Differences") were extracted.

Differences were also extracted for Fukushima Daiichi Unit 1 IC during this time. The contents are shown in Tables 1 & 2.

Table 1: Fukushima Daiichi Unit 1 IC specification differences (Reactor establishing permit application

body)

	Body text (As of 1991)	Actual facility (construction permit)	Remarks
Effective tank capacity	Approx. 100 m^3/tank	106 m^3	Due to progress of specific design

Table 2: Fukushima Daiichi Unit 1 IC specification differences
(Reactor establishing permit application attached documents 8)

	Attached documents 8 (As of 1991)	Actual facility (construction permit)	Remarks
Steam flowrate	100.7 T/h	100.6 T/hr	Due to progress of specific design
Steam temp.	285 ºC	285.6ºC	
Condensate outlet pressure	70.2kg/cm^2g	70.3kg/cm^2g	
Condensate outlet temp.	285 ºC	285.6ºC	
Condenser shell max. pressure	1.1 kg/cm^2g	1.125 kg/cm^2g	
Max. steam generation rate	68,040 kg/hr	67,880 kg/H	
Heat transfer capacity	36.3×10^6 kcal/hr	36.19×10^6 kcal/H	
Effective tank capacity	105 m^3	106 m^3	

However, the method of connecting drain pipe to PLR was overlooked since they were written on figures.

(3) December 1991

The Agency requested the reflection of actual facility conditions at the time of application for future reactor installation change permits, regardless of relation to application contents. This was made from the standpoint of PA (Public Acceptance) regarding differences between contents of reactor establishing permit application body reference fig. / attached documents 8 and actual facility conditions, which posed no problem from a strictly legal standpoint.

The stance on values is that those listed in the construction permit should be rounded up to match reactor establishing permit application values (effective figures).

(4) April 1993

Reactor installation change applications were submitted for Fukushima Daiichi from December 1991 onward, a first for that station. There are four reasons for the changes:

A. Installation of spent fuel dry storage facility for Units 4 through 6.

B. Installation of common spent fuel pool for Units 1 through 6.

C. Installation of common spent fuel transport container storage area for Units 1 through 6.

D. Making Units 1/2, Units 3/4, and Units 5/6 common DG into dedicated ones for Units 1, 3, and 5 respectively, alongside addition of individual DG for Units 2, 4, and 6.

The application was in accordance with the considerations listed in (3) above, reflecting actual facility conditions in the contents of reactor establishing permit application body reference fig. / attached documents 8,, regardless of their relation to items A through D above. This lead to over 100 changes in texts for Unit 1.

Changes shown in Table 3 were made to texts for IC in the attached documents 8 in accordance with the extracted contents shown in Table 2.

Table 3: Fukushima Daiichi Unit 1 IC specification text changes
(Reactor establishing permit application attached documents 8)

	<Before change> Attached document 8 text (As of 1991)	Actual facility (construction permit)	<After change> Attached document 8 text (As of 1993)
Steam flowrate	100.7 T/h	100.6 T/hr	100.6 t/h
Steam temp.	285 ºC	285.6ºC	286ºC
Condensate outlet pressure	70.2kg/cm^{2}g	70.3kg/cm^{2}g	70.3kg/cm^{2}g
Condensate outlet temp.	285 ºC	285.6ºC	286ºC
Condenser shell max. pressure	1.1 kg/cm^{2}g	1.125 kg/cm^{2}g	1.1 kg/cm^{2}g
Max. steam generation rate	68,040 kg/hr	67,880 kg/H	67,880 kg/h
Heat transfer capacity	36.3×10^6 kcal/hr	36.19×10^6 kcal/H	36.2×10^6 kcal/h
Effective tank capacity	105 m^3	106 m^3	106 m^3

As stated in (3), values (effective figures) have not been changed. Therefore, “steam temp.,” ”condensate outlet temp.,” ”condenser shell max. pressure” and “heat transfer capacity” were rounded up (resulting in “ condenser shell max. pressure” showing the same value after changes).

Differences in drain pipe PLR connection method were overlooked in 1991 and remained unchanged.

(5) 1994 onward

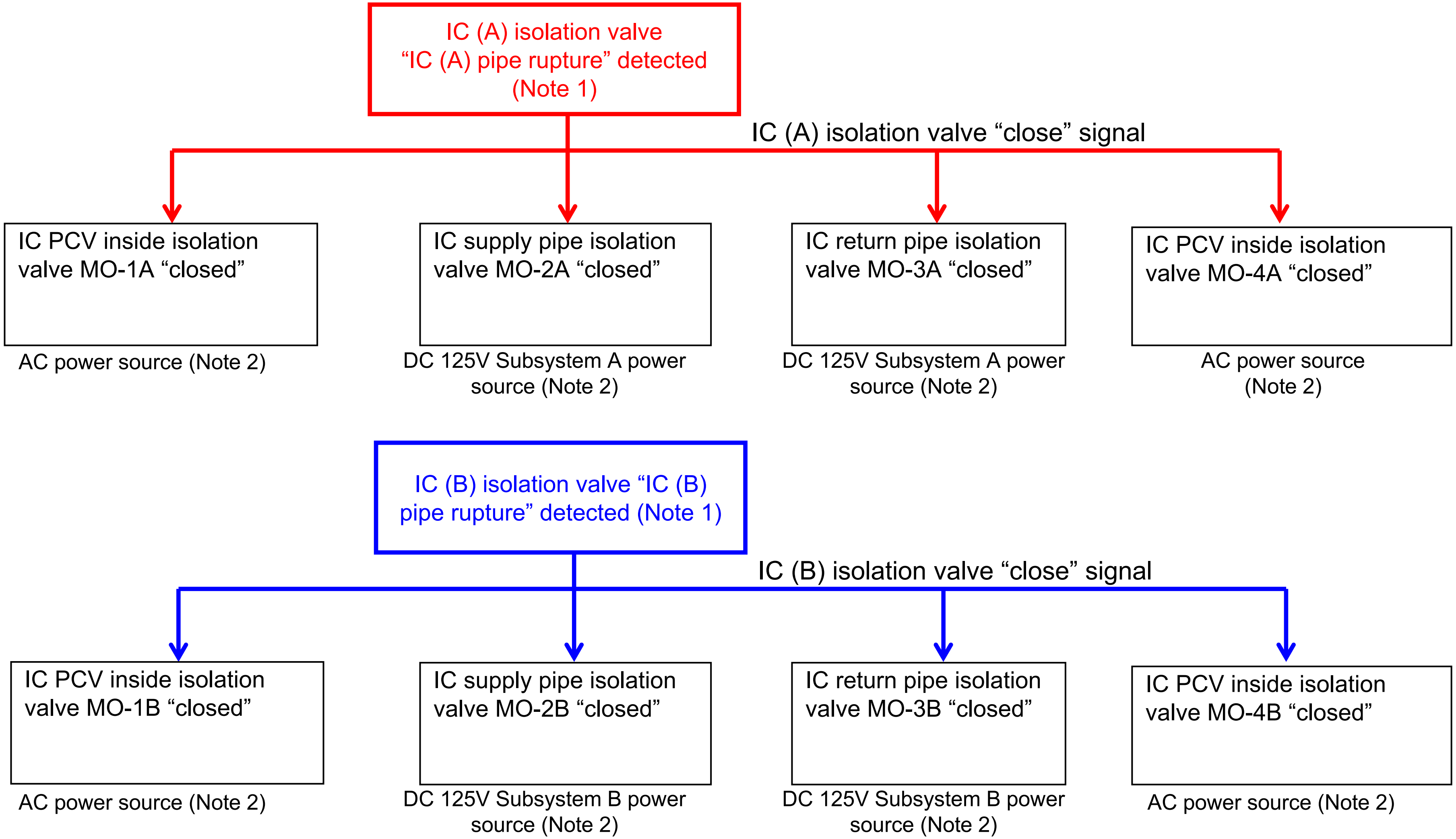
Due to the reactor installation change application (approved in March 1994) listed in (4), reflection of actual facility conditions was considered complete. From then on, IC reactor installation change applications and construction permit applications/submissions were not performed, and reactor establishing permit application attached document text was not reviewed.

Isolation Condenser (IC) MO valve Interlock Block Diagram

	DC 125V Subsystem A	DC 125V Subsystem B
IC (A) pipe rupture	Detection circuit (A)	Detection circuit (C)
IC (B) pipe rupture	Detection circuit (B)	Detection circuit (D)

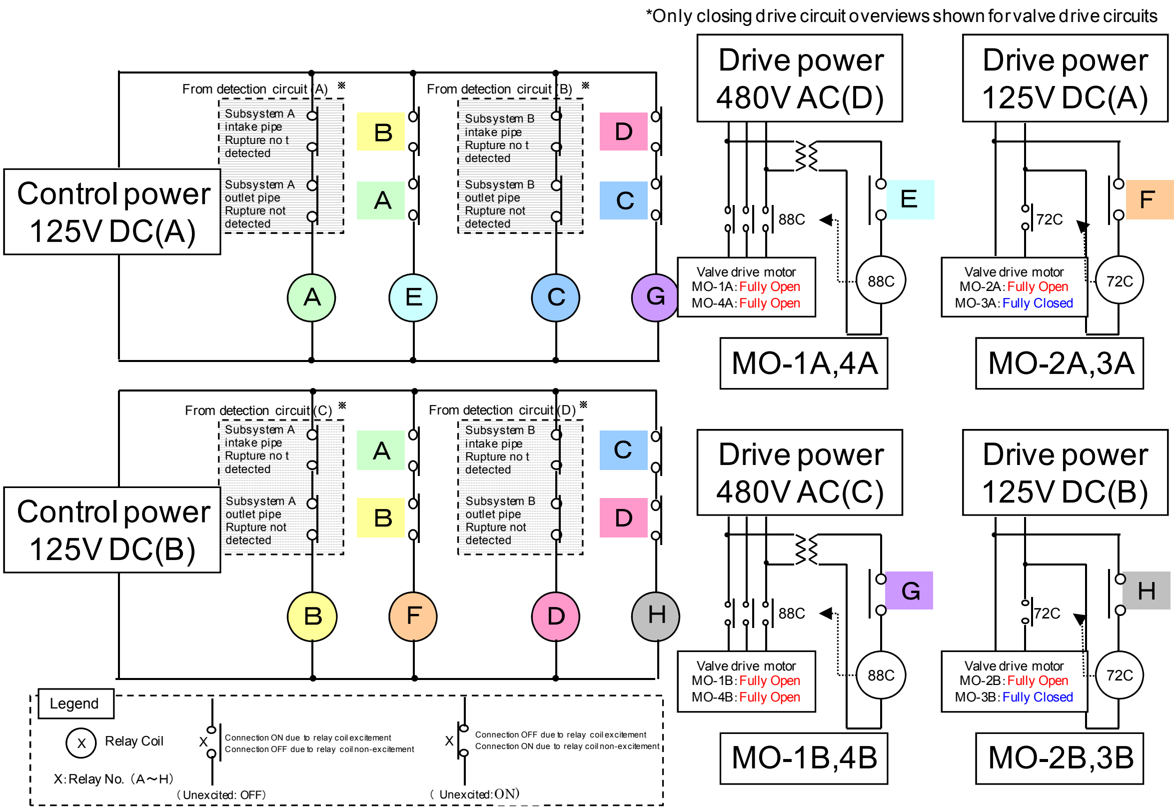
Note 1: The circuits which detect “IC (A) pipe rupture” and “IC (B) pipe rupture” are powered by both Subsystems A/B DC power sources. Even if one DC power source is lost, the detection circuits for both systems activate as a failsafe. This sends out a signal to close to all isolation valves for both IC (A) and (B).

Note 2: The power source which drives MO valve .



Attachment 8-7 (1)

Isolation Condenser (IC) Isolation Signal Circuit Diagram (Standby Status)



[Isolation signal (rupture detection signal) transmission]

(1) “Subsystem A intake pipe rupture detection signal” or ”Subsystem A outlet pipe rupture detection signal” reception causes Subsystem A/B relay coils to become unexcited.

(2) A/B relay coil non-excitement causes A/B connections to turn OFF and E/F relay coils to become unexcited.

(3) E/F relay coil non-excitement causes E/F connections to turn ON and MO-1A/2A/3A/4A close drive relay coils to become excited. In turn, this causes close drive connection circuits to close and power to flow to the valve drive motor, causing valve closing.

(4) The applicable valve will close if even one rupture detection signal is received.

*Same as Subsystem B.

[Control power loss]

(1) 125V DC (A) control power loss causes A/E/C/G relay coils to become unexcited.

(2) A/C relay coil non-excitement causes A/C connections to turn OFF and F/H relay coils to become unexcited.

(3) E/F/G/H relay coil non-excitement causes E/F/G/H connections to turn ON and MO-1A/2A/3A/4A/1B/2B/3B/4B close drive relay coils to become excited. In turn, this causes close drive connection circuits to close and power to flow to the valve drive motor, causing valve closing.

*Same as when control power is lost for 125V DC (B).

[Opening operation during isolation signal reception]

By setting the operation switch to the “F-OPEN” position, the isolation signal can be bypassed and opening operation becomes possible.

Fukushima Daiichi Unit 1 IC valve status history

Subsystem A		March 11								April 01	October 18
			14:52	15:03～	15:35	…………	18:18	18:25	21:30		
PCV inside valve (AC power)	PCV outside valve (DC power)	in operation	Post-earthquake automatic activation	IC startup / shutdown	Tsunami		(DC transformer restoration)			Evaluation based on survey results	Evaluation based on survey results
MO-1301−1A	−	○	○	○	○ ⇒	?				?	
−	MO-1301−2A	○	○	○	○ ⇒	×	×→○	○	○	○	○
−	MO-1301−3A	×	×→○	○⇄×	× ⇒	×	×→○	○→×	×→○	○	○
MO-1301−4A	−	○	○	○	○ ⇒	?				?	
IC status		Standby	Operation start	Reactor pressure control	All valve close signal transmission (due to isolation interlocking)	No operation	Operation	Shutdown operation	Operation	Valve circuit survey results	Field survey results

IC Subsystem B		March 11					April 01	October 18
			14:52	15:03	15:35	…………		
PCV inside valve (AC power)	PCV outside valve (DC power)	in operation	Post-earthquake automatic activation	IC startup / shutdown	Tsunami		Evaluation based on survey results	Evaluation based on survey results
MO-1301−1B	−	○	○	○	○ ⇒	?	?	
−	MO-1301−2B	○	○	○	○ ⇒	×	×	×
−	MO-1301−3B	×	×→○	○→×	× ⇒	×	×	×
MO-1301−4B	−	○	○	○	○ ⇒	?	?	
IC status		Standby	Operation start	Shutdown operation	All valve close signal transmission (due to isolation interlocking)	No operation	Valve circuit survey results	Field survey results

(Grey) Power loss period　○ : Valve open　× : Valve closed　? : Open/close status unclear

Attachment 8-8

Isolation Condenser (IC) shell side water level decrease amount investigation results

(1) IC shell side water level amount of decrease

IC shell side water level was 65% for Subsystem A and 85% for Subsystem B (normal water level: 80%) during field surveys performed on October 18. Although the accuracy of instrument displays could not be confirmed, the amount of decrease in Subsystem A would be 15% (approx. 21 tons) if IC shell side water level gauge is assumed to be correct. Since the Subsystem B shell side water level display value exceeded normal water level despite IC shell side not being supplied with water, measuring equipment may have had an error in measurement.

(2) IC performance records

IC performance is shown below:

14:52 - Subsystems A/B activated

15:03 - Subsystems A/B shut down

Prior to tsunami onslaught at 15:35

Reactor pressure controlled via Subsystem A

(activation / shutdown performed three times)

18:18 - Subsystem A activated

18:25 - Subsystem A shut down

21:30 - Subsystem A activated

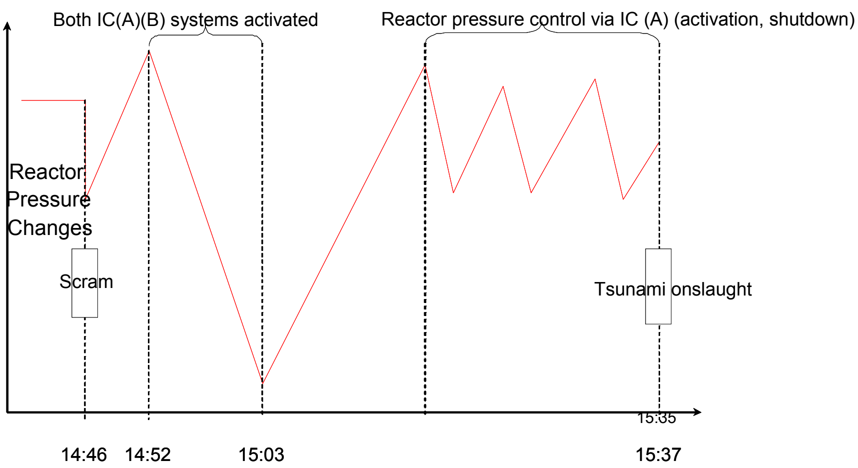


Fig.1. Visualization of reactor pressure changes (from chart)

(3) Assumptions regarding decay heat and shell side water level decrease amount

Since the IC operates for removing decay heat generated within the reactor, the IC operation status was evaluated by comparing decay heat generated in the reactor during IC operation with the residual heat needed to raise IC coolant temperature and potential heat needed to evaporate coolant.

Since Subsystem B only operated for a short time after automatic activation (14:52 to 15:03), evaluation results show Subsystem B coolant (approx. 160 tons per each subsystem) could not have reached 100ºC. According to IC coolant temperature records (Fig. 2), those for Subsystem B stopped rising at approx. 70ºC. These facts lead to the conclusion that Subsystem B coolant evapolation was minimal[*1].

As with Subsystem B, Subsystem A temporarily shut down after automatic activation. Reactor pressure was controlled solely via Subsystem A from then on (activated/shut down three times). Evaluation results show that coolant temperature had reached approx. 100ºC by the time of tsunami onslaught. According to IC coolant temperature records (Fig. 2), those for Subsystem A plateaued once around 70ºC, but rose to 100ºC by the time of tsunami onslaught due to later operations. These generally match evaluation results.

As shown above, Subsystem A coolant temperature is believed to have risen to 100ºC by the time of tsunami onslaught. Since the IC was isolated due to tsunami impact, Subsystem A coolant decrease is believed to have been mainly caused by operations which began at 18:18 and 21:30. This proves that the Subsystem A PCV inside isolation valve was open, though the extent is uncertain*2. The specifics of post-tsunami Subsystem A status (e.g. how long and at what levels functions were maintained, how long it remained in operation) are unclear due to the reasons listed in (1) through (3) below.

(1) PCV inside isolation valve openness still unclear after valve openness survey performed on April 1

(2) Hydrogen gas (non-condensed) generated due to fuel temperature increase accumulating in IC heat transfer pipe leading to IC heat removal function decrease

(3) Since reactor water level and pressure are unclear, it is uncertain how much steam was generated within the reactor (reactor pressure drop leads to IC function decrease)

Since 65% of the coolant within Subsystem A remained, it is believed Subsystem A valves were open, although actual IC heat removal function decreased and IC remained inoperable for a long time after tsunami due to reasons given in (2) and (3) above.

*1: If it is assumed Subsystem B coolant was not expended, a 5% increase drift in shell side water level gauge display value (instrument measurement error causing difference between display value and actual values) would be generated. If the same is assumed for Subsystem A shell side water level gauge, then the true Subsystem A shell side water level value would be approx. 60%. If this is the case, then Subsystem A coolant decrease amount would be approx. 30 tons.

*2: Since Subsystem AIC reactor return water temperature was confirmed to be approx. 140ºC as of March 24, the PCV inside isolation valve would not be fully closed, but partially open. Subsystem B valve openness surveys confirmed both PCV outside isolation valves were closed. This supports the theory that temperature was approx. 40ºC as of March 24 (see Table 1, Fig. 2)

Table 1: IC area temperature (Fig. 2 chart printed record read values)

No	Measurement area	12:00 on March 11	12:00 on March 24
12	ISOLATION CONDENSER"A"SHELL IC coolant temperature (Subsystem A)	23.0ºC	566.4ºC *3
13	ISOLATION CONDENSER"A"OUTLET IC reactor return water temperature (Subsystem A)	25.6ºC	135.1ºC
14	ISOLATION CONDENSER"A"OUTLET IC reactor return water temperature (Subsystem A)	25.7ºC	141.7ºC
15	ISOLATION CONDENSER"B"SHELL IC coolant temperature (Subsystem B)	23.6ºC	36.2ºC
16	ISOLATION CONDENSER"A"OUTLET IC reactor return water temperature (Subsystem B)	26.0ºC	38.7ºC
17	ISOLATION CONDENSER"A"OUTLET IC reactor return water temperature (Subsystem B)	26.9ºC	38.3ºC

*3: Still recorded as 574.5 degrees as of October 27. Since atmospherically released IC coolant temperature could not have greatly exceeded 100ºC, this is thought to be caused by measurement equipment failure.

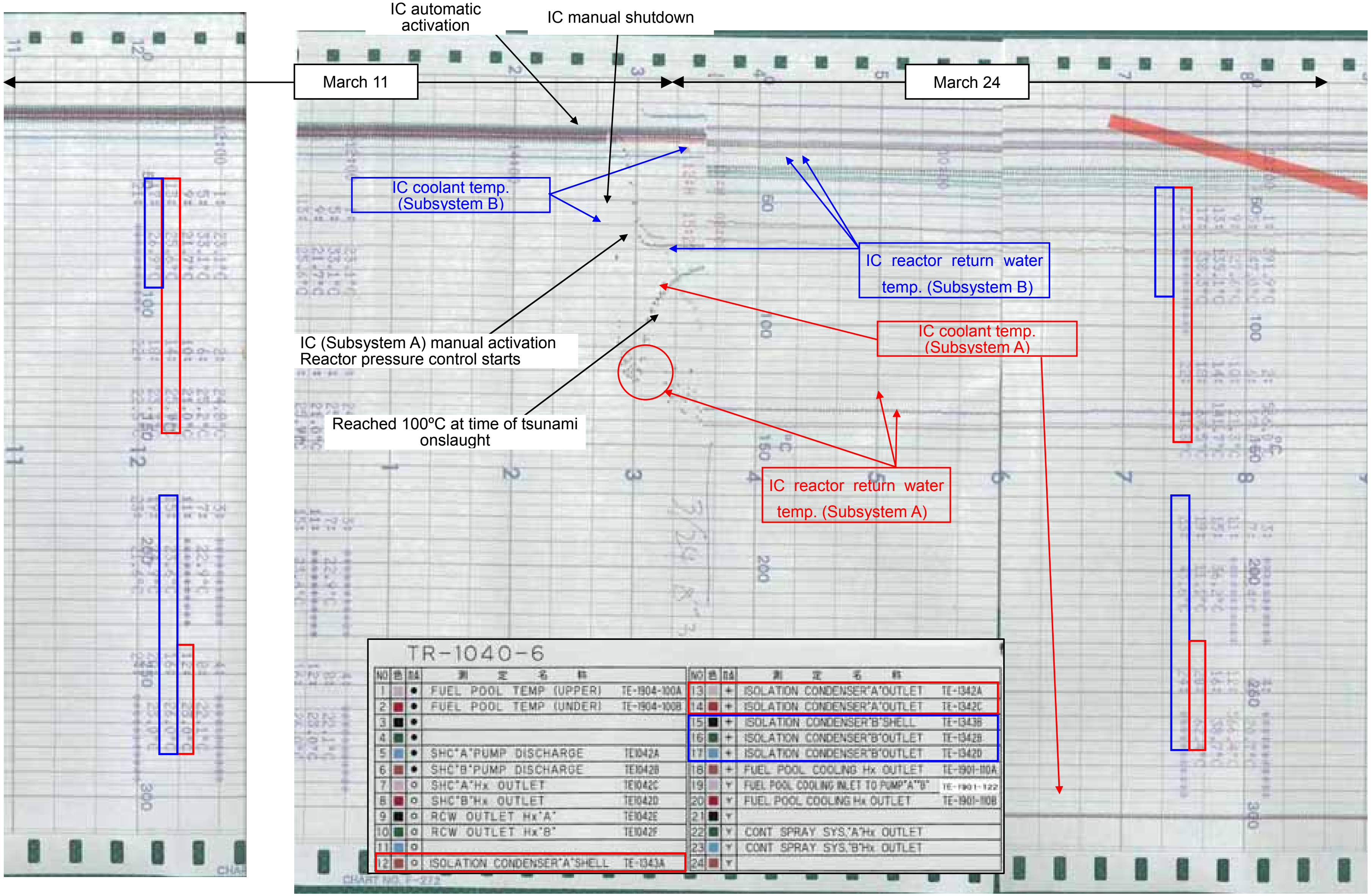


Fig. 2 Temperature near IC

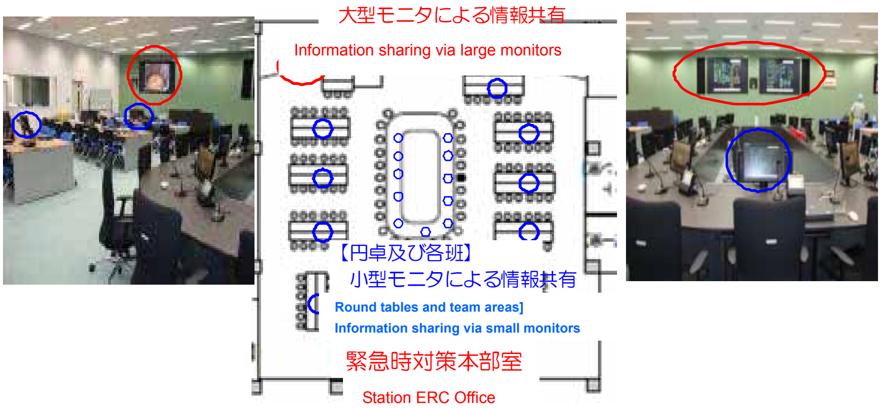
Awareness / assumptions regarding Fukushima Daiichi IC operation status post-tsunami

1. Awareness at station and head office ERC (reason why it was still considered operational)

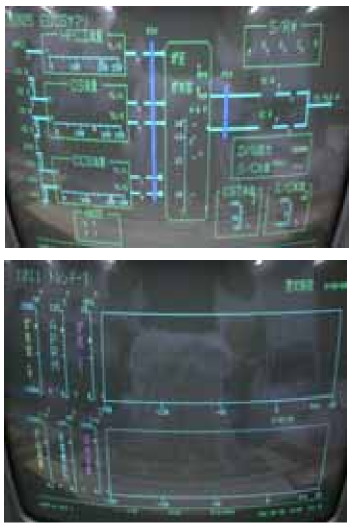
After reports were received that IC was active post-earthquake, the fact that IC had shut down escaped notice because the station ERC did not receive reports that IC had shut down, received reports that IC steam generation had been confirmed, and received reports that reactor water level was above TAF, etc. Also, since the head office ERC received reports of IC being active while busy with an urgent need to provide information to the government and equivalent external organizations, under initial confusion while attempting to understand earthquake damage status, etc., and under the situations where events specified in the Nuclear Emergency Act occurred, they did not become aware that it had shut down. The background factors that led to IC shutdown escaping notice are outlined below.

(1) Loss of ability to gain station information visually

The ERC in the seismic isolated building usually displays data from the Safety Parameter Display System (hereinafter referred to as “SPDS”) on large forward monitors, as well as on small monitors located at each round table and team area. This allows up-to-the-minute understanding and monitoring of station status.
However, since the SPDS became unusable during this accident, data on station status could not be collected or gained visually, and the only method remaining was of information via the MCR hotline by word of mouth



Layout of SPDS screens at station ERC



SPDS screen display (example)

(Allows station parameter and equipment operation status to be gained visually. This screen does not display data since transmission had been halted.)

(2) Transfer of information by word of mouth via hotline

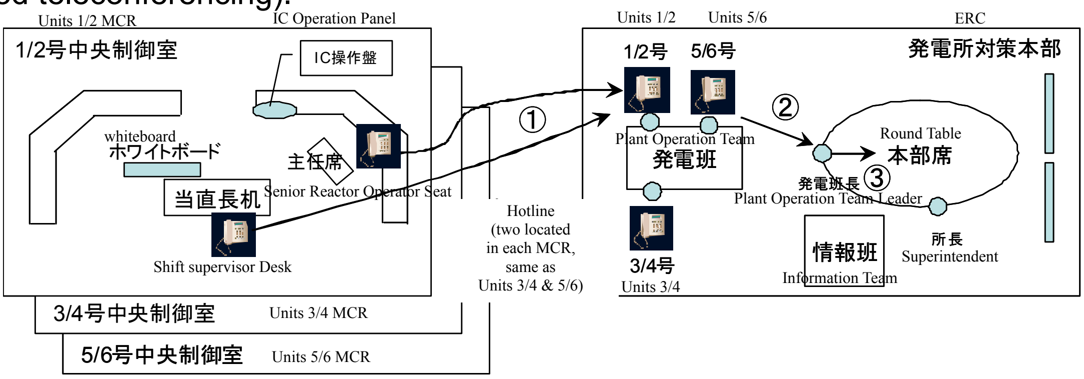
There are two hotlines in each MCR, which were connected to the station ERC plant operation team booth. Information transferred from the MCR:

① Station ERC plant operation team was contacted via hotline

② Information was transferred by word of mouth from the plant operation team to the team leader

③ Plant operation team leader reported this information throughout the ERC

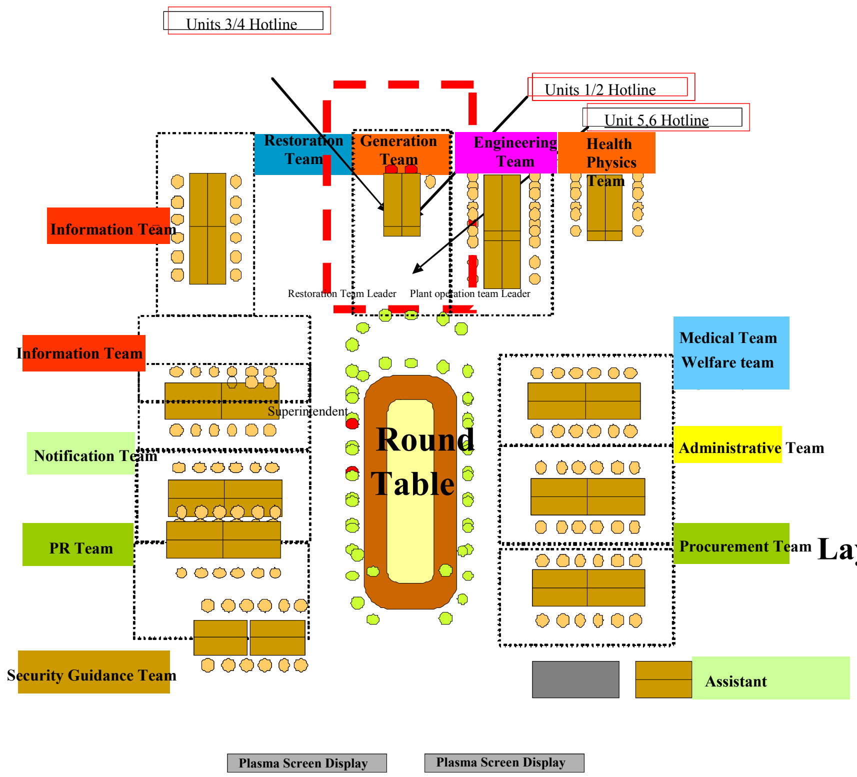
Information was shared for the first time with the station ERC via this process (head office ERC used teleconferencing).



Flow of information between the MCR and station ERC (example)

In a situation greatly deviating from normal accident response prerequisites, the plant operation team collected/organized data reported from each MCR via the hotline in order to understand station status. They would then deliberate accident restoration measures and details of MCR support. The same went for other function teams.

These were the conditions under which the station ERC collated various data (e.g., station data for Units 1 through 6 reported from 12 teams (including the plant operation team and restoration team), inquiries from head office and external organizations) before giving accident response orders and reporting to the head office via teleconferencing.



Layout of station ERC

(3) Flow of IC operation status information

Plant status could not be confirmed visually and communication by word of mouth via the hotline was the only method of information transfer. The flow of IC information under these conditions (MCR → station ERC plant operation team → station ERC) was organized, and the following features were confirmed as a result.

a. Specific MCR operation details (e.g., valve open/close status) were communicated as-is from the MCR to the station ERC plant operation team.
b. The station ERC plant operation team reported this information to the station ERC as results of operation.
c. Information denying earlier reports showing the possibility of IC operation (e.g., reactor water levels) may not have been correctly communicated or given awareness.

Event	MCR		Plant operation team		ERC
Automatic activation	[15:16] Reactor water level / pressure controlled via IC				[15:21] IC activated
Steam generation confirmed			[16:44] some type of gas heading out towards left side		
Valves 2A, 3A open	[18:18] IC MO-2A, 3A open (steam generation confirmed)	⇒ Notified as-is (a)	[18:20] Unit 1 MO-2A, 3A considered fully open [18:24] Unit 1 IC (A) operation confirmed	⇒ Operation results reported (b)	[18:21] IC line assembly completed, injection started [18:25] IC operation confirmed
3A closed	[18:25] IC MO-3A closed	- - →	- - →	×(c)	
DDFP activated	[20:50] DDFP activated		[21:17] FP base valve opened → Unit1 fire extinguishing pump activated to fill IC w/water	⇒	
Water level confirmed	(restoration team communicated information via hotline)	⇒	⇒	⇒	[21:19] Unit 1 water level confirmed at TAF +20cm. Line assembled to allow supply water to IC via DDFP.
3A open	[21:30] IC MO-3A open (steam generation confirmed)	⇒ Notified as-is (a)	[21:30] IC MO-3A opened, RPV depressurization started [21:34] IC compressed water confirmed to be spouting out!	- → ×(c)	[21:35] Unit 1 water level TAF +45cm. Supply water to IC via DDFP underway.

Since water level was above TAF, the assumption was that IC operation may have continued (based on assumption that IC was operating, assumed that DDFP activated as alternate reactor injection method from MCR was supplying IC body side with water)

(4) Summary

The actions below had to be carried out under conditions far exceeding normal accident response prerequisites.

- ✓ Limited communication tools; information transfer/sharing by word of mouth via hotline being the only method for communication between station ERC and MCR
- ✓ Station ERC deliberation on response and sharing of plant status not only for Unit 1, but Units 2 through 6 as well
- ✓ Station/head office ERC having to handle inquiries from external organizations in addition to understanding station information and report of station data via teleconferencing

It is speculated that under these circumstances, since IC operation information was reported as being the results of IC operation, etc., this led to gradual differences in awareness on IC operation status between the MCR and station/head office ERC, resulting in the station/head office ERC being continued to believe that the IC was in operation.

2. Awareness at MCR

Operators have verified that they no longer knew what the IC operation status was in the post-tsunami MCR. This is considered fact for this report. The results of operator surveys conducted via group deliberation on this topic are outlined below.

(1) Awareness held by operators

① Instrument and equipment status display lights turned off one after another in the post-tsunami MCR. Lights also turned off, and the MCR was lit only by emergency lighting. It was then that the IC isolation valve status display light turned off as well. Many operators, including the Shift Supervisor, have stated that they no longer knew what the IC operation status was at this time.

② The Shift Supervisor has stated that they requested that the station ERC check whether steam was being generated, since IC operation status could not be confirmed from the MCR. They have also stated that they heard from the station ERC that steam was being generated, although they do not remember the exact time. It was the low amount of steam generated that made them doubt whether the IC was operating.

③ The station ERC plant operation team had confirmed at 16:44 on March 11 that steam was being generated. It could not be confirmed whether this was due to the request from the Shift Supervisor stated in (2), but the plant operation team member who confirmed that steam was being generated stated that the amount was low. This corroborates the statement from the Shift Supervisor, and gives weight to the possibility that the check was performed due to a request by the Shift Supervisor.

④ The operators who headed into the field for IC field check stated that they went to check IC shell side water level as a part of measures to understand field status. However, none of the operators stated the purpose for their excursion as being the manual opening of the isolation valve under the assumption that the IC had shut down.

⑤ It can be assumed that the actions outlined in (2) and (4) were performed without an awareness of IC operation status.

⑥ An opinion differing from those above given by an operator performing IC isolation valve opening/closing prior to tsunami onslaught, stated that “power was lost while the isolation valve (3A) was closed” and that he “told other operators about this.” However, none of the other operators stated that they remembered this fact. As stated below, the operator who gave this statement later changed their statement on the position of the isolation valve (3A) operation switch. This change is likely due to various publicly released survey results. It is for these reasons that this statement was not considered a fact for the purposes of this report.

⑦ The Shift Supervisor stated that they assumed that the IC could have shut down when issuing the order for field response, since they did not know the operation status of the IC at that time. He also stated that, even if they received reports that the isolation valve (3A) was closed at that time, they would have ordered the same type of field checks at the same time due to the reasons given below.

- The basement floors of the T/B were flooded by tsunami, the S/B 1F was also flooded, aftershocks continued, a large tsunami alert was in effect, and waves of differing heights continued to strike the seaside area (including ones tall enough to cover seaside area). Field safety could not be checked under these conditions, and since necessary equipment had not been prepared, operators could not have immediately gone out into the field.
- However, since plant status could not be understood from the MCR while its monitoring instruments and various status display lamps were turned off, the Shift Supervisor began preparations for field checks for various reasons (e.g., understanding indoor damage conditions and entry routes for future restoration, understanding status of tsunami water damage to power source equipment, checking usability of equipment). The framework for field checks would use teams of two operators, comprised of personnel with in-depth knowledge/experience on field status (e.g., Shift Supervisor, Deputy Shift Supervisor). The reason younger operators were not used was due to the field status being unknown at the time. Destinations were made clear and field checking times limited so help could be sent from the MCR in a worst case scenario.

(Reference) According to reactor pressure charts for that time period, reactor pressure records stopped while reactor pressure continued rising. It can be assumed that the IC isolation valve (3A) was closed at the time.

(2) Position of return pipe isolation valve (MO-3A) operation switches

Operation switch position checks are one method of confirming isolation valve (3A) status after tsunami onslaught, but this did not take place. Results of the operator survey regarding this item are shown below.

① An operator performing opening operation at that time stated that the valve was closed when they checked them prior to work at 18:18. However, they stated they did not remember the position during later surveys. The operator who was next to the one giving the statement at the time stated they put the valve into automated position after closing, but also stated they did not remember later on.

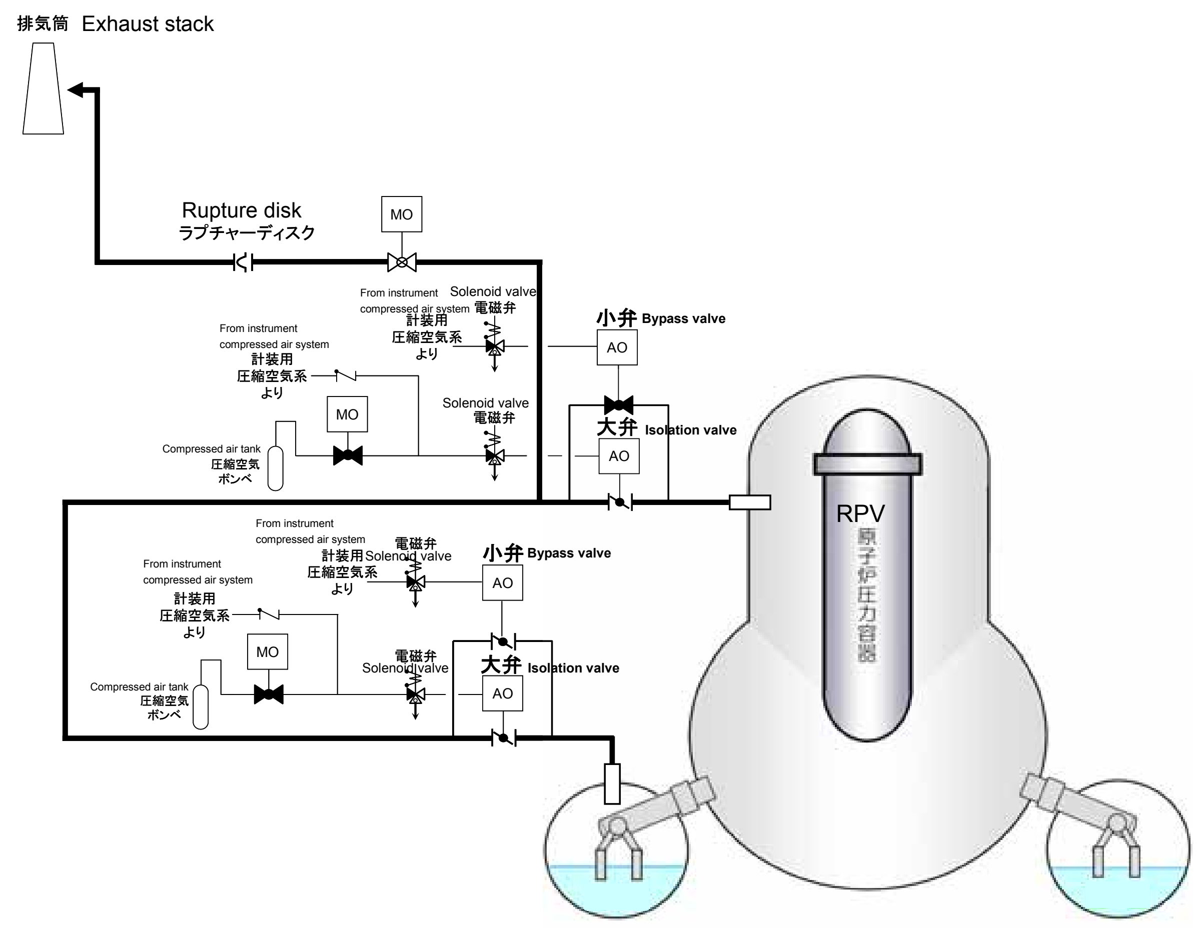
② In an unlit MCR after tsunami onslaught, the Shift Supervisor began checking operation panels starting with the ECCS. They made the decision that the situation fell under Article 15 of the Nuclear Emergency Act, but have stated that they did not notice whether the isolation valve operation switch was in the off position during that time.

③ The isolation valve (2A, 3A) “closed” display lamp was found to be flashing. Several operators deliberated future response and began opening operation at 18:18. Since the isolation valve (2A) operation switch, which would normally be in the automated position, was in the closed position, it was believed an isolation signal had been received. Therefore, diagrams were investigated by several operators, including the Shift Supervisor. Since several operators, including the Shift Supervisor, had been deliberating the issue, at least one of them should have noticed whether the isolation valve (3A) operation switch was in the “closed” position at the time. However, they have stated that they do not clearly remember the position of the operation switch at the time.

End

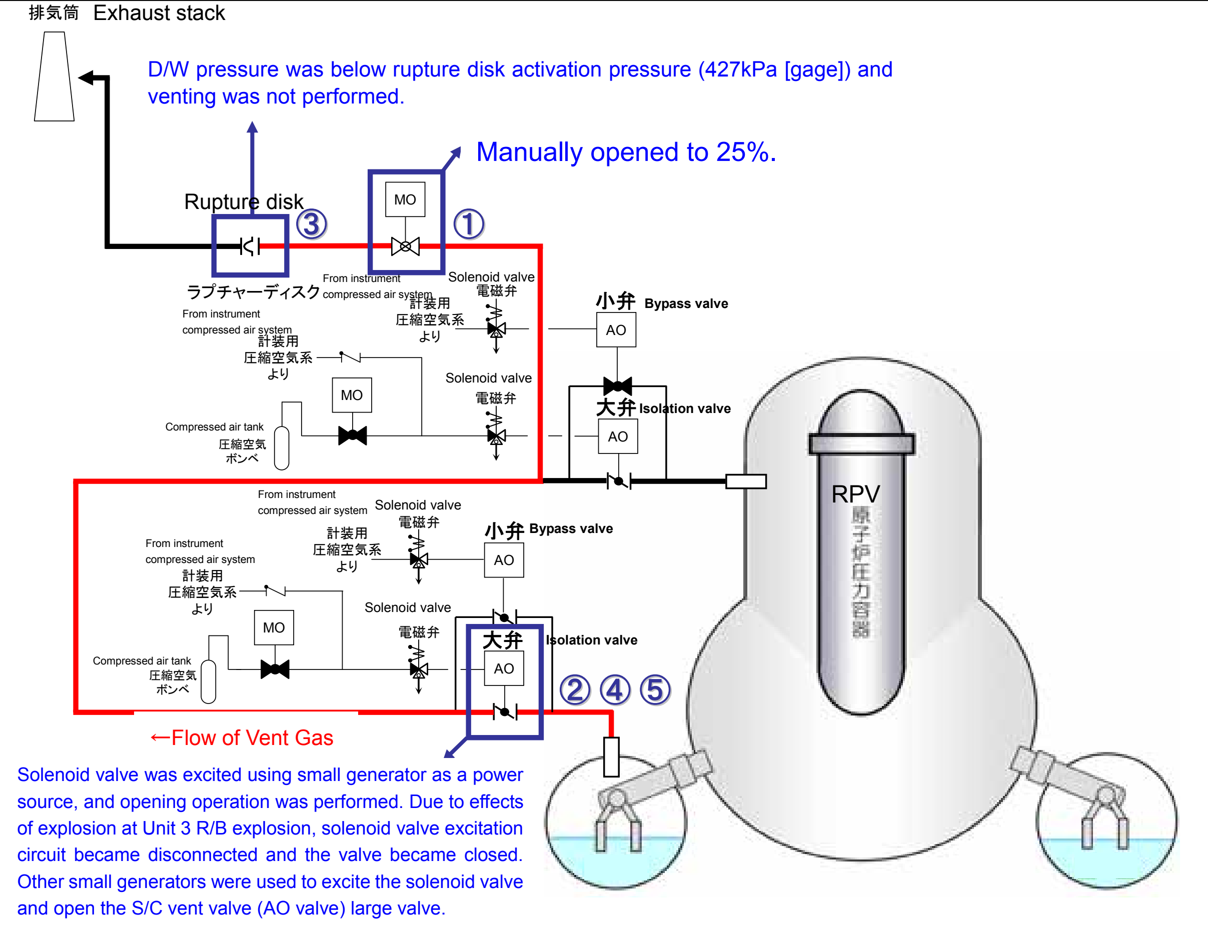
Fukushima Daiichi Unit 2 reactor PCV venting

Before earthquake occurrence on March 11



Rupture disk activation pressure: 427kPa [gage]

S/C side isolation valve use at 11:00 on March 13



Rupture disk activation pressure: 427kPa [gage]

[PCV vent valve (MO valve) and S/C vent valve (AO valve) isolation valve opening]

(1) 08:10 on March 13

PCV vent valve (MO valve) was opened to 25% as per procedures.

(2) 11:00 on March 13

Solenoid valve was excited using small generator as a power source, and S/C vent valve (AO valve) isolation valve opening operation was performed. Venting line assembly was completed (excluding rupture disk).

(3) Afterwards

D/W pressure was below rupture disk activation pressure (427kPa [gage]) and venting was not performed. Vent valve was kept open and D/W pressure monitoring continued.

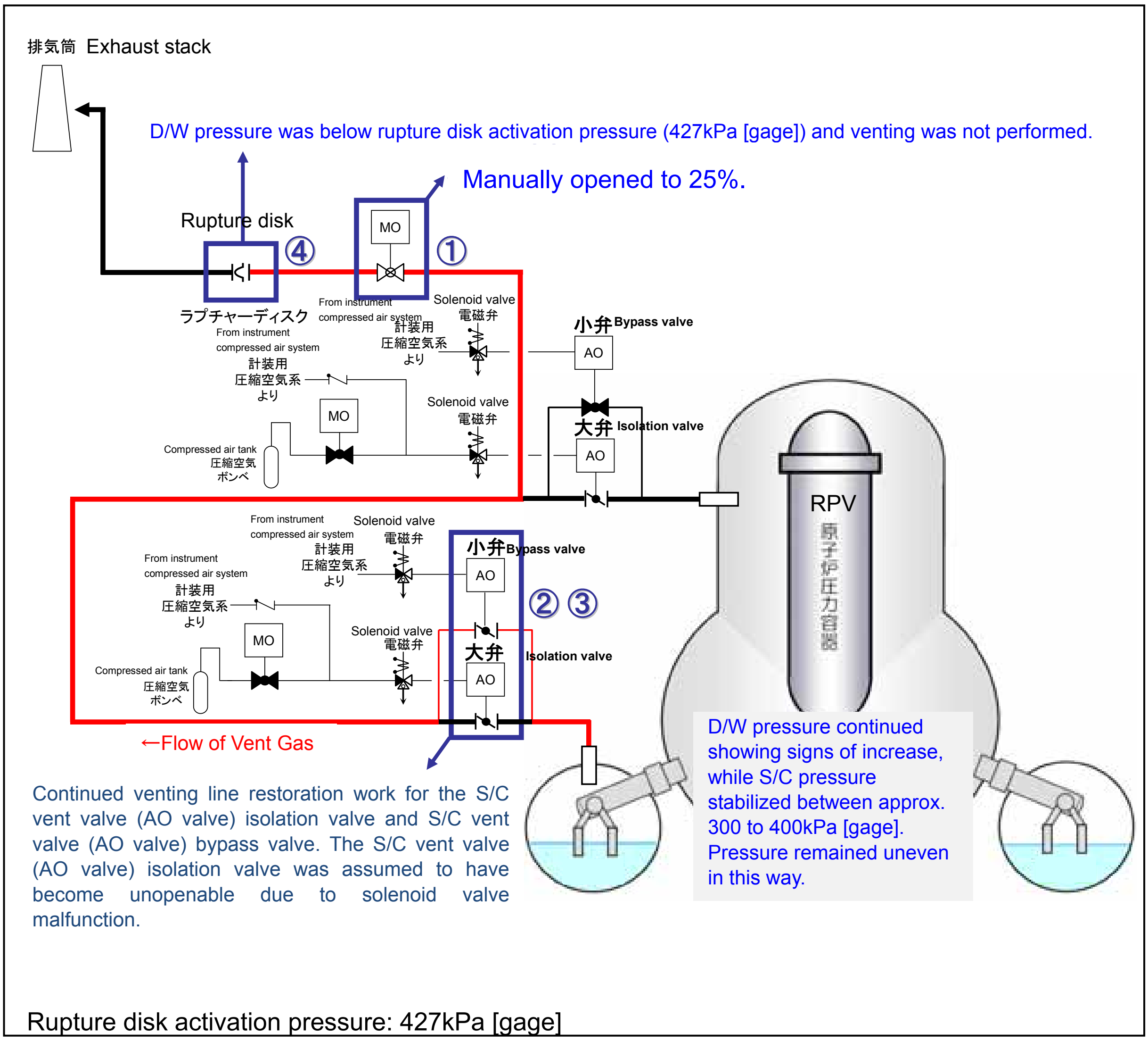
(4) 12:50 on March 14

Due to effects of explosion at Unit 3 R/B explosion, S/C vent valve (AO valve) isolation valve solenoid valve excitation circuit became disconnected and the valve became closed.

(5) Around 16:00 on March 14

The small generator shut down due to excessive voltage, so other small generators were used to excite the solenoid valve and open the S/C vent valve (AO valve) isolation valve.

S/C side bypass valve use around 21:00 on March 14



[S/C vent valve (AO valve) bypass valve opening]

(1) 08:10 on March 13

PCV vent valve (MO valve) was opened to 25% as per procedures.

(2) 18:35 on March 14

Continued venting line restoration work for the S/C vent valve (AO valve) isolation valve and S/C vent valve (AO valve) bypass valve. The S/C vent valve (AO valve) isolation valve was assumed to have become unopenable due to solenoid valve malfunction (grounding).

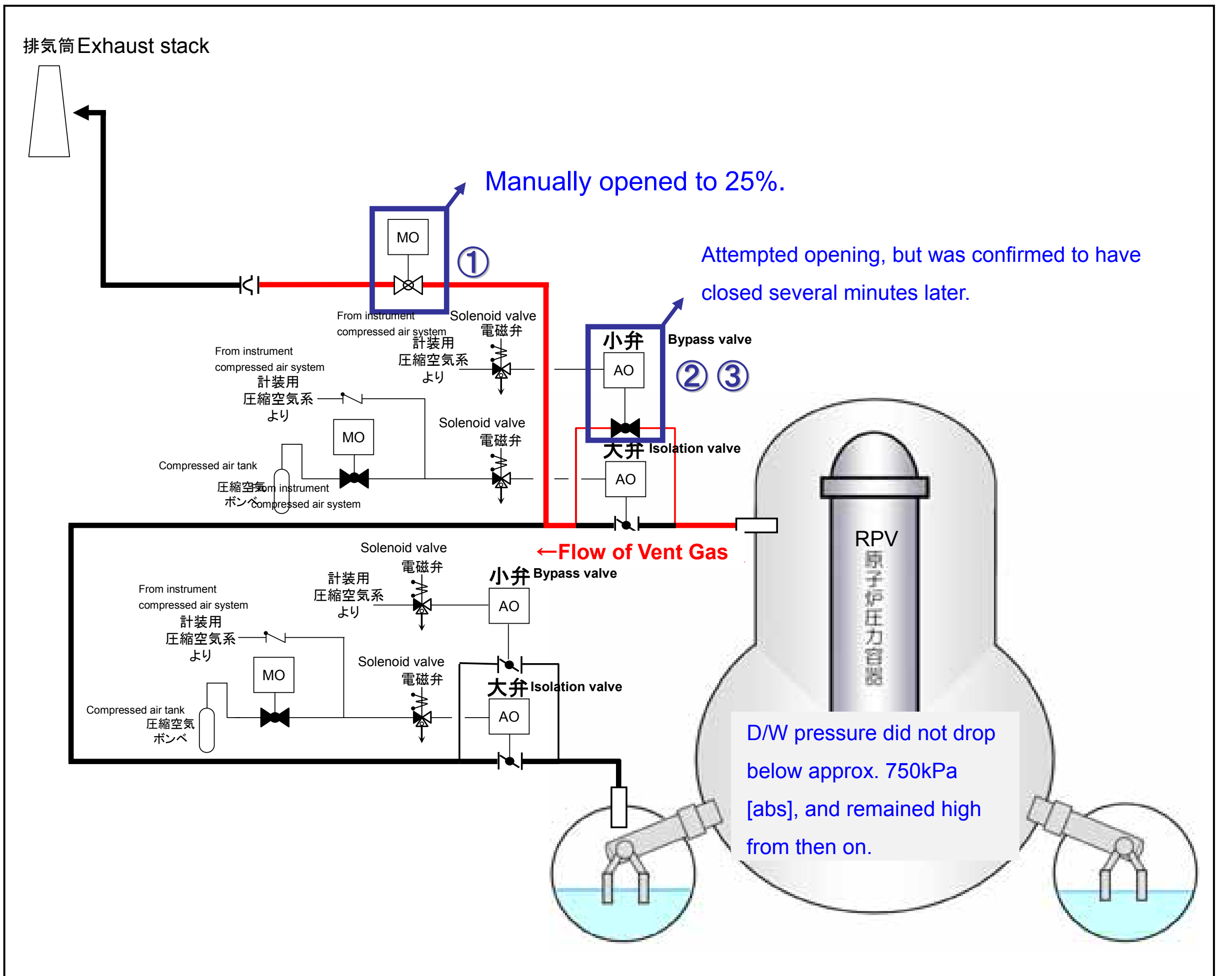
(3) Around 21:00 on March 14

The S/C vent valve (AO valve) bypass valve opened slightly due to solenoid valve excitation, and thus venting line assembly was complete (excluding rupture disk).

(4) Afterwards

D/W pressure was below rupture disk activation pressure (427kPa [gage]) and venting was not performed. Vent valve was kept open and D/W pressure monitoring continued.

D/W side bypass valve use at 00:01 on March 15

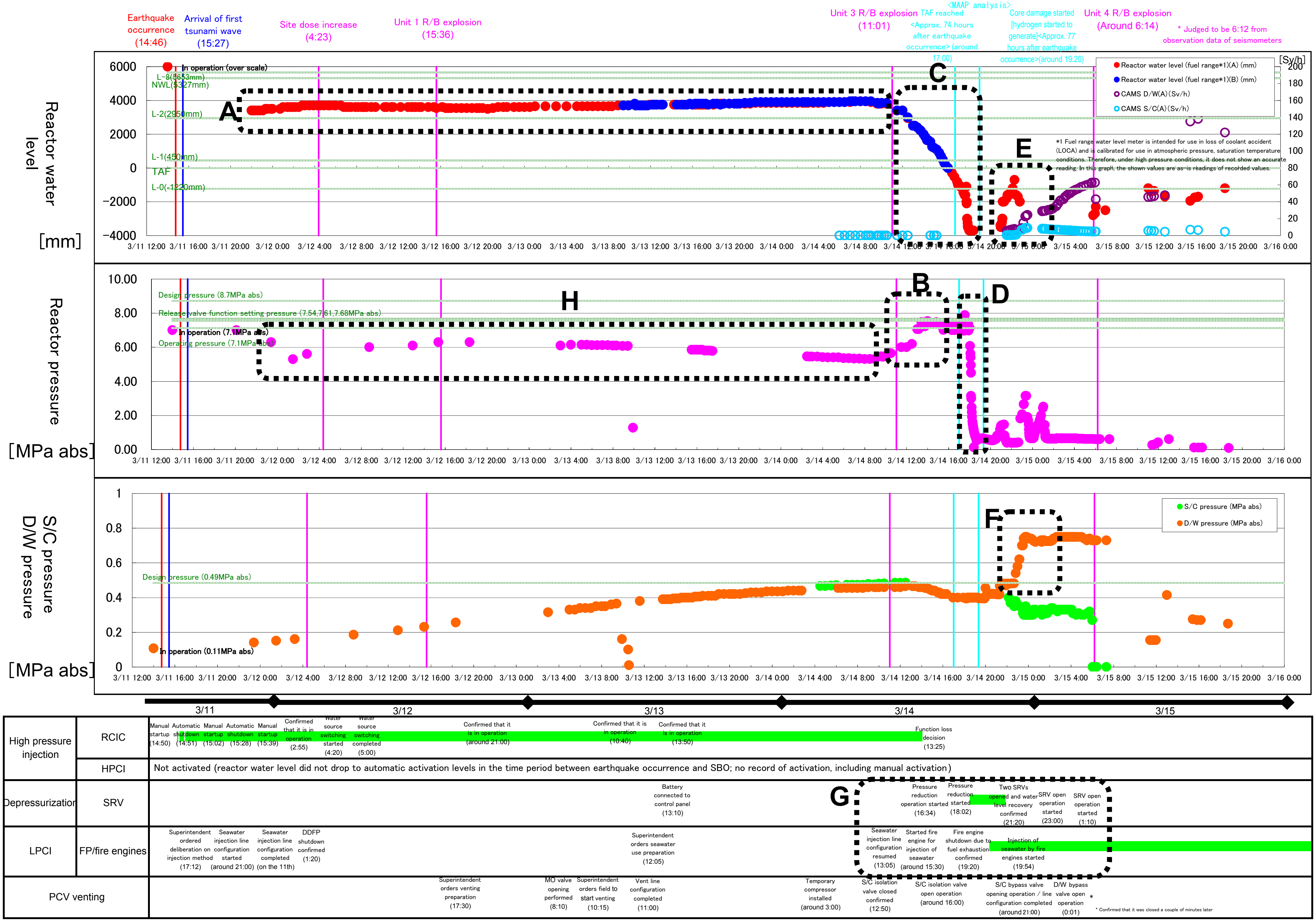


Rupture disk activation pressure: 427kPa [gage]

[D/W vent valve bypass valve opening (only D/W pressure begins to rise)]

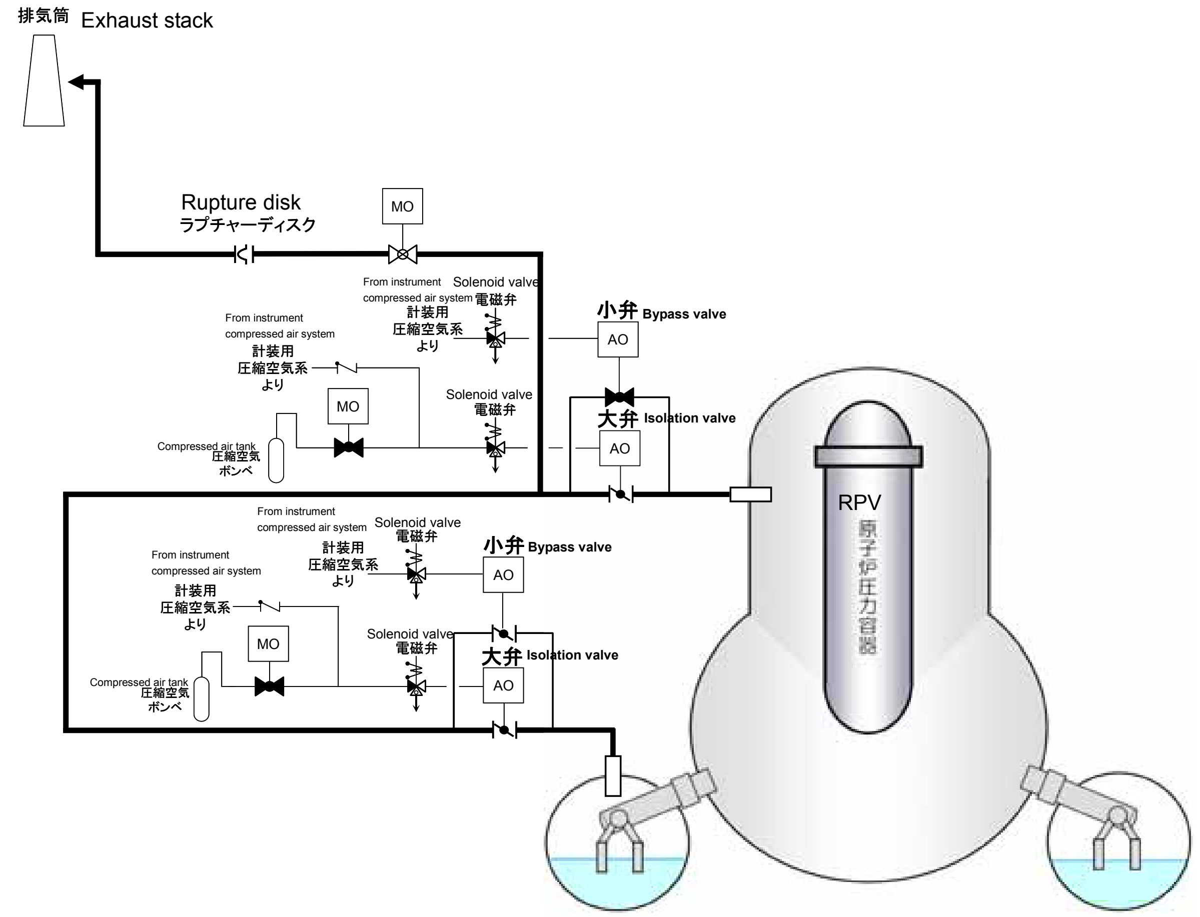
(1) 08:10 on March 13
PCV vent valve (MO valve) was opened to 25% as per procedures.
(2) 23:35 on March 14
Confirmed that S/C vent valve (AO valve) bypass valve was not open. Increase in D/W pressure led to the determination of a policy where venting would be performed by opening the D/W vent valve (AO valve) bypass valve.
(3) 00:01 on March 15
D/W vent valve (AO valve) bypass valve solenoid valve was excited in an attempt to open bypass valve, but it was confirmed to have shut several minutes later.

Fukushima Daiichi Unit 2 Plant Parameters Transient



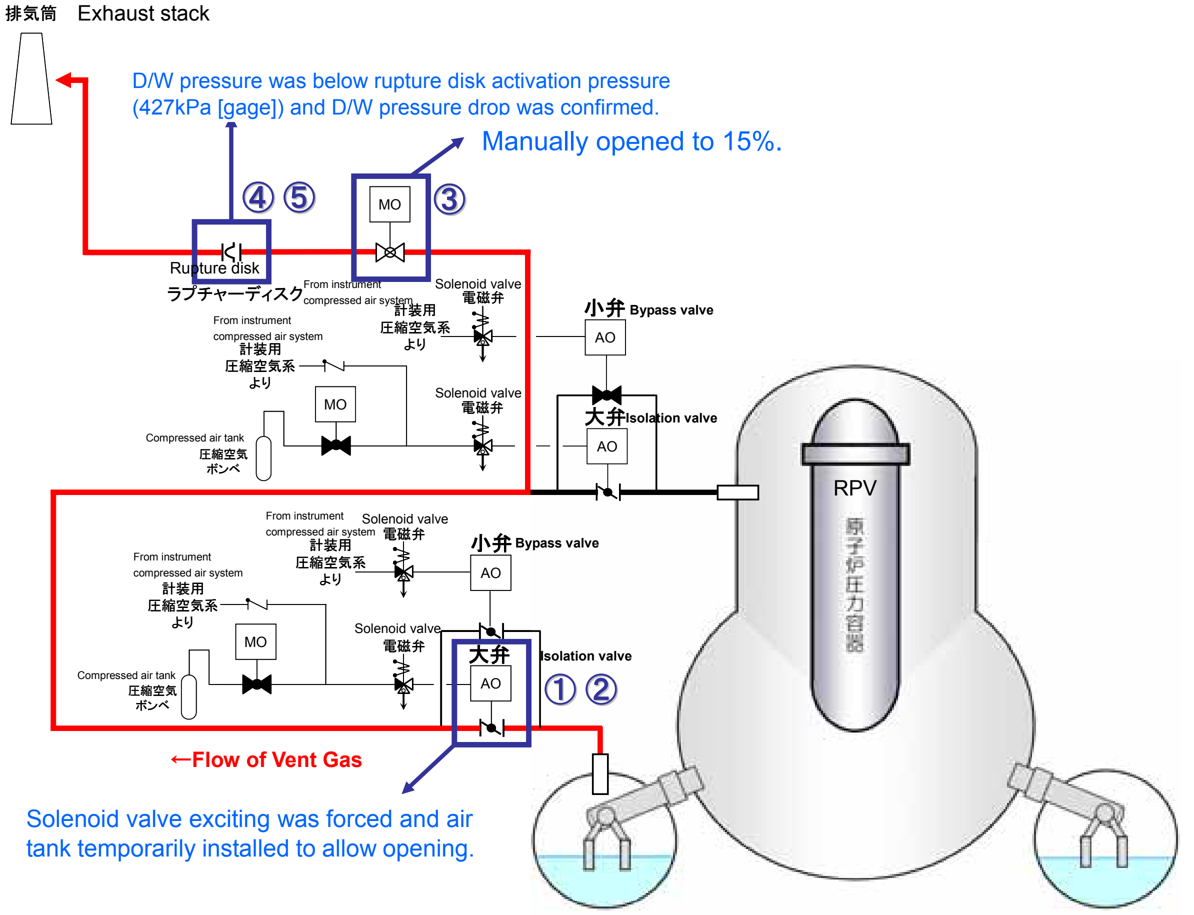
Fukushima Daiichi Unit 3 reactor PCV venting

Before earthquake occurrence on March 11



Rupture disk activation pressure: 427kPa [gage]

PCV venting line assembly at 08:41 on March 13



Rupture disk activation pressure: 427kPa [gage]

[Venting line assembly completion]

(1) 04:52 on March 13

Small generators were used to force excitation of the solenoid valve to allow S/C vent valve (AO valve) isolation valve opening. However, the openness display remained “closed” and S/C vent valve (AO valve) isolation valve drive air tank pressure display was at 0.

(2) 05:23 on March 13

S/C vent valve (AO valve) isolation valve restoration work began. D/W oxygen concentration gauge correction tank was exchanged with the AO valve drive air tank, and it was confirmed sound.

(3) 08:35 on March 13

Vent valve (MO valve) was manually opened to 15%.

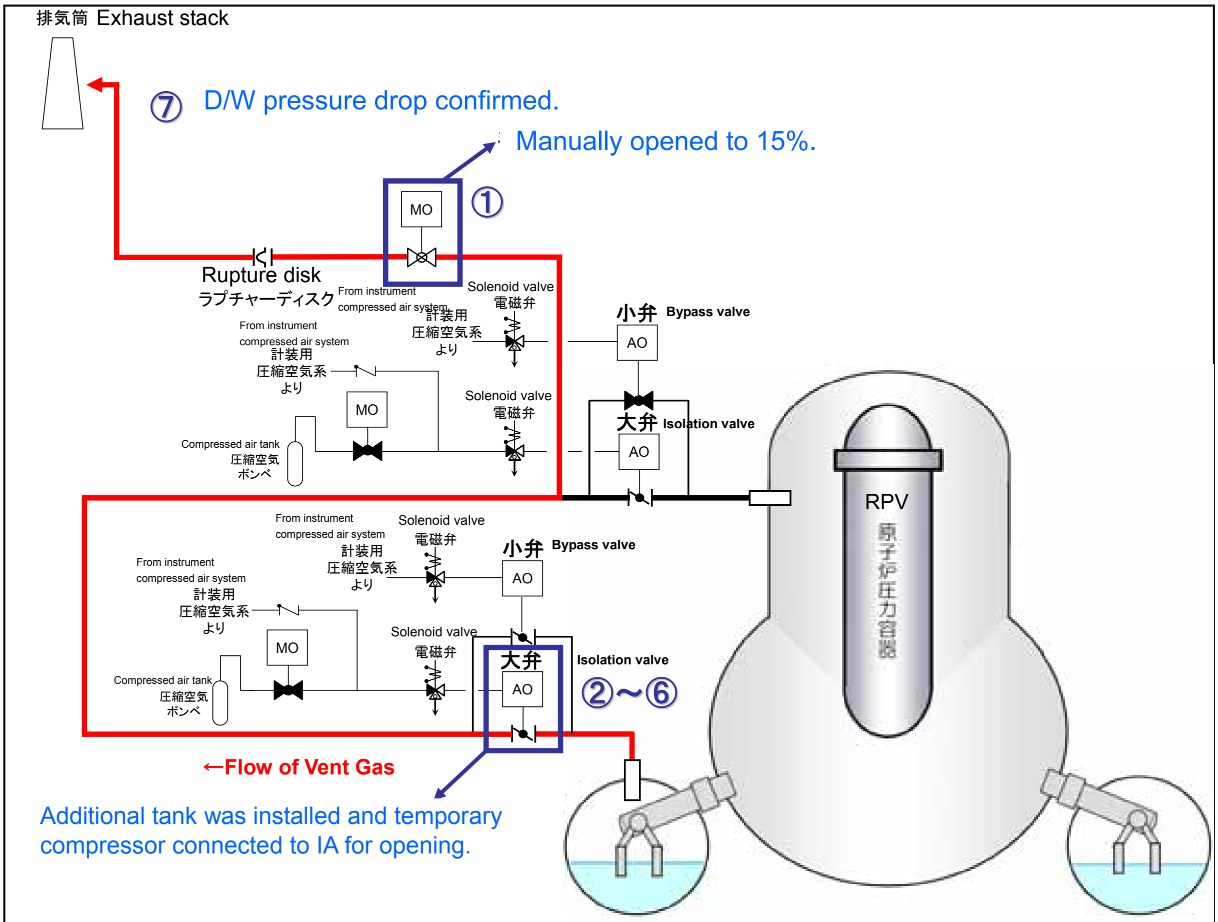
(4) 08:41 on March 13

Venting line assembly completion was reported to the Station ERC, and all that remained was to wait for rupture disk rupturing.

(5) 09:24 on March 13

After D/W pressure rose to 637kPa [abs] (09:10), it was confirmed to have dropped to 540kPa [abs] (09:24). It was reported to the Station ERC around 09:20 that venting had been performed.

Continued PCV venting line maintenance at 21:10 on March 13



Rupture disk activation pressure: 427kPa [gage]

[Continued venting line maintenance]

(1) 08:35 on March 13

Vent valve (MO valve) manually opened to 15%.

(2) 09:28 on March 13

Temporary signs of D/W pressure increase confirmed. S/C vent valve (AO valve) isolation valve drive air tank status was checked. Leakage from its connections was confirmed, and repair performed.

(3) 11:17 on March 13

Since S/C vent valve (AO valve) isolation valve closed due to tank pressure loss, opening operation was begun. D/W oxygen concentration gauge correction tank was exchanged with drive tank.

(4) 12:30 on March 13

S/C vent valve (AO valve) isolation valve was confirmed to be opened. D/W pressure drop began later (480kPa [abs] (12:40) → 300kPa [abs] (13:00)).

(5) 15:05 on March 13

Since D/W pressure began rising again (230kPa [abs] (14:30) → 260kPa [abs] (15:00)), a temporary compressor was installed.

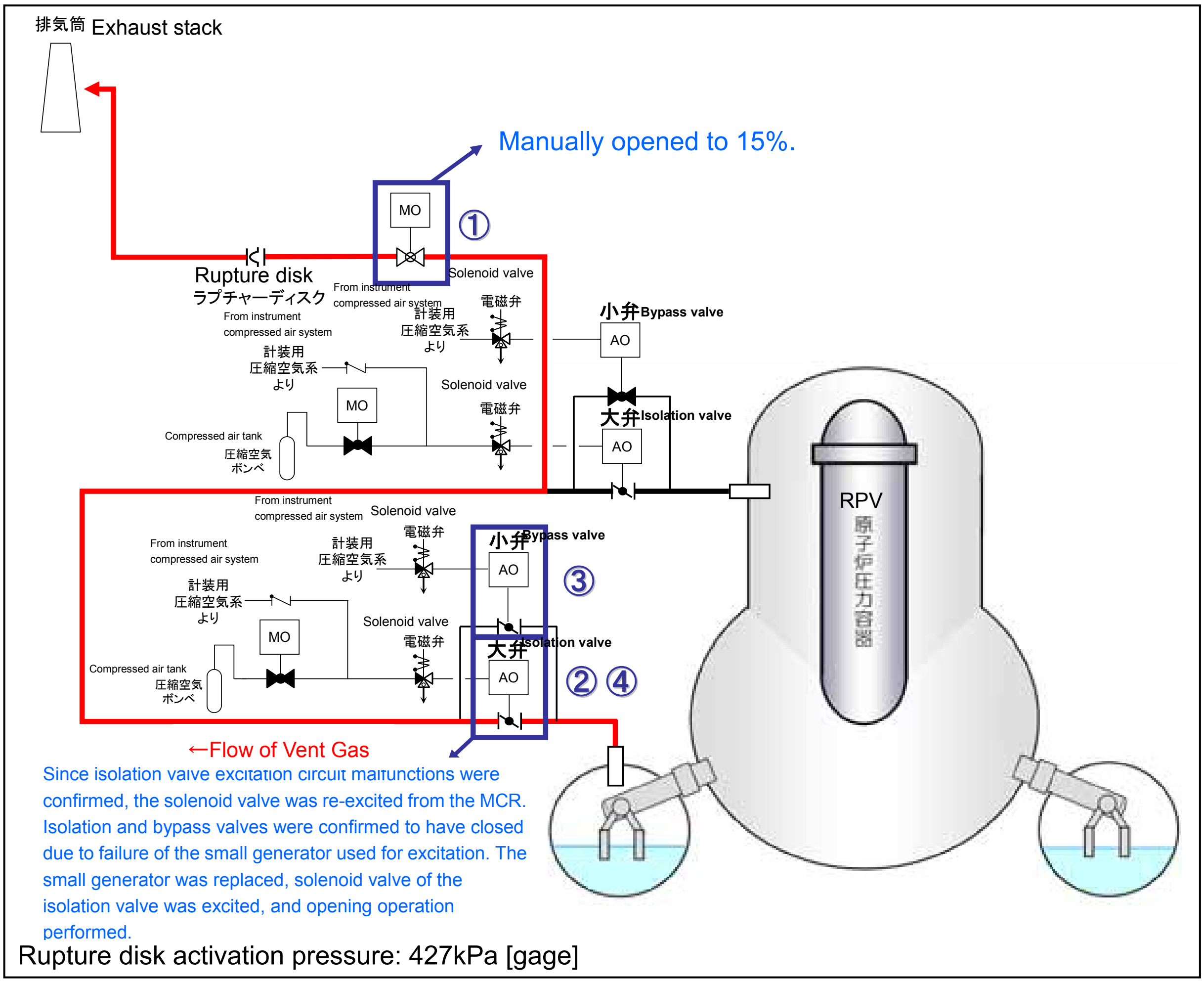
(6) Around 19:00 on March 13

Temporary compressor was connected to the IA line and activated.

(7) 21:10 on March 13

It was assumed that S/C vent valve (AO valve) isolation valve opened due to D/W pressure drop.

S/C side bypass and isolation valve use at 05:20 on March 14



[Additional venting line assembly]

(1) 08:35 on March 13

Vent valve (MO valve) was manually opened to 15%.

(2) 03:40 on March 14

Since S/C vent valve (AO valve) isolation valve excitation circuit malfunctions were confirmed, the solenoid valve was re-excited from the MCR.

(3) 05:20 on March 14

Solenoid valve excitation began to open the S/C vent valve (AO valve) bypass valve. This was later completed at 06:10.

(4) 16:00 on March 15

It was confirmed that the S/C vent valve (AO valve) isolation and bypass valve solenoid valves had closed due to failure of the small generator being used to excite them. The small generator was later replaced at 16:05, the S/C vent valve (AO valve) isolation valve solenoid valve was excited, and opening operation performed.

[Later PCV venting]

Keeping the S/C vent valve (AO valve) isolation and bypass valves open proved difficult due to problems with keeping the solenoid valves excited for the drive air pressure and air supply lines excited. Thus, opening operation was performed several times.

[S/C vent valve (AO valve) isolation valve]

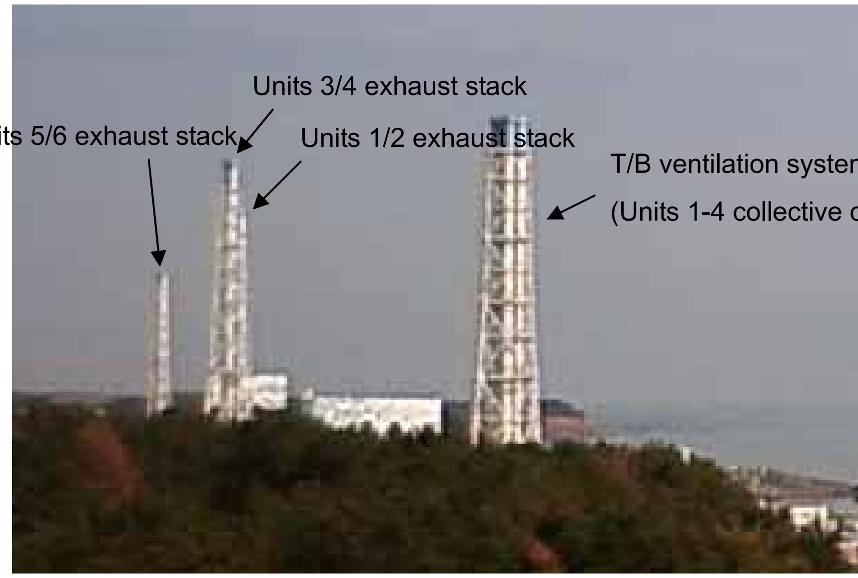
March 17	21:00	Confirmed closed →	Same day	Around 21:30	Opening operation
March 18	05:30	Confirmed closed →	Same day	Around 05:30	Opening operation
March 19	11:30	Confirmed closed →	March 20	Around 11:25	Opening operation
April 8	Around 18:30	Confirmed closed			

[S/C vent valve (AO valve) bypass valve]

March 16	01:55	Opening operation
April 8	Around 18:30	Confirmed closed

Fukushima Daiichi Unit 3 reactor Primary Containment Vessel (PCV) venting exhaust according to photos from the Fukuichi Live Camera

■Taken at 09:00 on March 13



8:41 – PCV venting line assembly complete (excluding rupture disk)
9:24 – D/W pressure drop confirmed

■Taken at 10:00 on March 13

Faint steam-like mass seen toward sea side of Units 3/4 exhaust stack

(Not seen in photos taken at 11:00 or 12:00)

11:17 – S/C vent valve (large valve) confirmed to be closed via tank pressure release. Drive air tank replaced, opening operation performed.
12:30 - S/C vent valve (AO valve) large valve confirmed to be open

■Taken at 13:00 on March 13

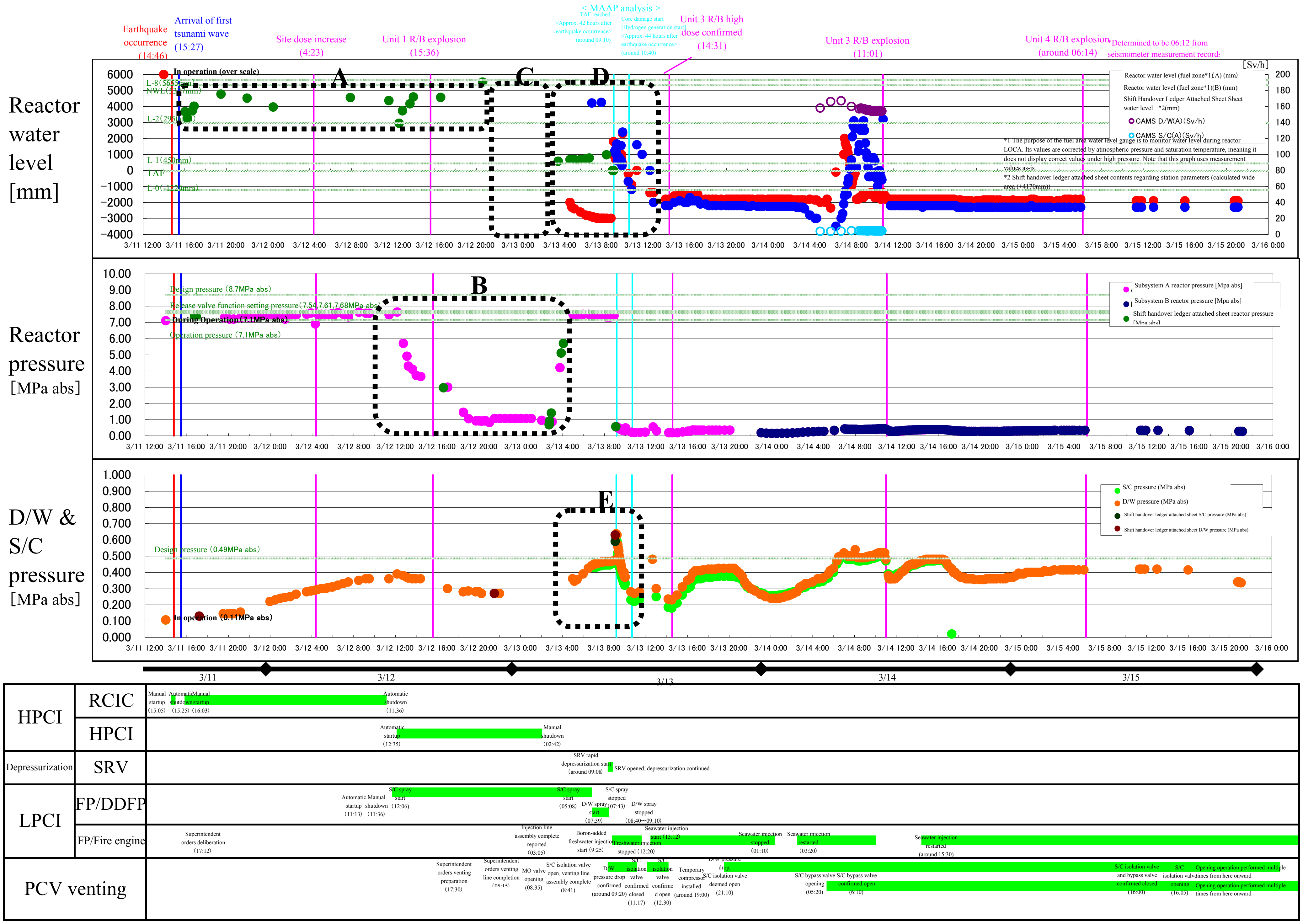
Faint steam-like mass seen toward sea side of Units 3/4 exhaust stack

■Taken at 14:00 on March 13

Faint steam-like mass seen toward mountain side of Units 3/4 exhaust stack

(Not seen in photos taken after 15:00)

Fukushimda Daiichi Unit 3 Plant Parameters Transient



Fukushima Daiichi Unit 3 reactor pressure movements

The details of Fukushima Daiichi Unit 3 reactor pressure movements following automatic activation of HPCI are outlined in this document (including estimations). Charts are shown in the latter half of this document, and the numbered items on those charts are explained below.

① The Unit 3 HPCI automatically activated at 12:35 on March 12 due to low reactor water level (L-2) caused by reactor water level drop from RCIC shutdown.

② Since the HPCI possesses pumps driven by steam turbine, reactor pressure dropped due to reactor steam consumption by the turbine. Reactor injection via HPCI would continue, and reactor pressure stabilized at 1MPa from 19:00 onward.

③ Reactor pressure, which had previously stabilized at 1MPa, began showing signs of decrease around 02:00 on March 13. The HPCI was manually shut down at 02:42. Reactor pressure had dropped to 0.58MPa. The HPCI was designed to automatically shut down at 0.69MPa to protect the facility, but interlocking of shutdown did not occur. The reasons for this are unclear.

④ Opening of the main steam release SRV was attempted at 02:45 on March 13, but this failed. Reactor pressure at this time was 0.8MPa, and the MCR control panel SRV display light was on. Opening was attempted again at 02:55 (reactor pressure: 1.3MPa), but failed again. The reason it did not open is unclear (possible theorized reasons include: D/W pressure being high while pressure of nitrogen gas needed for opening was relatively low; low pressure difference between reactor pressure and D/W pressure not allowing valve body to move; solenoid valve not being able to open due to power needed for this being used for HPCI oil pump, which would later shut down).

⑤ Opening of the main steam release SRV was attempted again at 03:38 on March 13, but this failed. The reason it did not open is unclear (possibly due to relative difference between nitrogen gas and D/W pressures, as stated in (4), or due to lack of power). Minor changes in the reactor pressure chart (reactor pressure decrease) were seen, although this may not be the effects of the above.

Prior to this, the Flow Indicatior/Controller display light for the HPCI connected to DC power Subsystem B turned off at 03:35. Attempts were made to activate the RCIC vacuum pump connected to DC power Subsystem A at 03:37, but these failed. Afterwards, the HPCI oil pump and condensate pump were shut down in the field (03:39 and 04:06 respectively).

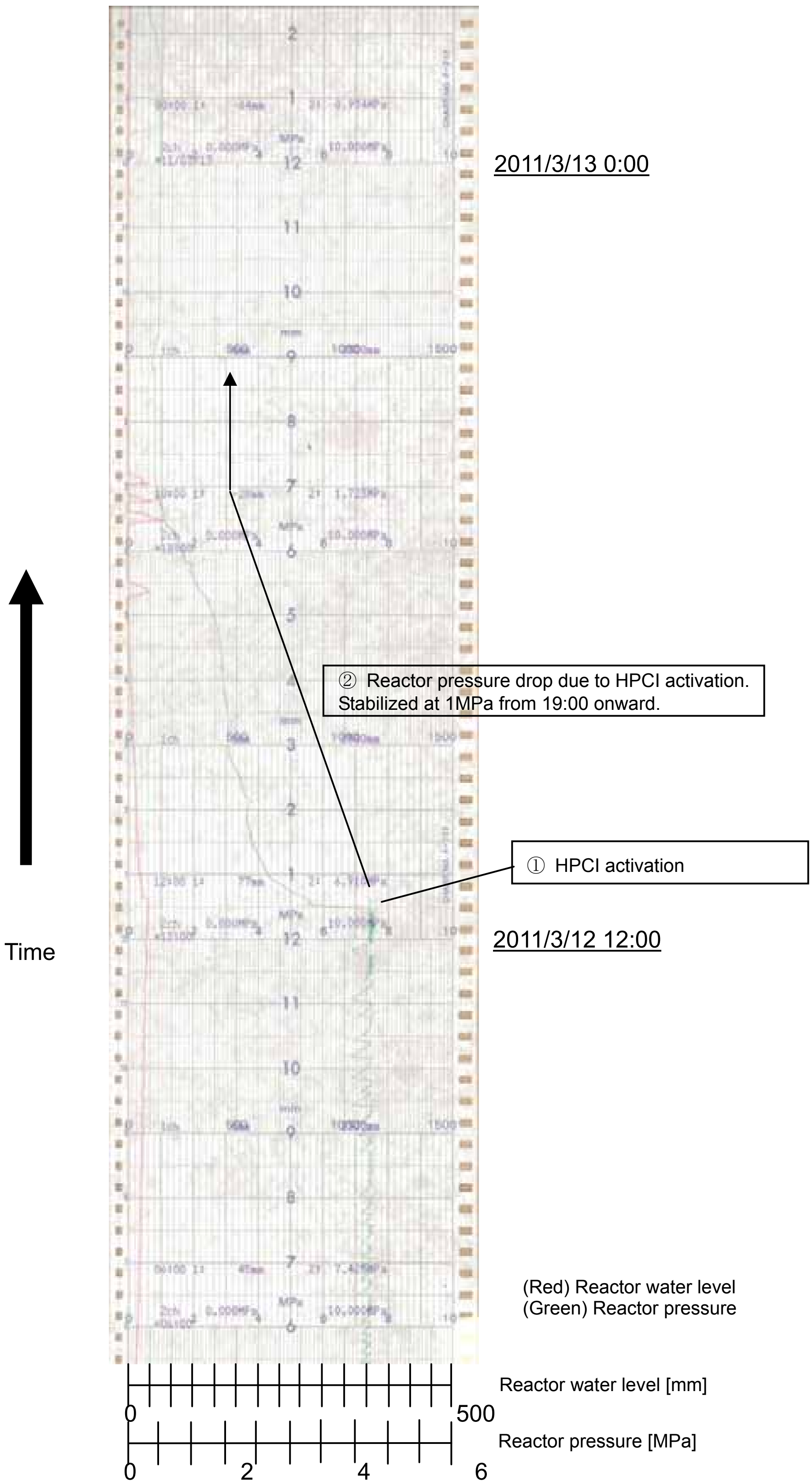
⑥ After reactor pressure reached approx. 7.4MPa, it is assumed the main steam release SRV automatically opened/closed to control reactor pressure. These movements can be confirmed on the reactor pressure chart. This movement continued until just before 06:00. From that point onward, reactor pressure did not show fluctuations associated with main steam release SRV opening/closing, and remained mostly level. The reason for values plateauing are unclear (possible theorized reasons include: fluctuations stopping due to inability to open/close valve equipment upon nitrogen provision halting after power ran out; some form of reactor leakage, such as leakage from the main steam release SRV sheet path).

At this time, a temporarily installed battery was being connected to the solenoid valve from the

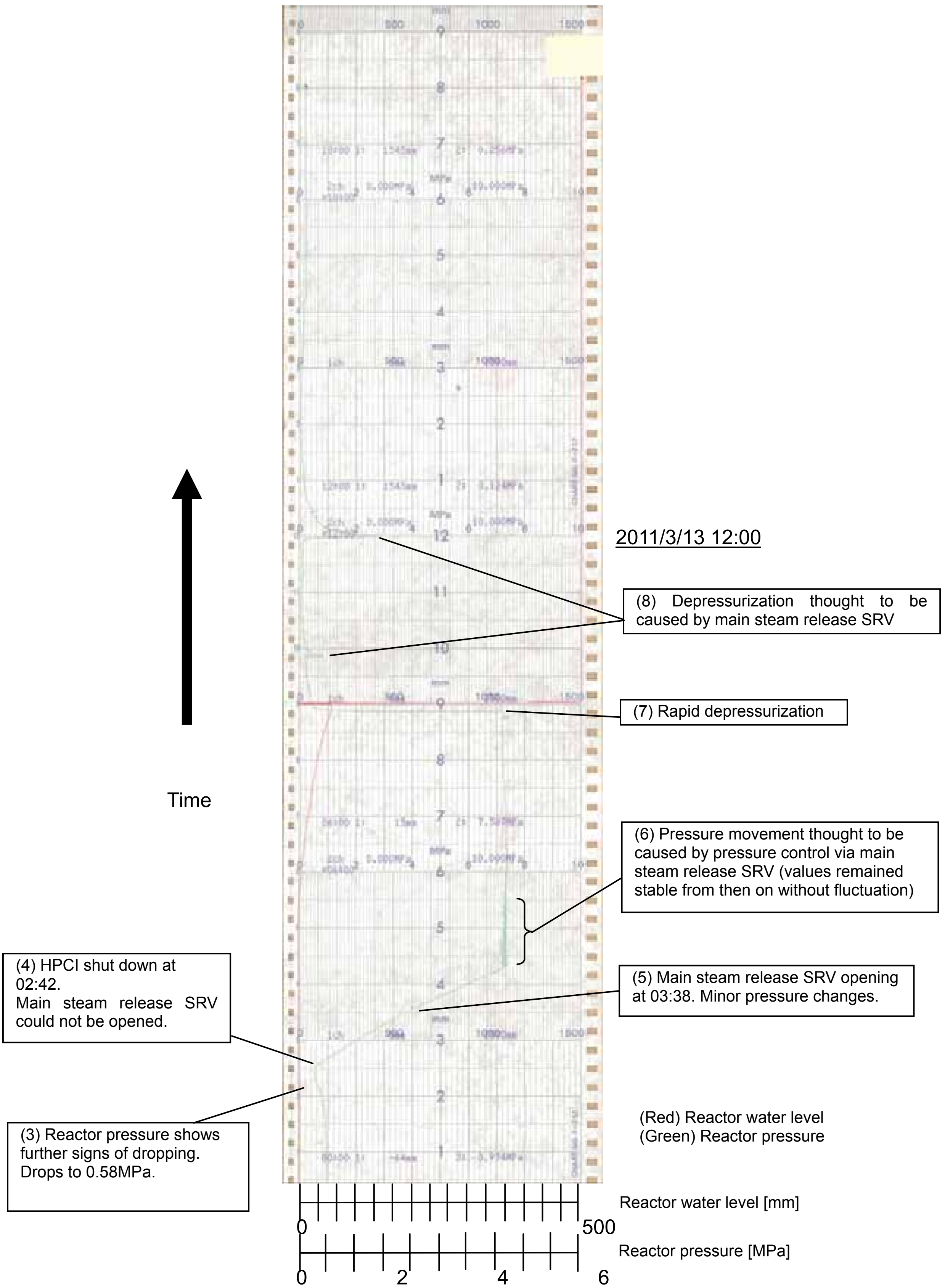
MCR in order to supply the main steam release SRV with nitrogen gas.

⑦ Reactor pressure swiftly dropped around 09:08. Since connection of a battery to the main steam release SRV nitrogen gas supply solenoid valve was completed and opening operation commenced at 09:50, this was not caused by main steam release SRV operation after battery connection. It is believed the main steam release SRV operated for some unknown reason, and this caused depressurization. On the main steam release SRV control panel, both open/close status display lights were on (which means partially open) at the time of depressurization. Although this could be due to leakage from RPV, the possibility is though low due to the reasons stated in ⑧.

⑧ After reactor depressurization, reactor pressure rose and quickly dropped again twice (just before 10:00 and around 12:00). If RPV leakage continued or main steam release SRV remained open, this type of reactor pressure increase would not have been seen. As stated earlier, connection to the battery had been completed by the times given here, meaning reactor pressure maintenance via main steam release SRV was possible. It is believed that main steam release SRV operation was what caused the depressurizations at those times.



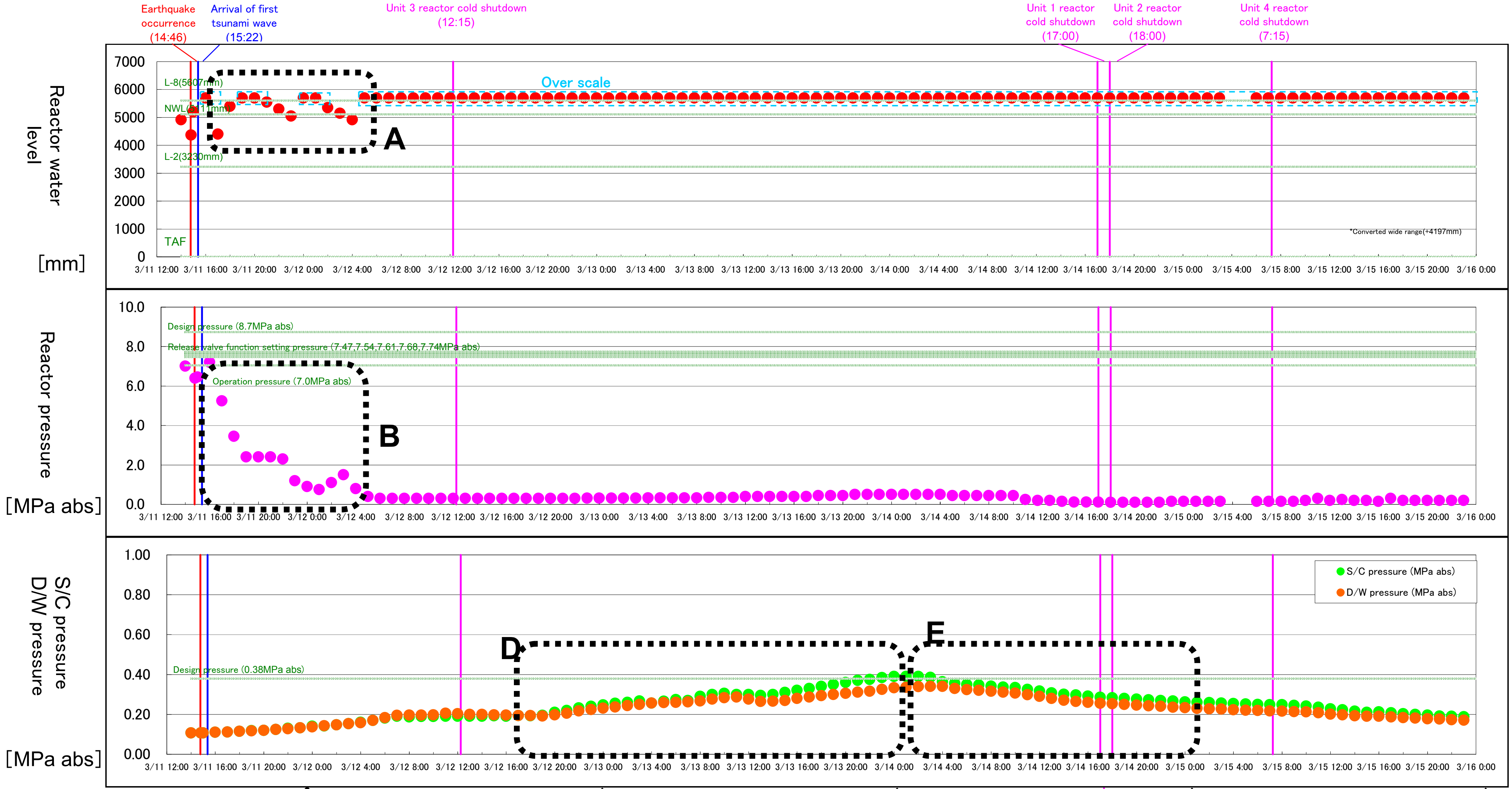
Unit 3 reactor water level / pressure (1/2)



Unit 3 reactor water level / pressure (2/2)

Fukushima Daini Unit 1 Plant Parameters Transient

Attachment 8-17

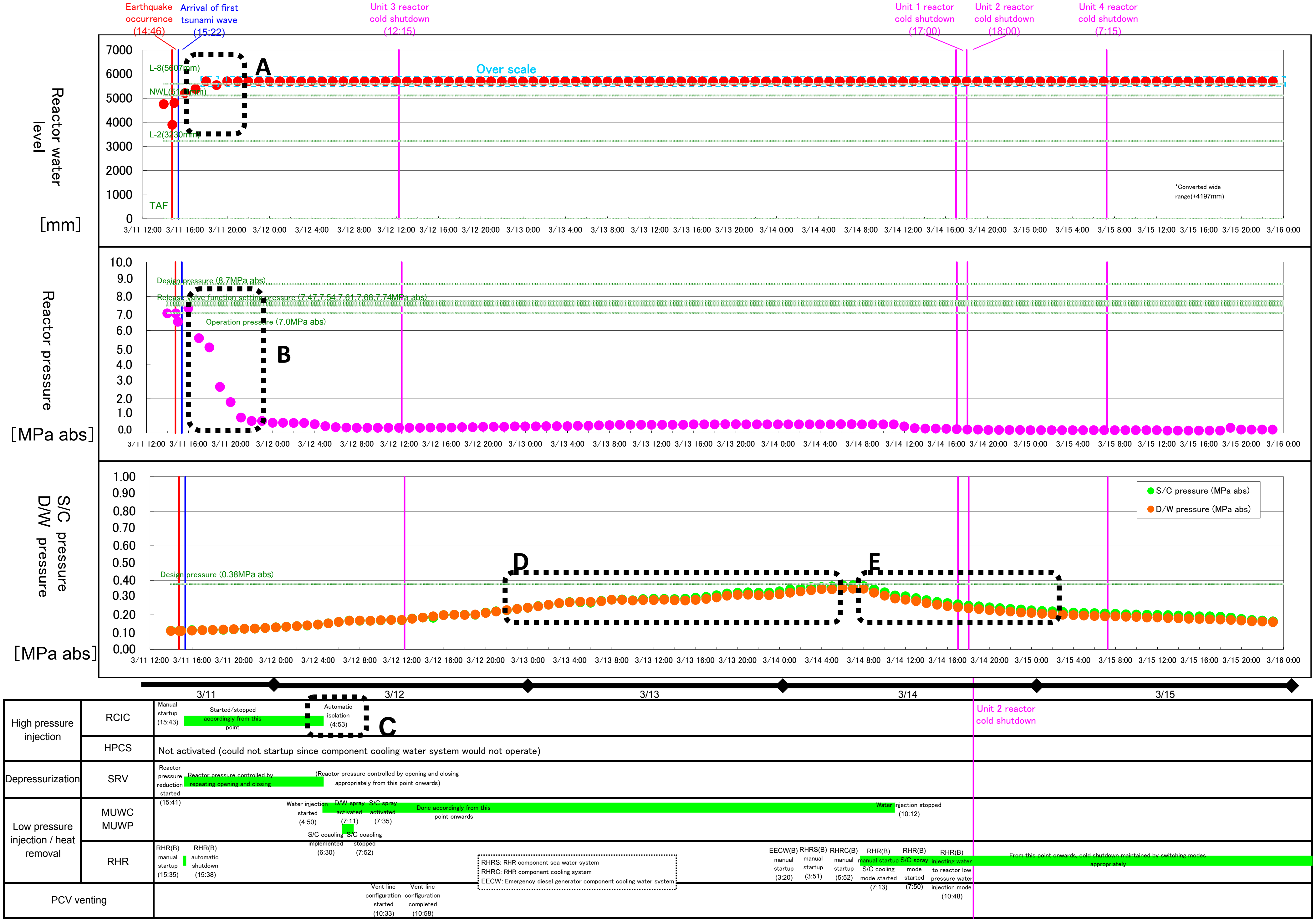


		3/11 – 3/12 – 3/13 – 3/14 – 3/15
High pressure injection	RCIC	Manual startup (15:36); Started/stopped accordingly from this point; Manual isolation (4:58) **C**
	HPCS	Not activated (could not startup since power was submerged and component cooling water system would not operate)
Depressurization	SRV	Reactor pressure reduction started (15:55); Reactor pressure controlled by repeating opening and closing; Rapid pressure reduction started (3:50); Rapid pressure reduction completed (4:56); (Reactor pressure controlled by opening and closing appropriately from this point onwards)
Low pressure injection / heat removal	MUWC	Water injection started (0:00); S/C cooling started (6:20); D/W spray activated (7:10); S/C spray activated (7:37); S/C cooling stopped (7:45); From this point onwards, D/W spray, S/C spray activated; Water injection stopped (9:40)
	RHR	RHRS(B) manual startup (20:17); RHRC(D) manual startup (21:03); RHR(B) manual startup S/C cooling mode started (1:24); EECW (B) manual startup (1:44); RHR(B) S/C spray mode started (3:39); RHR(B) injecting water to reactor low pressure water injection mode (10:05); From this point onwards, cold shutdown maintained by switching modes appropriately
PCV venting		Vent line configuration started(10:21); Vent line configuration completed(18:30)

Unit 1 reactor cold shutdown (17:00)

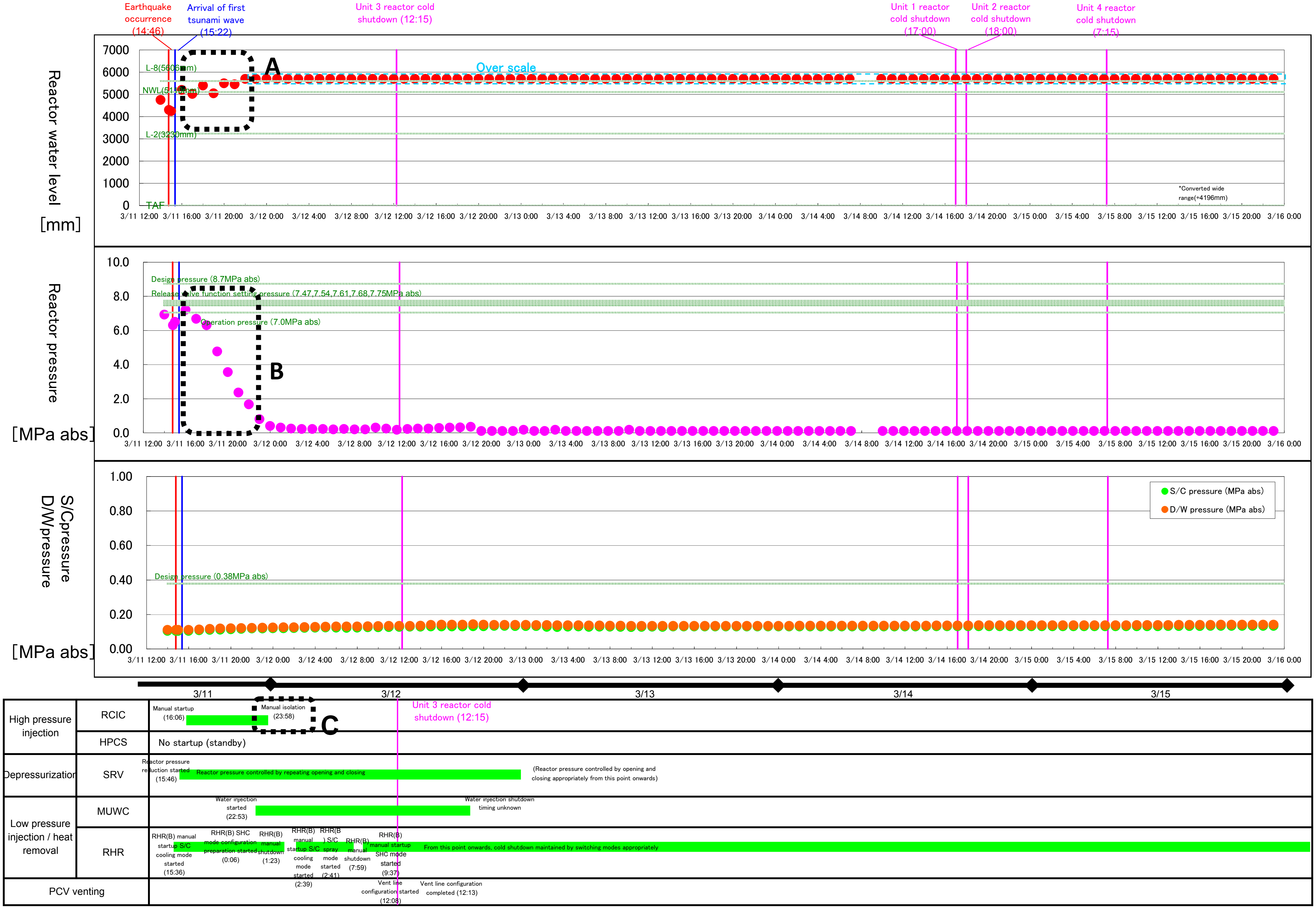
RHRS: RHR component sea water system
RHRC: RHR component cooling system
EECW: Emergency diesel generator component cooling water system

Fukushima Daini Unit 2 Plant Parameters Transient

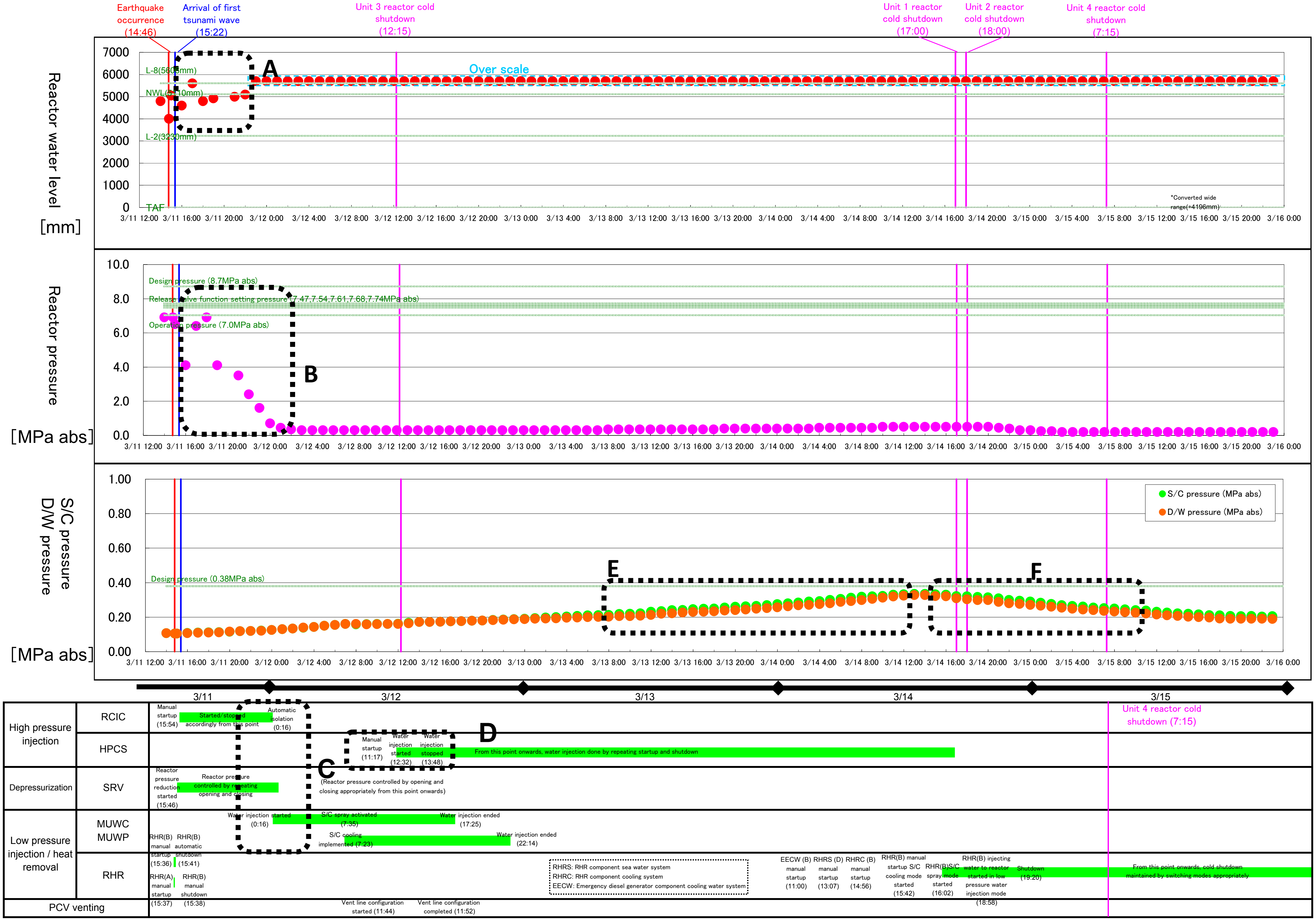


Reference 8-19

Fukushima Daini Unit 3 Plant Parameters Transient



Fukushima Daini Unit 4 Plant Parameters Transient



Fukushima Daiichi Nuclear Power Station (NPS) Spent Fuel Pool (SFP) Water Level Evaluation Method

1. Foreword

The tsunami caused a loss of normal cooling function to the Unit 1-6 R/B SFP and common pools resulting in a situation where the decay heat from the fuel stored in the SFP could not be removed. If the fuel decay heat cannot be removed, the temperature of the SFP water will rise and SFP water will begin to evaporate. Evaporation of SFP water will cause the SFP water volume to decrease and if the water level decreases remarkably the fuel will become exposed. However, due to the explosions entry to the R/B for Units 1-4 was impossible which made it difficult to ascertain the temperature and level of water in the SFP, so in order to clarify the condition of the SFP, and in particular if the fuel became exposed, an evaluation based on the fuel decay heat and SFP cooling water injection for Units 1-4 is being implemented. The details of evaluation methods for evaluating SFP water level, etc. using this evaluation are discussed in the next chapters.

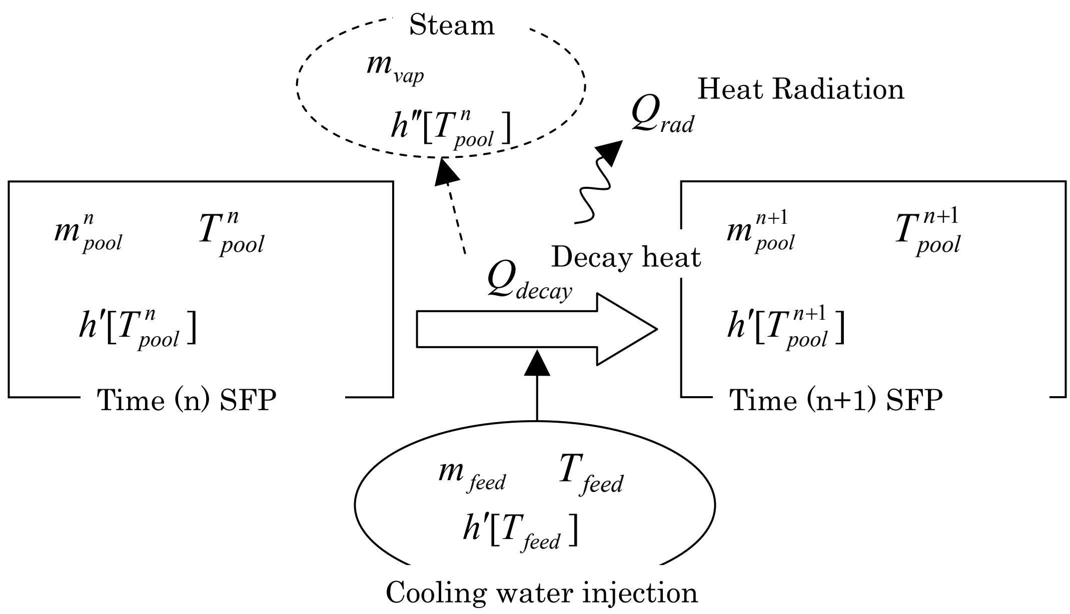
2. SFP water level

(1) Evaluation conditions

The following conditions were used for evaluation

① Evaluation model

A summary diagram of the model used for evaluation is shown below. As time progresses from T^n to T^{n+1} SFP water is lost due to evaporation from the decay heat of spent fuel in the SFP. Meanwhile, SFP water level rises by the amount of cooling water being injected during this time. Furthermore, some of the decay heat energy is consumed through heat radiation. When various information related to water level changes is evaluated from the perspective of mass conservation (hereinafter referred to as, “mass balance”) and energy conservation (hereinafter referred to as, “energy balance”) it becomes possible to estimate pool water levels that change from moment to moment.



The following formulas are obtained for water mass balance and energy balance from the diagram above.

(Mass balance formula)

$$m_{pool}^{n+1} = m_{pool}^{n} + m_{feed} - m_{vap} \quad \cdots \text{Formula ①}$$

(Energy balance formula)

$$m_{pool}^{n+1} h'[T_{pool}^{n+1}] = m_{pool}^{n} h'[T_{pool}^{n}] + m_{feed} h'[T_{feed}] - m_{vap} h''[T_{pool}^{n}] + \left(Q_{decay} - Q_{rad}\right) \quad \cdots \text{Formula②}$$

m_{pool}^{n} : Mass of water in SFP at Time (n)

m_{feed} : Mass of water injected into the SFP from Time (n) to (n+1)
(0 if cooling water was not injected)

m_{vap} : Mass of water that evaporated from Time (n) to (n+1)
(0 if no water evaporated)

T_{pool}^{n} : SFP water temperature at Time (n)

T_{feed} : Temperature of cooling water injected into SFP

$h'[T]$: Temperature T saturated water enthalpy

$h''[T]$: Temperature T saturated steam enthalpy

Q_{decay} : Fuel decay heat generated inside SFP during Time (n) to (n+1)

Q_{rad} : Heat radiation from SFP generated during Time (n) to (n+1)

Formula ③ below is obtained from formula ① and formula ②.

$$m_{pool}^{n}(h'[T_{pool}^{n+1}] - h'[T_{pool}^{n}]) + m_{feed}(h'[T_{pool}^{n+1}] - h'[T_{feed}]) + m_{vap}(h''[T_{pool}^{n}] - h'[T_{pool}^{n}]) = Q_{decay} - Q_{rad} \quad \cdots \text{Formula ③}$$

During the time period from immediately after the accident until prior to the beginning of evaporation and prior to cooling water injection, until the evaporation commencement temperature is reached energy is used only to increase the temperature of the SFP water, so formula ③ becomes formula ④. This formula is used to obtain SFP water temperature T_{pool}^{n+1}.

$$m_{Pool}^{n}(h'[T_{Pool}^{n+1}] - h'[T_{Pool}^{n}]) = Q_{decay} - Q_{rad} \quad \cdots \text{formula ④}$$

After evaporation begins SFP water temperature remains constant and energy is used only to increase the temperature of injected cooling water to the evaporation point temperature and for steam. Under these conditions formula ③ becomes formula ⑤. This formula is used to obtain boiling volume m_{vap}. Furthermore, m_{pool}^{n+1} is obtained from formula ① to obtain the volume variation of SFP water volume (or water level).

$$m_{Feed}(h'[T_{Pool}^{n+1}] - h'[T_{Feed}]) + m_{Vap}(h''[T_{Pool}^{n}] - h'[T_{Pool}^{n}]) = Q_{decay} - Q_{rad} \quad \cdots \text{Formula ⑤}$$

② Decay heat (Q_{decay})

The decay heat of fuel inside the SFP is obtained by calculating the decay heat for each assembly and summing them up for all the stored fuel. Table 1 shows the fuel stored in the SFP and Table 2 shows evaluation values for decay heat at representative times.

Genral-purpose calculation code “ORIGEN”, which have been used to evaluate SFP cooling performance for licensing procedures, was used to calculate decay heat. ORIGEN Version 2.2 with a cross-sectional area library compatible with high burn-up BWR fuels (BWRUE) was used. Values for degree of burn-up and cooling period are used for each fuel assembly.

Output history was fixed using average specific output over the burn-up period. These conditions were used for the licensing procedures because of its resulting conservative estimates of spent fuel decay heat by overestimating the amount of fission products and actinide generated at the end of burn-up by assuming that output at the end of burn-up is higher than in reality where output decreases as a result of a decrease in reactivity. The level of conservativeness was set at 10% of the decay heat for all the SFP stored fuel and a decay heat of 0.9 times of those shown in Table 2 was used during this evaluation. However, all the core fuel that had been burned during the cycle prior to Unit 4 outage was being stored in the SFP, which was under outage on the March 11, so there are fuel with high average specific output and fuel with low average specific output so the conservativeness of homogeneous specific output is offset. Since spent fuel being burned during previous cycle contributes approximately 80% of the entire decay heat, the constant specific output conservativeness of the Unit 4 SFP decay heat is approximately 2% (= 10% x (100-80)%), and a decay heat 0.98 times of those shown in Table 2 was used in this evaluation.

③ SFP water volume (m^{n}_{pool})

Table 3 shows each SFP water volume. The amount of water when the SFP is filled was set as the designed SFP capacity value, and the volume of the fuel and fuel storage racks, etc. inside the SFP were not considered since they do not impact the assessment of the fuel water level after the commencement of boiling, which is important for this evaluation.

The water volumes in Table 3 are SFP water volume prior to the accident, but it is evaluated conservatively assuming that water level immediately after the accident was reduced by 50cm due to sloshing caused by the earthquake. Furthermore, this evaluation was performed under the assumption that water level in SFPs of plants for which the reactor buildings were damaged by the explosions (Unit 1, Unit 3, Unit 4) dropped by 1m when the buildings were damaged.

When the accident occurred the reactor well next to the SFP of Unit 4, which was undergoing outage work, was completely filled with water. The SFP and well are separated by a pool gate that is designed to seal SFP by being pushed in the direction of the well by the water pressure of the water in the SPF, but if the SAFP water volume decreases the lack of SFP water pressure hinders the gate from functioning like a seal and water from the well will flow into the SFP. The Unit 4 SFP evaluation considers this fact and concludes that if SFP water volume decreases through evaporation when both the SFP and well are completely full then water will flow from the well into the SFP thereby causing the SFP and well to maintain the same water level. Also, if both the SFP and well experience decreases in water level and cooling water is then injected into the SFP only the SFP water level will rise (water will not flow from the SFP into the well). Furthermore, since the steam separator storage pools next to the reactor well were full at the time of the accident, the water volume of the steam separator storage pool is considered to be the same as the reactor well.

④ Amount of cooling water injected into the SFP (m_{feed})

Since SFP water cooling function for Units 1-4 remained unrecovered, cooling water was injected into the SFP from the outside. Tables 4(1) to 4(4) show the cooling water injection records for each unit. The date of cooling water injection, cooling water injection volume, injection measure and cooling water injection rate are shown in the Tables. When there were great discrepancies between the cooling water injection volumes in a Table the largest value was used for evaluation purposes.

Cooling water injection rate refers to the ratio between the actual volume of injected water into the SFP (unmeasured) and the volume of discharged water targeted for SFP (values in Table 4), and considers water that missed the SFP when injected through the upper structure of the reactor building and water leaking from broken pipes, etc. Since the amount of water that was actually injected into the SFP has not been measured it is difficult to calculate cooling water injection rate, however this value was determined based on injection method conditions and water level measurement records. In detail, a value of 0.1 has been determined for cooling water injection via helicopter or water truck; a value of 1 has been determined for cooling water injection using the Fuel Pool Cooling and Clean-up Water System (FPC); and a value of 0.95 for cooling water injection via a concrete pump truck when cooling water injection was assisted by a monitoring camera and 0.7 for all other times. Furthermore, both seawater and fresh water were used for cooling water injection but this evaluation does not differentiate between the two.

⑤ SFP water and cooling water injection water temperature (T^n_{pool}, T_{feed})

SFP water and cooling water injection water temperature has been set as shown in Table 5. Cooling water injection water temperature has been set at 10°C regardless of injection measure, and initial SFP water temperature has been set at 30°C for all SFPs.

Water temperature during evaporation has been set based on records. As will be mentioned later, the highest value for the Unit 2 SFP water temperature is 70°C while Unit 4 remains steady at 90°C and no temperature increases that exceed this value were seen. It is assumed that this is because the temperature of water in contact with fuel and the temperature of water in contact with the atmosphere balanced and equalized at this temperature. It is assumed that the temperatures of Unit 2 and Unit 4 differ because there was more decay heat from the fuel in the Unit 4 SFP. Since the decay heats of the fuel in the other SFPs are close to Unit 2 values, the same values as Unit 2 were employed.

⑥ Heat radiation (Q_{rad})

The types of heat radiation considered were heat radiated from the surface of the SFP into the atmosphere, and heat radiated from the walls and floor of the SFP. Four wall surfaces were considered for the Unit 4 SFP that does not have radiation heat from the well side wall and three wall surfaces excluding the well side for the other SFPs. The heat transfer coefficients were set based on documentation with the heat transfer coefficient for heat radiated into the atmosphere being set as 11.6W/m^2・K, and the heat conductivity rate of the SFP walls set at 1.5W/m^2・K with the external air temperature of 10°C. Table 6 shows the heat radiation evaluation results for representative temperatures.

Table 1 SFP Fuel Storage Conditions

	Number of fuel assemblies stored (numbers in parenthesis indicate new fuel assemblies)	Storage capacity
Unit 1 SFP	292 (100)	900
Unit 2 SFP	587 (28)	1240
Unit 3 SFP	514 (52)	1220
Unit 4 SFP	1331 (204)	1590

Table 2 SFP Decay Heat

	Decay Heat (MW)	
	When the accident occurred (3/11)	3 months after the accident (6/11)
Unit 1 SFP	0.18	0.16
Unit 2 SFP	0.62	0.52
Unit 3 SFP	0.54	0.46
Unit 4 SFP	2.26	1.58

Table 3 SFP Water Volume

	Water Volume (m^3)
Unit 1 SFP	990
Unit 2 SFP	1390
Unit 3 SFP	1390
Unit 4 SFP	1390*

* : Water volume is 2,790m^3 when the volumes of the reactor well and steam separator storage pool are added.

Table 4 (1) Unit 1 SFP cooling water injection record

Date of cooling water injection	Cooling water injection volume (t)	Injection measure	Cooling water injection rate
3/31	90	Concrete pump truck	0.7
5/20	60	Concrete pump truck	0.7

5/22	90	Concrete pump truck	0.7
5/29	168	FPC	1
6/5	15	FPC	1

Table 4 (2) Unit 2 SFP cooling water injection record

Date of cooling water injection	Cooling water injection volume (t)	Injection measure	Cooling water injection rate
3/20	40	FPC	1
3/22	18	FPC	1
3/25	30	FPC	1
3/29	15-30	FPC	1
3/30	Under 20	FPC	1
4/1	70	FPC	1
4/4	70	FPC	1
4/7	36	FPC	1
4/10	60	FPC	1
4/13	60	FPC	1
4/16	45	FPC	1
4/19	47	FPC	1
4/22	50	FPC	1
4/25	38	FPC	1
4/28	43	FPC	1
5/2	55	FPC	1
5/6	58	FPC	1
5/10	56	FPC	1
5/14	56	FPC	1
5/18	53	FPC	1
5/22	56	FPC	1
5/26	53	FPC	1
5/30	53	FPC	1

Table 4 (3) Unit 3 SFP cooling water injection record

Date of cooling water injection	Cooling water injection volume (t)	Injection measure	Cooling water injection rate
3/17	30	Helicopter	0.1
3/17	44	Water cannon truck	0.1
3/17	30	Water cannon truck	0.1
3/18	40	Water cannon truck	0.1
3/18	2	Water cannon truck	0.1
3/19	60	Water cannon truck	0.1
3/19	2430	Water cannon truck	0.1
3/20	1137	Water cannon truck	0.1
3/22	150	Water cannon truck	0.1
3/23	35	FPC	0
3/24	120	FPC	0
3/25	450	Water cannon truck	0.1
3/27	100	Concrete pump truck	0.95
3/29	100	Concrete pump truck	0.95
3/31	105	Concrete pump truck	0.95
4/2	75	Concrete pump truck	0.95
4/4	70	Concrete pump truck	0.95
4/7	70	Concrete pump truck	0.95
4/8	75	Concrete pump truck	0.95
4/10	80	Concrete pump truck	0.95
4/12	35	Concrete pump truck	0.95
4/14	25	Concrete pump truck	0.95
4/18	30	Concrete pump truck	0.95
4/22	50	Concrete pump truck	0.95
4/26	47.5	FPC	1
5/8	60	FPC	1
5/9	80	FPC	1
5/16	106	FPC	1

Table 4 (4) Unit 4 SFP cooling water injection record

Date of cooling water injection	Cooling water injection volume (t)	Injection measure	Cooling water injection rate
3/20	80	Water cannon truck	0.1
3/20	80	Water cannon truck	0.1
3/21	92.2	Water cannon truck	0.1
3/22	150	Concrete pump truck	0.7
3/23	125	Concrete pump truck	0.7
3/24	150	Concrete pump truck	0.7
3/25	150	Concrete pump truck	0.7
3/27	125	Concrete pump truck	0.7
3/30	140	Concrete pump truck	0.7
4/1	180	Concrete pump truck	0.7
4/3	180	Concrete pump truck	0.7
4/5	20	Concrete pump truck	0.7
4/7	38	Concrete pump truck	0.7
4/9	90	Concrete pump truck	0.7
4/13	195	Concrete pump truck	0.7
4/15	140	Concrete pump truck	0.7
4/17	140	Concrete pump truck	0.7
4/19	40	Concrete pump truck	0.7
4/20	100	Concrete pump truck	0.7
4/21	140	Concrete pump truck	0.7
4/22	200	Concrete pump truck	0.95
4/23	140	Concrete pump truck	0.95
4/24	165	Concrete pump truck	0.95
4/25	210	Concrete pump truck	0.95
4/26	130	Concrete pump truck	0.95
4/27	85	Concrete pump truck	0.95
5/5	270	Concrete pump truck	0.95
5/6	180	Concrete pump truck	0.95
5/7	120	Concrete pump truck	0.95
5/9	100	Concrete pump truck	0.95
5/11	120	Concrete pump truck	0.95
5/13	100	Concrete pump truck	0.95
5/15	140	Concrete pump truck	0.95

Table 5 SFP water and cooling water injection water temperature

Cooling water injection		10°C
SFP water	Initial value (prior to accident)	30°C
	During evaporation (other than Unit 4 SFP)	70°C
	During evaporation (Unit 4 SFP)	90°C

Table 6 Heat radiation evaluation results for representative SFP temperatures

	Unit 1	Unit 2	Unit 3	Unit 4
SFP water temperature (°C)	70	70	70	90
Amount of radiated heat (MW)	0.08	0.11	0.11	0.16

Results of Fukushima Daiichi Unit 1 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 292 assemblies of spent fuel and 100 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 1. Decay heat has been evaluated to be 0.18MW as of March 11, and 0.16MW as of June 1. Chart 1 shows the number of fuel assemblies that were stored in the Unit 1 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck, all AC power sources were lost and functions for cooling and filling the SFP with water were lost. At 15:36 on March 12, the R/B was damaged by a hydrogen explosion and the ceiling fell on top of the SFP. However, the ceiling did not fall all the way to the operating floor and got caught up on the ceiling crane, etc. thereby coming to a halt in the space above the operating floor.

On March 31, when concrete pump trucks were used to spray water (fresh water) on the building for the first time, steam was seen emanating from the top of the R/B. Furthermore, although the cause-and-effect relationship is unclear in this instance, D/W pressure also dropped.

On April 1, when the upper structure of the R/B was observed using a camera mounted on the concrete pump truck from the positional relationship it was estimated that a part of the ceiling had fallen onto the operating floor. However, it had fallen near the border between the SFP and the floor and the exact location where it came to rest could not be ascertained.

On May 14, attempts are made to spray water using a concrete pump truck however these attempts were abandoned due to strong winds. The status of the upper structure of the R/B and the operating floor was confirmed.

On May 20, water was sprayed using a concrete pump truck, however scattered debris from the fallen ceiling hindered operations and cooling water could not be injected directly into the SFP. Consequently, it was impossible to confirm whether or not SFP water was replenished. On May 22 water was sprayed using a concrete pump truck while observing the operation with the camera. However, clear proof of whether or not cooling water injection was being achieved could still not be obtained. It is unclear whether or not cooling water injection implemented with concrete pump trucks up until this point were effective or not.

On May 28, a cooling water injection test using FPC pipes that use fresh water as a water source was implemented, and when actual cooling water injection was implemented the following day, an increase in the skimmer surge tank level was confirmed so it was confirmed that the SFP tank was full with water.

On June 5, cooling water injection via FPC piping was implemented again. Skimmer surge tank levels increased at the point when cooling water injection equivalent to the amount of water that it is estimated had evaporated since May 29 concluded.

Since it became possible to predict changes in SFP water volume cooling water injection was implemented approximately once a month until alternative cooling systems could be introduced in order to maintain SFP water level by replenishing the amount of water that had evaporated. Chart 2 shows the Unit 1 SFP cooling water injection records.

Furthermore, at 11:22 on August 10 SFP cooling began using alternative cooling systems (refer to Figure 1). The water temperature when cooling commenced was approximately 47°C (temperature at the inlet to the alternative cooling system) and reached equilibrium on around August 27 with water temperature stabilizing at approximately 30°C.

Chart 1 Number of fuel assemblies stored in the Unit 1 SFP

7x7	68
8x8	6
STEP2	218
Spent fuel total	292
New fuel (STEP3-B)	100
Total number of fuel assemblies	392

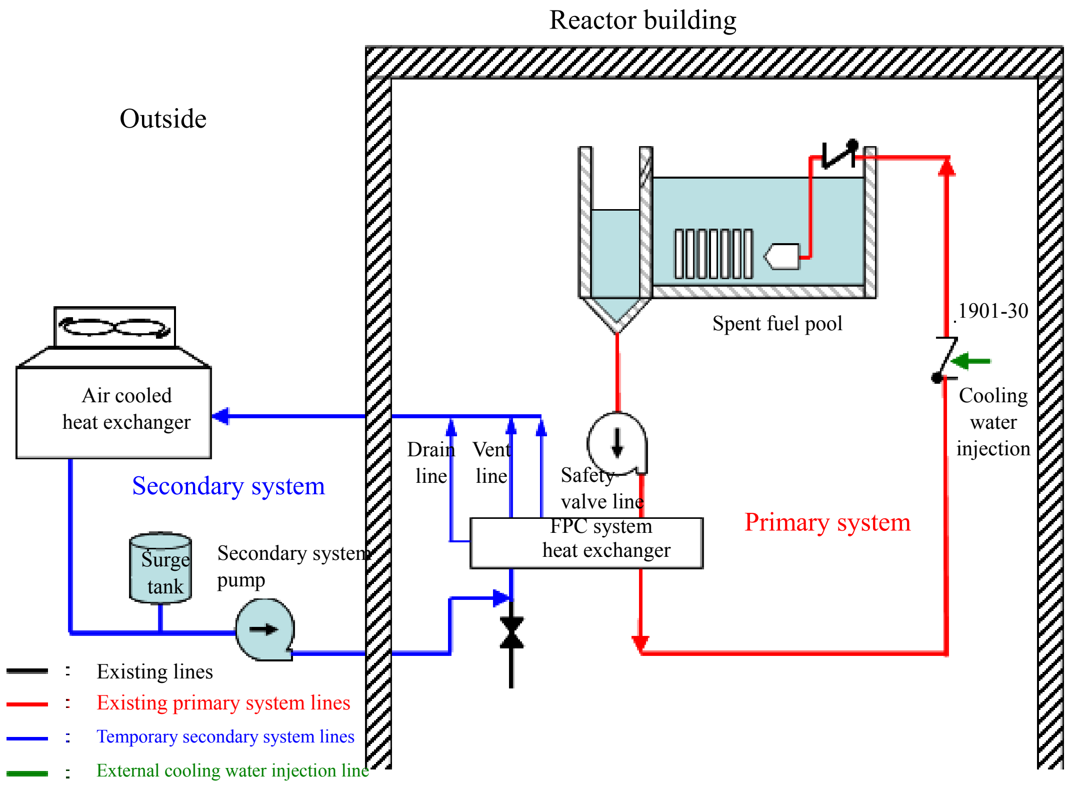


Figure 1 Unit 1 alternative cooling system schematic

Chart 2 Unit 1 SFP cooling water injection record

As of 9:00 8/12

		Total amount of cooling water	Approx. 588 (t)
Date/Time	Measure	Type	Cooling water volume (t)
3/31 13:03-16:04	TEPCO concrete pump truck (62m class)	Fresh water	90
4/2 17:16-17:19	TEPCO concrete pump truck (62m class)	Fresh water	(water spraying position confirmed)
5/14 15:07-15:18 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	— (water spraying postponed due to strong winds)
5/20 15:06-16:15 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	60 (Approx. 90t were to be sprayed but the operation was postponed due to strong winds)
5/22 15:33-17:09 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	90
5/28 16:47-17:00 (water sprayed)	FPC	Fresh water	5 (leak test)
5/29 11:10-15:35	FPC	Fresh water	168
6/5 10:16-10:48	FPC	Fresh water	15
7/5 15:10-17:30	FPC	Fresh water	75
8/5 15:20-17:51	FPC	Fresh water	75
8/10 8:59-9:19	FPC	Fresh water	10
8/10 10:06 (Alternative cooling system activated)	SFP circulation cooling device	Fresh water	-

2. Items verified through the investigation

(1) Unit 1 skimmer surge tank water sampling

On June 22, 2011 and August 19, 2011 samples of water that flowed from the SFP into the skimmer surge tank at Unit 1 were taken and the sampled water was analyzed for radioactive material nuclear species (analysis dates: June 22, August 19). Figure 2 is a system diagram of the FPC system including the skimmer surge tank, and Chart 3 shows the analysis results.

An evaluation based on the analysis results is as follows.

- Unit 1 was stopped on March 25, 2010 for periodic inspection, and since the even fuel removed from reactor with the shortest cooling period would take at least approximately one year to cool, it is unlikely that I-131, which is a nuclear species with a short half-life (approximately 8 days), could have been discharged from the fuel stored in the SFP and it is more likely that it originated from the reactor.
- In regard to the discharge path of greater radioactivity originating from the reactor, it is highly possible that radioactive nuclides originating from the reactor adhered to condensed steam water, dust, and scattered debris within the reactor building and melted into SFP water.

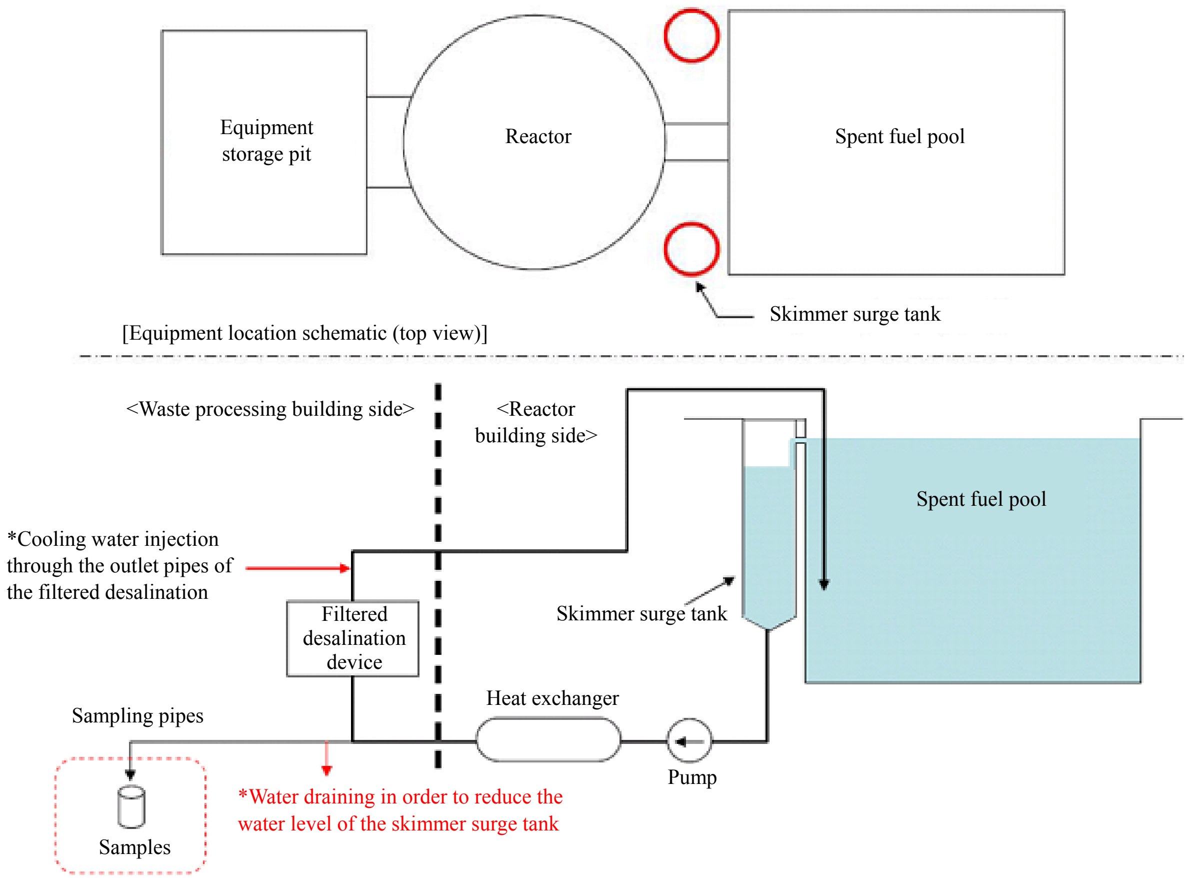


Figure 2 FPC System Diagram

Chart 3 Unit 1 skimmer surge tank water analysis results

Detected nuclear species	Half-life	Concentration (Bq/cm^3)			
		Sampled on 6/22	Sampled on 8/19	(reference) Unit 1 SFP water (2/11)	(reference) Unit 1 T/B subfloor puddles (3/26)
Cs-134	Approx. 2 years	12,000	18,000	Below detection limits	1.2×10^5
Cs-137	Approx. 30 years	14,000	23,000	0.078	1.3×10^5
I-131	Approx. 8 days	68	Below detection limits	Below detection limits	1.5×10^5

(2) Unit 1 SFP water level evaluation

Figure 3 shows the results of the Unit 1 SFP evaluation. Results of the valuation estimate that water levels decreased by March 13 as a result of explosions and sloshing caused by the earthquake. Thereafter water level was maintained until the water temperature reached the evaporation commencement temperature of 70°C after which water level is estimated to have dropped as a result of evaporation. Water level was replenished as a result of the cooling water injection of March 31 and the cooling water injection via a PC piping at the end of May and the SFP was confirmed to be full of water due to an increase in skimmer surge tank levels on May 29 and June 5 [Figure 4]. 413 tons of cooling water had to be injected to fill the SFP and since it is difficult to imagine that all of this water found its way into the SFP, it is assumed that the amount of water lost from the time of the accident until the SFP was confirmed to be full is lower than this amount. Abnormal water level the SFP holds approximately 1,000t, and since the depth of the SF P is approximately 3 times that of the active length of the fuel, it is assumed that the water level of the Unit 1 SFP was maintained and that the fuel did not become exposed. Furthermore, in comparison with the SFP of other units, since the Unit 1 SFP has a smaller decay heat even though cooling water was not injected for over a month the decrease in water level was minimal and it has been evaluated that as of the end of June the water level was approximately 6 m above the fuel racks.

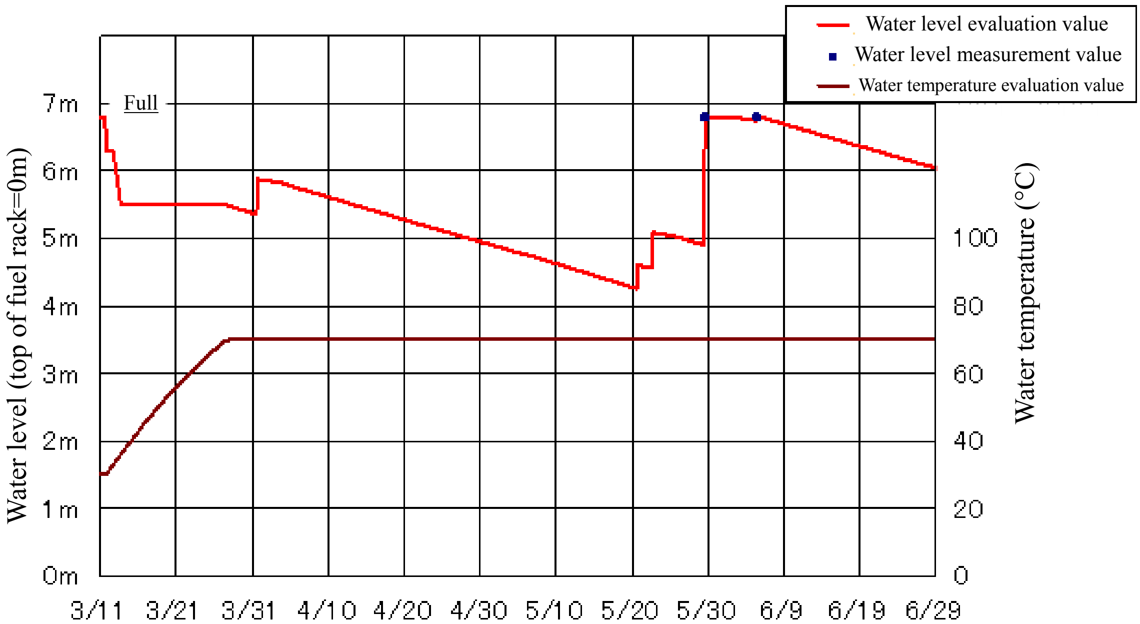


Figure 3 Unit 1 SFP evaluation results

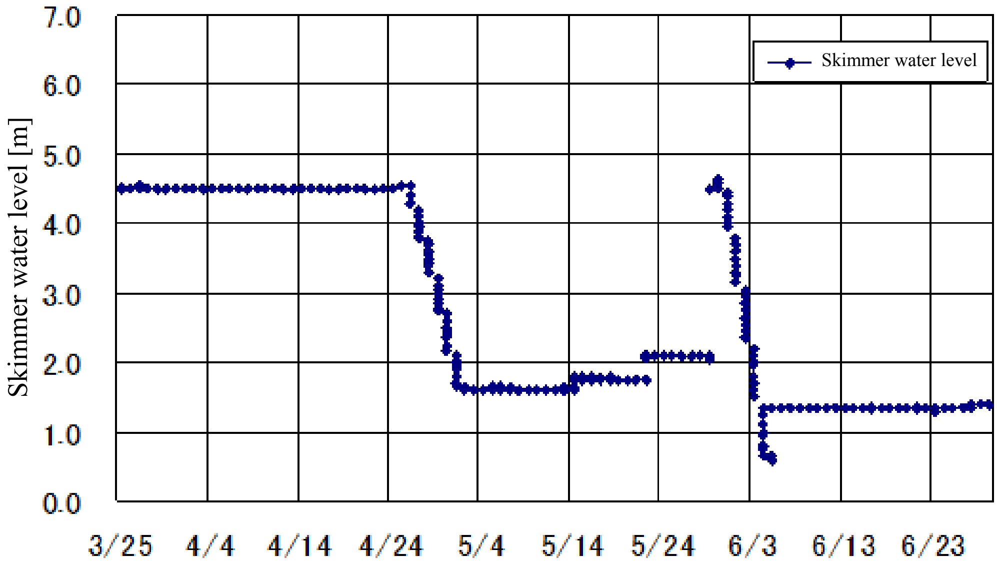


Figure 4 Unit 1 skimmer surge tank level

Results of Fukushima Daiichi Unit 2 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 587 assemblies of spent fuel and 28 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 2. Decay heat has been evaluated to be 0.62MW as of March 11, and 0.52MW as of June 11. Chart 1 shows the number of fuel assemblies that were stored in the Unit 2 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck all AC power sources were lost and functions for cooling and filling the SFP with water were lost. At 15:36 on March 12, the Unit 1 R/B was damaged by a hydrogen explosion and it is hypothesized that this explosion blew out the blowout panels of the Unit 2 R/B. It is unclear when it began but white mist was seen being discharged from the blowout panels.

On March 20 existing FPC pipes that use seawater as a water source were used for cooling water injection. On March 22 when cooling water injection was implemented again the skimmer surge tank level rose thereby confirming that the SFP had been filled completely. Since fresh water sources were able to be used after March 29 the amount of seawater injected as cooling water was 88t.

On April 16, samples of skimmer tank water (water that overflowed from the SFP) were taken.

On April 10, hydrazine was injected during cooling water injection using existing FPC pipes in order to prevent corrosion and thereafter 1,082t of cooling water was injected at fixed intervals until alternate cooling systems were put in service.

On May 31 at 17:21, SFP cooling via alternate cooling systems (refer to Figure 1) began, however on June 1 cooling water was injected due to a drop in skimmer surge tank level. The water temperature when cooling commenced was 70°C (SFP thermometer indicator) and reached equilibrium on around June 5 with water temperature stabilizing at approximately 30°C. Chart 2 shows the cooling water injection record for the Unit 2 SFP.

Chart 1 Number of fuel assemblies stored in the Unit 2 SFP

7x7	3
STEP2	248
STEP3-B	336
Spent fuel total	587
New fuel (STEP3-B)	28
Total number of fuel assemblies	615

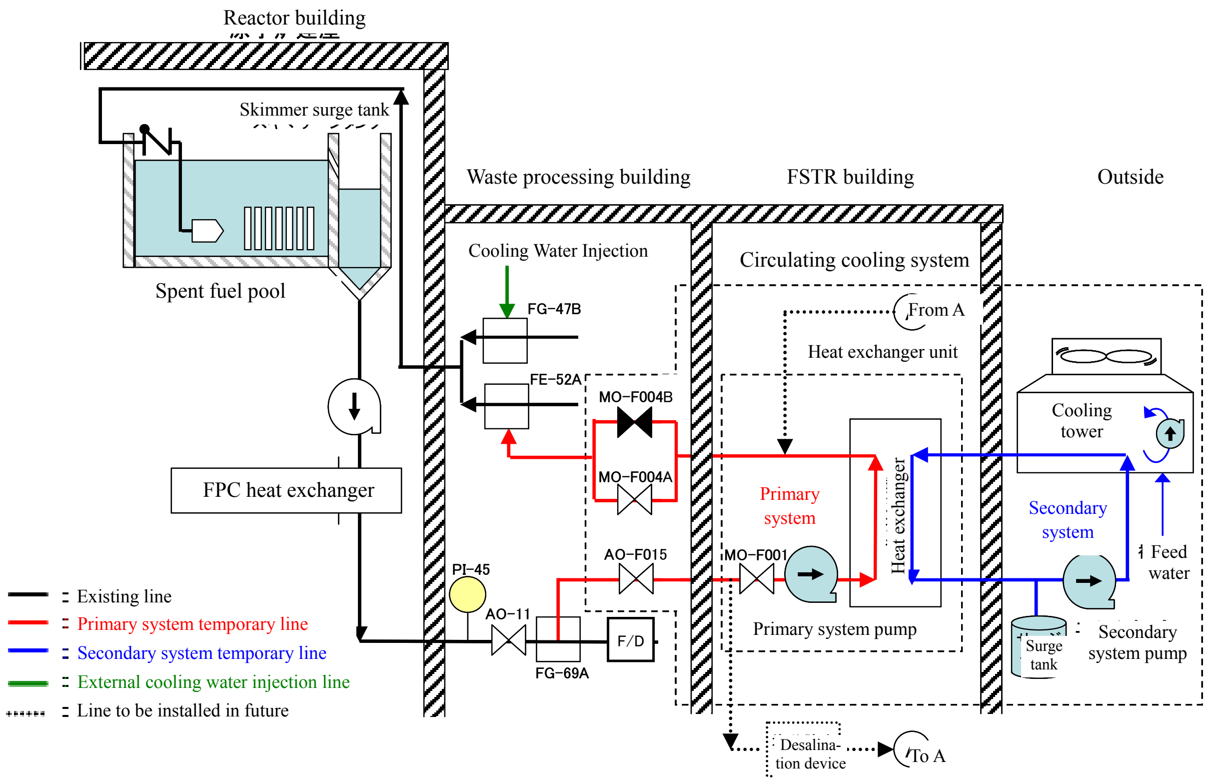


Figure 1 Alternate cooling system diagram

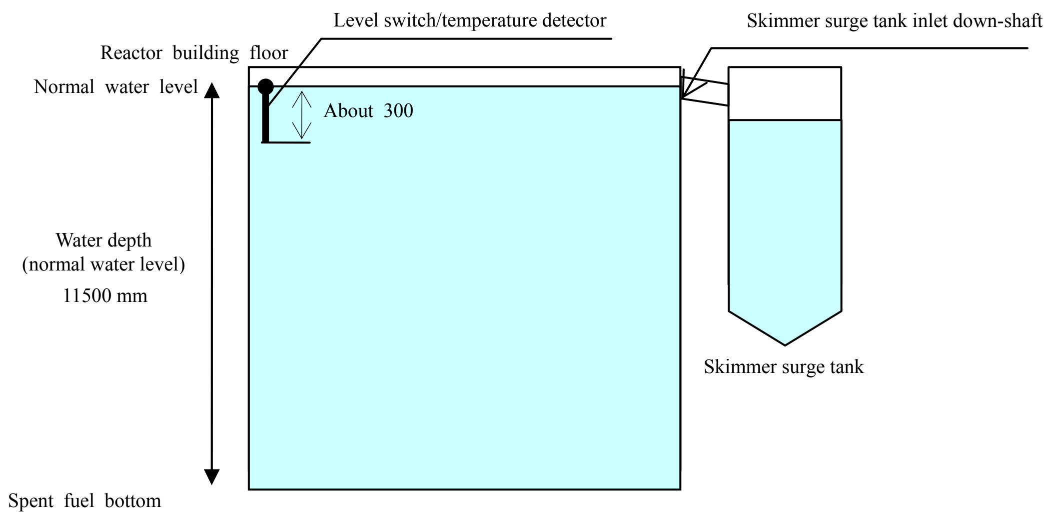


Figure 2 SFP schematic

Chart 2 Unit 2 SFP cooling water injection record

As of 9:00 8/12

		Cooling water injection volume total	(Maximum) Approx. 1,122(t)
Date/Time	Measure	Type	Cooling water injection volume (t)
3/20 15:05-17:20	FPC	Seawater	40
3/22 16:07-17:01	FPC	Seawater	18
3/25 10:30-12:19	FPC	Seawater	30
3/29 16:30-18：25	FPC	Fresh water	15-30
3/30 19:05-23:50	FPC	Fresh water	Below 20
4/1 14:56-17:05	FPC	Fresh water	70
4/4 11:05-13:37	FPC	Fresh water	70
4/7 13:29-14:34	FPC	Fresh water	36
4/10 10:37-12:38	FPC	Fresh water	60
4/13 13:15-14:55	FPC	Fresh water	60
4/16 10:13-11:54	FPC	Fresh water	45
4/19 16:08-17:28	FPC	Fresh water	47
4/22 15:55-17:40	FPC	Fresh water	50
4/25 10:12-11:18	FPC	Fresh water	38
4/28 10:15-11:28	FPC	Fresh water	43
5/2 10:05-11:40	FPC	Fresh water	55
5/6 9:36-11:16	FPC	Fresh water	58
5/10 13:09-14:45	FPC	Fresh water	56
5/14 13:00-14:37	FPC	Fresh water	56
5/18 13:10-14:40	FPC	Fresh water	53
5/22 13:02-14:40	FPC	Fresh water	56
5/26 10:06-11:36	FPC	Fresh water	53

5/30 12:06-13:52	FPC	Fresh water	53
5/31 10:47-11:04 (Primary system flooded) 11:40-11:50 (leak test) 17:21-Alternate cooling system activated (put into service after testing)	SFP circulation cooling device	Fresh water	—
6/1 6:06-6:53 (Due to decrease in skimmer surge tank water level)	FPC	Fresh water	25

2. Items verified through the investigation
   (1) Unit 2 skimmer surge tank water sampling
   At Unit 2, water that leaked into the skimmer surge tank from the SFB was sampled on April 16, 2011 and August 19, 2011, and analyzed for radioactive material nuclear species (analysis date: April 17, August 19). Chart 3 shows the analysis results.

Chart 3 Unit 2 skimmer surge tank water analysis results

Detected nuclear species	Half-life	Concentration (Bq/cm^3)			
		Sampled 4/16	Sampled 8/19	(Reference) Unit 2 SFP water (2/10)	(Reference) Unit 2 turbine building basement puddles (3/27)
Cs-134	Approx. 2 years	160,000	110,000	Below detectable limits	3.1×10^6
Cs-137	Approx. 30 years	150,000	110,000	0.28	3.0×10^6
I-131	Approx. 8 days	4,100	Below detectable limits	Below detectable limits	1.3×10^7

The following is an evaluation based on these analysis results.
- Unit 2 was stopped on September 16, 2010 for periodic inspection, and since even fuel removed from reactor with the shortest cooling period would take at least approximately seven months to cool, it is unlikely that I-131, which is a nuclear species with a short half-life (approximately 8 days), could have been discharged from the fuel stored in the SFP and it

is more likely that it originated from the reactor.

- In regard to the discharge path of greater radioactivity originating from the reactor, it is highly possible that radioactive nuclides that leaked from the Unit 2 PCV adhered to condensed steam water and dust within the reactor building (R/B) and melted into SFP water. Since the Unit 2 R/B was not damaged, it is hypothesized that there was no impact from radioactivity that came flying from the Unit 1 and Unit 3 reactors and it is highly possible that the radioactivity originated from the Unit 2 reactor.

(2) Unit 2 SFP water level evaluation

Figure 3 shows the Unit 2 SFP evaluation results along with actual measurements.

Evaluation results assume that water level decreased as a result of sloshing caused by the earthquake and that the further decrease thereafter was the result of evaporation, however water level gradually recovered with each cooling water injection. The jagged line shows how water level decrease due to evaporation was balanced with cooling water injection and in the end water level was restored to near full.

Furthermore, when cooling water in injection was implemented on March 22 using existing FPC pipes that use seawater as a source, skimmer surge tank levels increased so it was confirmed that the SFP was full [Figure 4]. A total of 58t of cooling water was injected before the SFP became full so assuming that this was the amount of water lost after the accident, compared with the approximate 1,400t of SFP water at normal water levels, this amount is considerably small.

Based on this information, it is assumed that the water level of the Unit 2 SFP was maintained and that the fuel was not exposed.

Since the Unit 2 reactor building was not heavily damaged, it was possible to inject cooling water using the existing FPC and cooling water injection was implemented periodically using the aforementioned line. The Unit 2 SFP water level was confirmed by implying the principle that when the SFP is full it overflows and water flows into the skimmer surge tank causing the skimmer surge tank water level gauge to rise. In other words, an increase in skimmer surge tank water levels indicates that the SFP is full of water. Figure 3 shows the water level measurements indicating this. It is clear from Figure 3 that

water level evaluation values closely match measurements. It is presumed that the reason why the evaluation values are lower than measurement values (full of water) from the middle of March until the end of March is because the impact of sloshing was initially overestimated.
Furthermore, at Unit 2 the existing SFP water thermometer is operational and periodically used to take measurements which are shown in the figure. Immediately after cooling water injection the water temperature rises to near 70°C and then decreases to approximately 50°C 1 to 2 days later, a pattern which is repeated thereafter. This is because the thermometer was exposed as SFP water level he creased, so the temperature indicated is not the temperature of the water but rather of the surrounding atmosphere.
After the alternate cooling system was put in service at 17:21 on May 31, cooling of the SFP water continued and water temperature became approximately 30°C (34°C as of 14:00 on July 7).

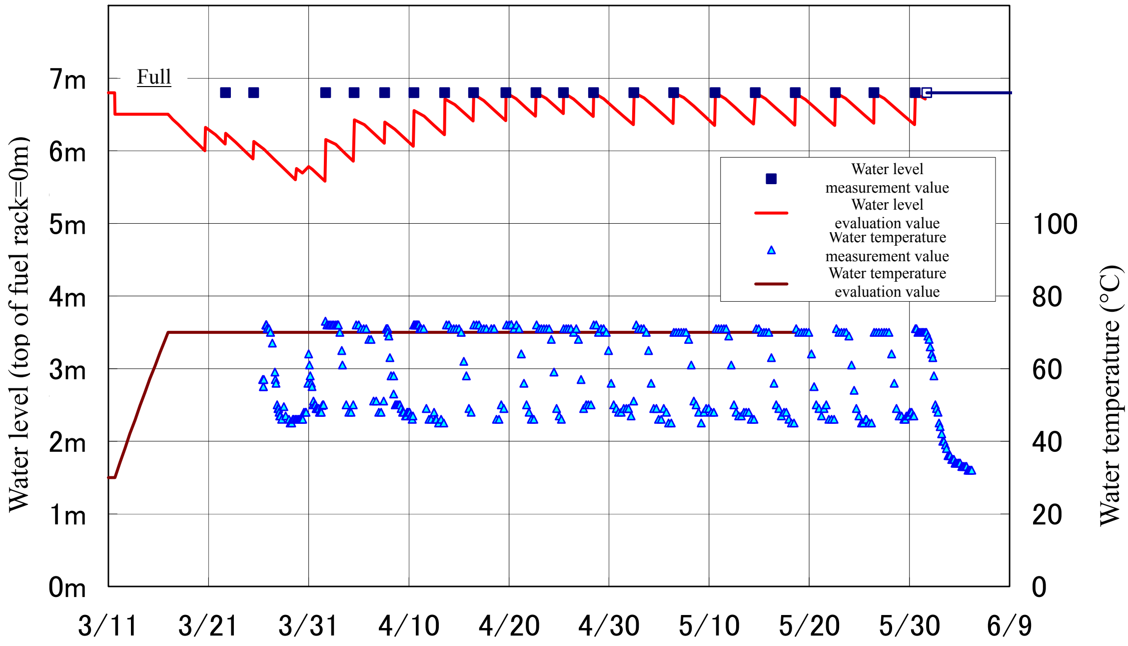


Figure 3 Unit 2 SFP evaluation results

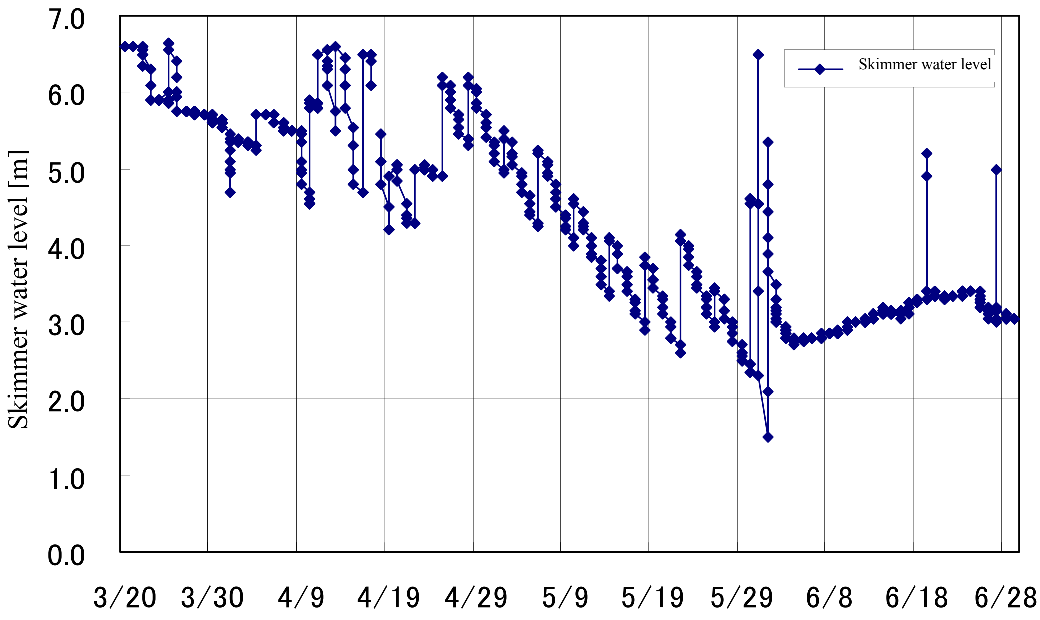


Figure 4 Unit 2 skimmer surge tank levels

Results of Fukushima Daiichi Unit 3 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 514 assemblies of spent fuel and 52 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 3. Decay heat has been evaluated to be 0.54MW as of March 11, and 0.46MW as of June 11. Chart 1 shows the number of fuel assemblies that were stored in the Unit 3 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck all AC power sources were lost and functions for cooling and filling the SFP with water were lost. At 11:01 on March 14 a hydrogen explosion occurred which damaged the outside wall of the entire upper structure of the reactor building (R/B) operating floor thereby scattering a large amount of debris on the SFP. As a result of the extensive damage a large amount of steam was discharged from the operating floor which was completely exposed.

At around 9:48 on March 17, sea water was sprayed on the upper structure of the R/B using a helicopter. After the water was sprayed, steam was seen emanating from the building. At 19:05 on March 17 water trucks were used to begin to spray water on the SFP. Thereafter until March 25 water trucks and squirt trucks were used to spray water on the SFP. (See water being used for the most part).

On March 23 and March 24, existing FPC piping was used to inject cooling water (seawater), however since the pump discharge pressure was higher than anticipated and there was the possibility of a clogging of the system hardly any cooling water was injected.

On March 27 the first spraying of water using a concrete pump truck was implemented. After implementation, an increase in the amount of steam being generated from the upper structure of the R/B was observed. Thereafter until April 22, concrete pump trunks were used to spray approximately 815t of water on the structure.

On March 29 the concrete pump truck water source was switched to a freshwater water source and the spraying of water was implemented. On April 12 it became possible to inject cooling water on the structure while confirming increases in water level using a camera image when the existing concrete pump truck was replaced with another one installed with a camera thereby enabling confirmation for the first time that the Unit 3 SFP was full of water. Since the SFP was confirmed to be full of water after injecting only approximately half of the cooling water planned, it was confirmed that the initial steam amount estimates were conservative and that the amount of cooling water that was injected exceeded what was necessary. It is assumed that the surplus cooling water that was injected up until this point had overflowed. Although the cause-and-effect relationship is unclear, after cooling water injection that is estimated to have generated overflow, the temperature of the reactor bellow seal repeatedly increased and decreased for a short time.

On April 22 cooling water injection tests without a strainer were implemented using the existing FPC piping. After approximately 10t of cooling water was injected over 20 minutes, the SFP water level rose by approximately 9 cm, so it was determined that cooling water injection was possible by this means. On April 26 cooling water injection using existing FPC piping was implemented in full force until June 29 over which time approximately 824.5t of cooling water was injected using the existing FPC piping.

On May 8 SFP water was sampled and videoed.

On May 9, hydrazine started to be injected along with cooling water via existing FPC piping in order to prevent corrosion. Since sampling results indicated alkalinity of the SFP water as a result of the elution of alkaline metals (Ca, etc.) from fallen scattered debris, a boric acid solution was injected during cooling water injection via existing FPC pipes on June 26 and June 27 in order to neutralize the alkalinity. As a result, water quality improved from a strong alkalinity level of pH 11.2 (measured on May 8) prior to cooling water injection to a weak alkalinity level of pH 9.0 (measured on July 7) after cooling water injection.

On June 30, SFP cooling using an alternate cooling system (referred to Figure 1) commenced. The water temperature when cooling commenced was 62C (alternative cooling system inlet temperature) and reached equilibrium on around July 7 with water temperature stabilizing at approximately 30C.

On July 7 SFP water that had overflowed into the skimmer surge tank was sampled from PC sampling pipes. Chart 2 shows the cooling water injection records for the Unit 3 SFP.

Chart 1 Number of fuel assemblies stored in the Unit 3 SFP

8x8	42
STEP2	148
STEP3-A	324
Total spent fuel	514
New fuel (STEP3-A)	52
Total fuel	566

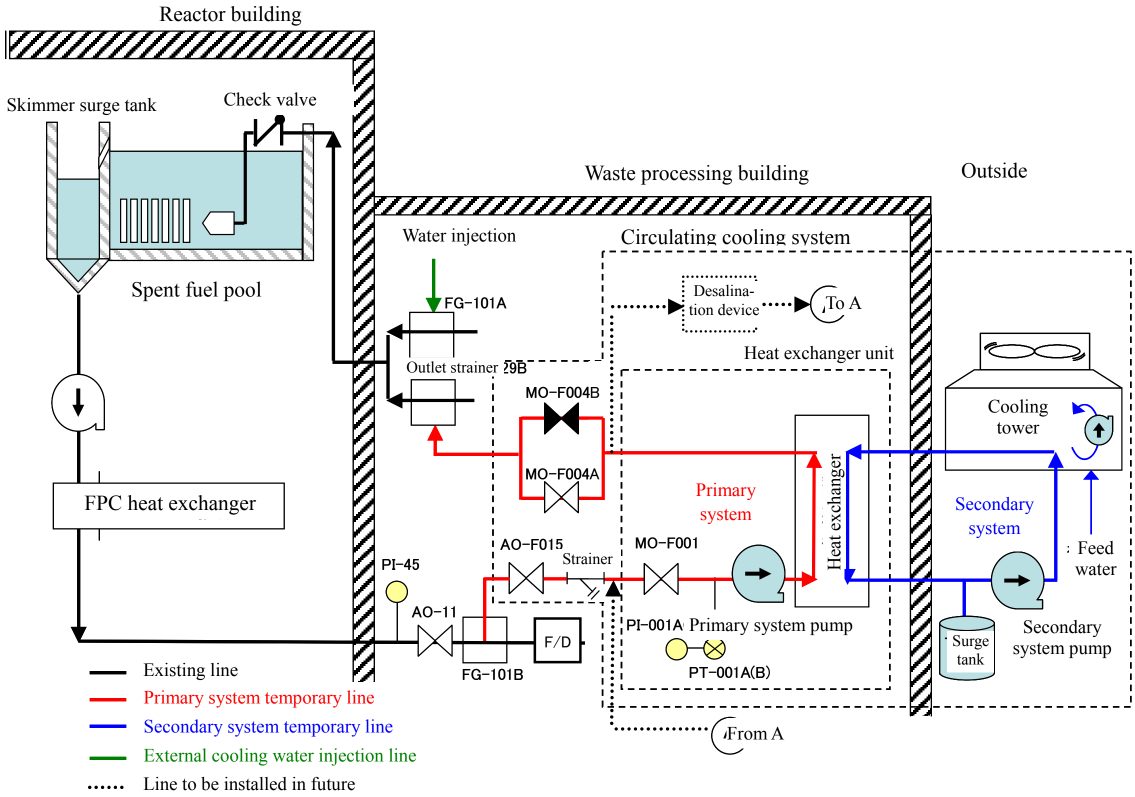


Figure 1 Alternate cooling system diagram

Chart 2 Unit 2 SFP cooling water injection record

As of 9:00 8/12

Cooling water injection volume total	(Maximum) Approx. 6,167.5(t)

Date/Time	Measure	Type	Cooling water injection volume (t)
3/17 9:48-10:01	Self-DefenseForce(SDF) helicopter	Seawater	30
3/17 19:05-19:13	Response unit high pressure water truck	Seawater	44
3/17 19:35- 19:45- 19:53- 20:00- 20:07-20:09	SDF high pressure water truck	Fresh water	30
3/18 Around 14:00-14:38	SDF high pressure water truck	Fresh water	40
3/18 14:42-14:45	US military high pressure water truck	Fresh water	2
3/19 0:30-1:10	Tokyo Fire Dept. squirt truck	Seawater	60
3/19 14:10 - 3/20 3:40	Tokyo Fire Dept. squirt truck	Seawater	2,430
3/20 around 21:36 -3/21 3:58	Tokyo Fire Dept. squirt truck	Seawater	1,137
3/22 15:10-15:59	Tokyo Fire Dept. squirt truck (Tokyo Fire Dept./Osaka City Fire Dept.)	Seawater	150
3/23 11:03-13:20	FPC	Seawater	35
3/24 Around 5:35-around 16:05	FPC	Seawater	120
3/25 13:28-16:00	Tokyo Fire Dept. squirt truck (Kawasaki City Fire Dept.)	Seawater	450
3/27 12:34-14:36	TEPCO concrete pump truck (52m class)	Seawater	100
3/29 14:17-18:18	TEPCO concrete pump truck (52m class)	Fresh water	100
3/31 16:30-19:33	TEPCO concrete pump truck (52m class)	Fresh water	105
4/2 9:52-12:54	TEPCO concrete pump truck (52m class)	Fresh water	75
4/4 17:03-19:19	TEPCO concrete pump truck (52m class)	Fresh water	70
4/7 6:53-8:53	TEPCO concrete pump truck (52m class)	Fresh water	70
4/8 17:06-20:00	TEPCO concrete pump truck (52m class)	Fresh water	75
4/10 17:15-19:15	TEPCO concrete pump truck (52m class)	Fresh water	80

4/12 16:26-17:16	TEPCO concrete pump truck (62m class)	Fresh water	35
4/14 15:56-16:32	TEPCO concrete pump truck (62m class)	Fresh water	25
4/18 14:17-15:02	TEPCO concrete pump truck (62m class)	Fresh water	30
4/22 14:19-15:40	TEPCO concrete pump truck (62m class)	Fresh water	50
4/26 12:00-12:02	TEPCO concrete pump truck (62m class)	Fresh water	Water level (confirmation)
4/26 12:25-14:02	FPC	Fresh water	47.5
5/8 11:38(water level gauge) 12:10-14:10 (cooling water injection) 14:10-14:50 (water level gauge, sampling)	FPC	Fresh water	(water level gauge, sampling) 60
5/9 12:14-15:00 (cooling water injection) (water gauge around time of cooling water injection)	FPC	Fresh water	(water level gauge) 80
5/16 15:00-18:32	FPC	Fresh water	106
5/24 10:15-13:35	FPC	Fresh water	100
5/28 13:28-15:08	FPC	Fresh water	50
6/1 14:34-15:54	FPC	Fresh water	40
6/5 13:08-15:14	FPC	Fresh water	60
6/9 13:42-15:31	FPC	Fresh water	55
6/13 10:09-11:48	FPC	Fresh water	42
6/17 10:19-11:57	FPC	Fresh water	49
6/26 9:56-11:23	FPC	Fresh water (including boric acid)	45
6/27 15:00-17:18	FPC	Fresh water (including boric acid)	60
6/29 14:45-15:53	FPC	Fresh water	30
6/30 9:45-10:43 (water filling and leakage check) 18:33 (operation check) 19:47 (alternate cooling system activated)	SFP circulation cooling device	Fresh water	-

2. Items verified through the investigation
   (1) Unit 3 SFP water sampling
   On May 8, 2011 a concrete pump truck was used to sample water from the Unit 3 SFP, and on July 7, 2003 and August 19, 2003 SFP water that had overflowed into the skimmer surge tank was sampled from FPC system sampling pipes. The sampled SFP water was analyzed for radioactive material nuclear species (analysis date: May 9, July 7, August 19). Chart 3 shows the analysis results.

Chart 3 Unit 3 SFP water analysis results

Detected nuclear species	Half-life	Concentration (Bq/cm^3)				
		Unit 3 SFP water				(Reference) Unit 3 turbine building basement puddles (4/22)
		Sampled 5/8	Sampled 7/7	Sampled 8/19	(Reference) sampled 3/2	
Cs-134	Approx. 2 years	140,000	94,000	74,000	Below detectable limits	1,500,000
Cs-136	Approx. 13 days	1,600	Below detectable limits	Below detectable limits	Below detectable limits	44,000
Cs-137	Approx. 30 years	150,000	110,000	87,000	Below detectable limits	1,600,000
I-131	Approx. 8 days	11,000	Below detectable limits	Below detectable limits	Below detectable limits	660,000

The following is an evaluation based on these analysis results.
- Unit 3 was stopped on June 19, 2010 for periodic inspection, and since even fuel removed from reactor with the shortest cooling period would take at least more than ten months to cool, it is unlikely that Cs-136 and I-131, which are nuclear species with a short half-lives, could have been discharged from the fuel stored in the SFP and it is more likely that it originated from the reactor.

-The results of the analysis of the water accumulated in the basement of the Unit 3 T/B taken with the fact that the ratio for each nuclear species is approximately the same indicates a high possibility that the reactor was the origin of the radioactivity.

- In regard to the discharge path of radioactivity originating from the reactor, it is highly possible that radioactive nuclides originating from the reactor adhered to condensed steam water, dust, and scattered debris within the reactor building and melted into SFP water.

-According to the analysis results of SFP waters sampled on May 8 and July 7, whereas there is an abundance of Cs-134 and 137 isotopes, the concentration differs by approximately 30%. However, it is not clear whether or not this concentration discrepancy in significant since sampling was only performed a few times and sampling methods differ.

(2) Unit 3 SFP water evaluation

Figure 2 shows the Unit 3 SFP evaluation results along with actual measurements.

Evaluation results assume that the water level decreased by approximately 2m by March 14 as a result of the explosions and sloshing caused by the earthquake, however water level recovered after March 17 as a result of concentrated water spraying, and water level has been maintained near full thereafter through periodic cooling water injections (cooling water could not be injected from the end of April until the beginning of May due to pump truck failure). Furthermore, since it is assumed that the actual amount of water initially sprayed on the SFP using a water truck, injected into the SFP using concrete pump trucks, and injected using FPC piping differ, yield rates have been set for each method.

Water level measurements made after the middle of April are based on video from a camera installed on the pump truck; however measurements closely match evaluation values. SFP water level repeatedly decreases due to evaporation and increases due to cooling water injections and it is assumed that water level is being maintained at near full.

Furthermore, since the amount of cooling water that had been injected by the time that the SFP was confirmed to be full on April 12 (approximately 35t) is smaller than the amount of cooling water predicted to be needed in consideration of replenishing water that was lost through leaks, etc.) for approximately 80t (results as of April 10), it is assumed that water level decreased only as a result of decay heat.

Furthermore, since it is estimated from cooling water injection results following confirmation that the SFP was full that the amount of steam generated daily was around approximately 10-20t, the amount of water lost through evaporation up until the time when the SFP was confirmed to be full is around 320-640t. Even if cooling water was not injected into the SFP until it was full, since the SFP holds approximately 1,400t of water and the depth of the SFP is approximately three times the active length of the fuel, water level was calculated to be more than half. Furthermore, even if it is assumed that water level was reduced by the building explosions and sloshing, it was still more than 2m above the level at which the fuel would have been exposed. Therefore, it is hypothesized that Unit 3 SFP water level was maintained and that the fuel was not exposed.

Only one water temperature measurement of 60°C was taken, however since this measurement was made using water sampled from the surface of the SFP it is assumed that this is lower than the average SFP water temperature. Water temperature used for evaluation purposes was set at 70°C from the SFP records for Unit 2 which has approximately the same decay heat.

After the Unit 3 reactor building explosion, much whiter vapor was seen emanating from the upper structure of the R/B as compared to other units. Since the amount of steam generated from the decay heat from fuel within the SFP is not larger than that of other units it is hypothesized that this vapor is not steam from the SFP but rather the result of steam produced by sprayed water that did not enter the Unit 3 SFP and found its way somehow to the PCV head side.

After the alternate cooling system was put in service at 19:47 on June 30, cooling of the SFP water continued and water temperature became approximately 30°C (30.8°C (heat exchanger inlet temperature) as of 11:00 on July 7).

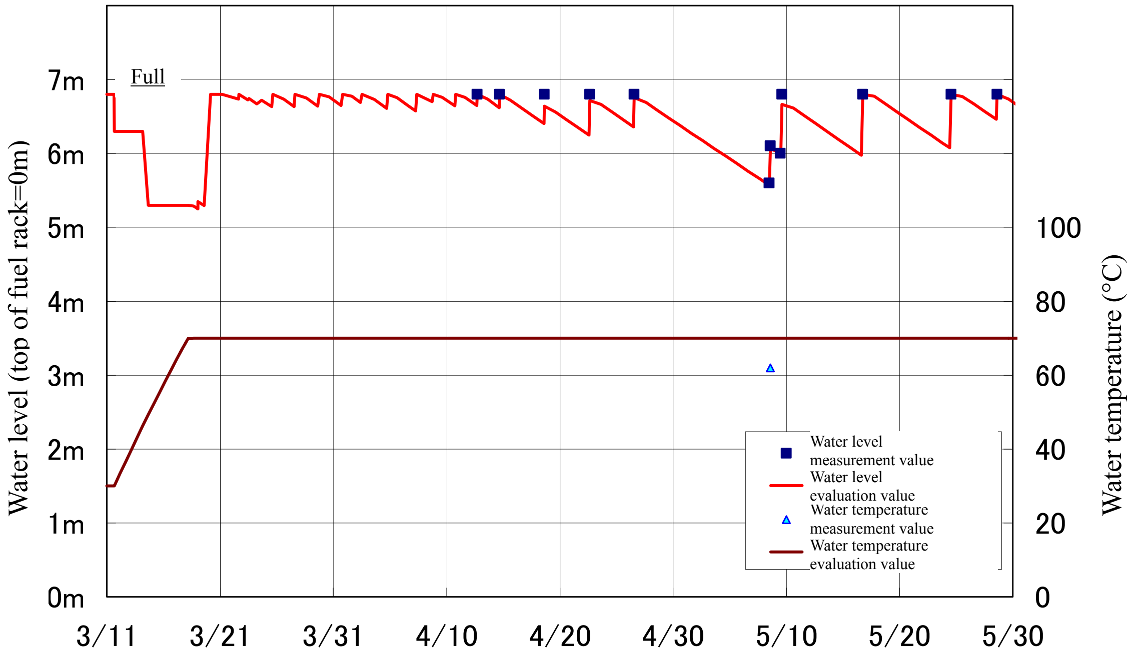


Figure 2 Unit 3 SFP evaluation results

(3) Conditions under SFP water

On May 8, sampling of the SFP water was recorded on video. An image that was taken is shown in Figure 3. The condition of the fuel stored in the SFP could not be confirmed due to the large amount of debris present in the water.

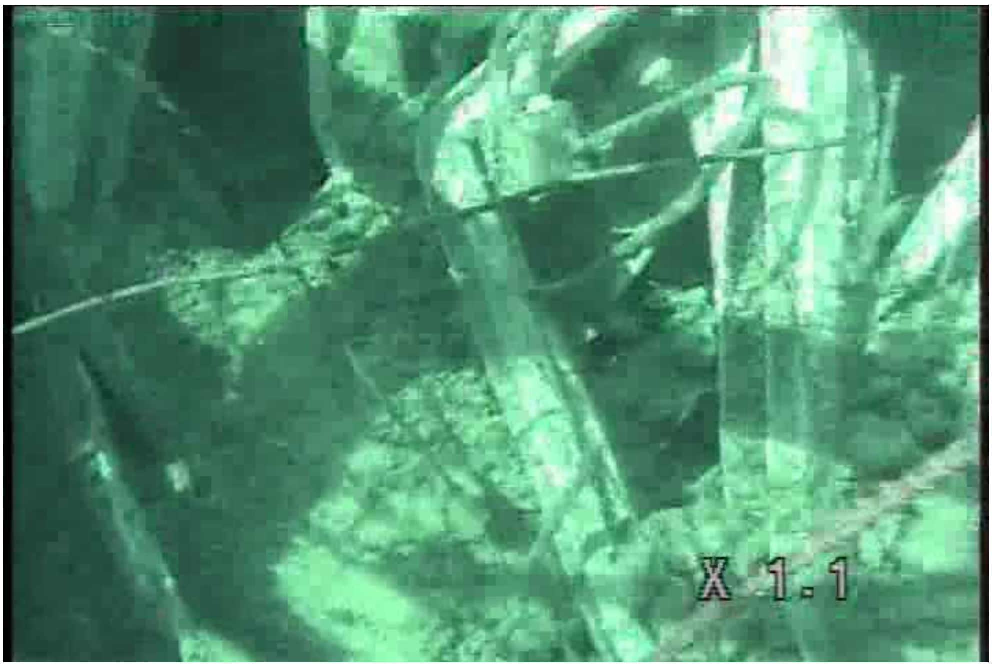


Figure 3 Conditions under the Unit 3 SFP water

(4) Methods of measuring SFP water level and water temperature

The temperature of the water was measured when sampling the Unit 3 SFP water. As shown in Figure 4, the water was measured by using a concrete pump truck to lower a thermocouple attached to a cable from the upper structure of the building until it reached the water. Since this temperature is the temperature of the surface of the SFP water it is highly likely that higher temperatures would be found at greater depths.

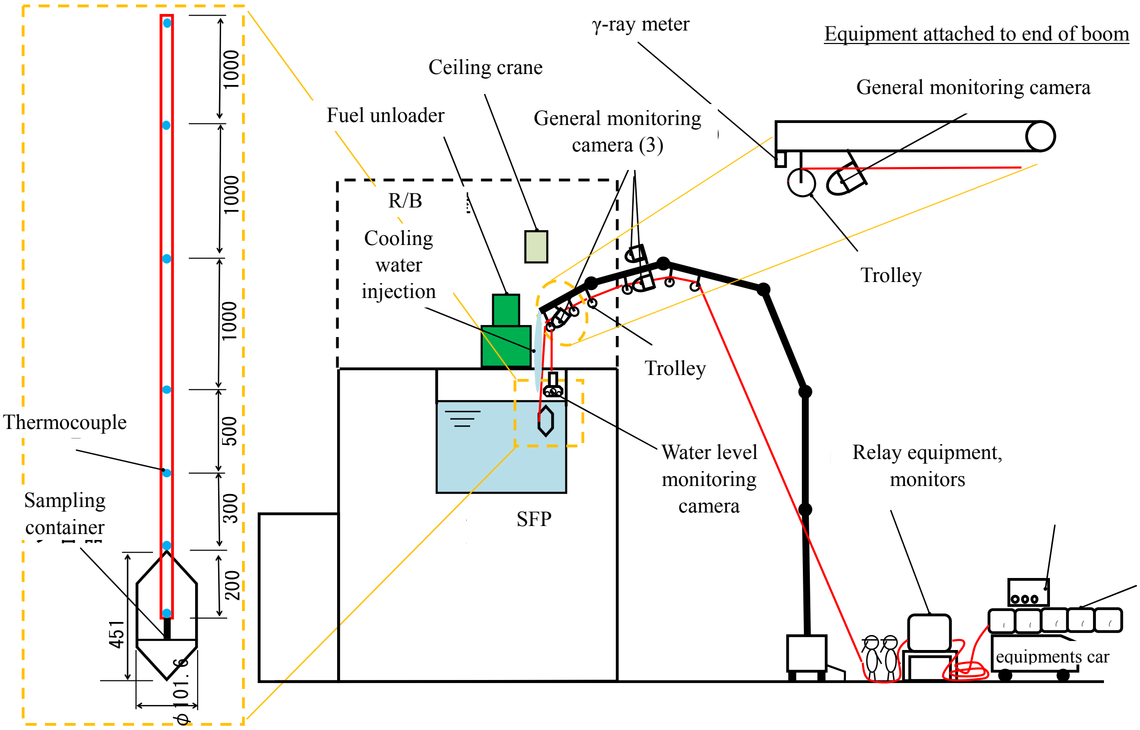


Figure 4 Method for measuring SFP water level and water temperature using a concrete pump truck

Results of Fukushima Daiichi Unit 4 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 1,331 assemblies of spent fuel and 204 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 4. Decay heat has been evaluated to be 2.26MW as of March 11, and 1.58MW as of June 11. Chart 1 shows the number of fuel assemblies that were stored in the Unit 4 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck all AC power sources were lost and functions for cooling and filling the SFP with water were lost. At a little past 6:00 on March 15, a hydrogen explosion for which the cause is unclear occurred damaging the upper structure of the operating floor.

On March 16, when checking radiation levels in preparation for spraying water on Unit 3 by helicopter, the helicopter came close to the operating floor of Unit 4. At this time the water level of the Unit 4 SFP was observed visually and it was confirmed that the fuel was not exposed.

On March 20, the Self-Defense Force (SDF) began spraying fresh water using a pump truck. From then until March 21st approximately 250t of water was sprayed from the ground.

On March 22, a concrete pump truck was used to spray seawater. From then until June 14 approximately 5,700t of water was sprayed.

On March 25, existing FPC piping was used to inject cooling water, however it has been deemed that very little cooling water was injected due to excessive piping resistance.

On March 25, water was sprayed using a concrete pump truck. Since skimmers surge tank levels rose it was assumed that the SFP had become full with water. Thereafter until April 12 skimmers surge tank levels were observed to rise multiple times by a couple of centimeters each time, which was an extremely small amount compared with the level increases of Unit 2 (several tens of centimeters) for which full tank capacity was able to be confirmed through skimmers surge tank levels at the time.

On April 12, a concrete pump truck was used to measure water levels and sample water from the SFP. At this time the measured water level was TAF+2.1m which made it apparent that increases in skimmers surge tank levels that have been observed up until that point were not the result of overflow from a full SFP. The most likely explanation for skimmer surge tank level increases is not cooling water injection into the SFP but rather water dripping onto the floor of the operating floor and flowing into the skimmer surge tank via drains thereby increasing water level.

On April 22, a concrete pump truck was used once again to confirm water levels. The water level had further decreased to TAF+1.7m most likely because only the minimum required spraying of water was implemented after the 12 and it is estimated that all water that was sprayed did not find its way into the SFP. Since SFP water level was within predicted ranges if the yield rate of sprayed water and evaporation from decay heat is considered, water levels were measured and water was sprayed using a concrete pump truck in order to completely full the SFP and on April 27, skimmer surge tank levels rose considerably (4,300→ 6,050mm) thereby confirming that the SFP was full. It has been suggested that the Unit 4 SFP was leaking, but the relationship between cooling water injection and water level thereafter is within the range of decrease caused by the amount of evaporation predicted from decay heat and it is estimated that there was no large leak of water from the SFP.

On April 27, water levels on the well site of the reactor were able to be measured for the first time since the accident. The water level was TAF+1.8m and it is difficult to imagine that a large amount of water was lost through evaporation since there are no heat sources and because the tank was full prior to the earthquake. Furthermore, it is estimated that water flowed via the pool gate into the SFP side in accordance with SFP water level decreases and assumed that the water levels of the SFP and the well are approximately the same (approx. TAF+1.8m).

On April 29, confirmation of a lack of a large amount of drain water in the SFP drain system within the building was proof that there was not a large leak of water from the SFP.

On April 28 and May 7, SFP water was sampled, water levels were measured, and video was taken. Video images confirm that scattered debris had fallen inside the SFP, that spent fuel was still stored within fuel racks, and that the pool gate was sound.

On May 21, when water was sprayed using a concrete pump truck hydrazine was added to prevent corrosion.

On June 16, cooling water injection using existing SFP cooling equipment was implemented. Thereafter until July 31, 280t of cooling water was injected using existing SFP cooling water injection equipment.

On June 19, cooling water was injected through CRD pipes to the reactor well and device storage pit (DS pit) in an attempt to suppress radiation levels of core internals stored in the DS pit.

Measures for cooling water injection have been secured for the Unit 4 SFP as well as the reactor well and DS pit, skimmer surge tank levels indicate that the SFP is full and water level is being maintained in a stable manner. Chart 2 shows the cooling water injection results for the Unit 4 SFP.

At 12:44 on July 31, cooling of the SFP water using the alternate cooling system (refer to Figure 1) began. The water temperature when cooling commenced was approximately 75°C and reached equilibrium on around August 3 with water temperature stabilizing at approximately 40°C.

Chart 1 Number of fuel assemblies stored in the Unit 4 SFP

7x7RD	1
8x8	4
8x8BJ	30
STEP2	560
STEP3-B	736
Total spent fuel	1,331
New fuel (STEP3-B)	204
Total fuel	1,535

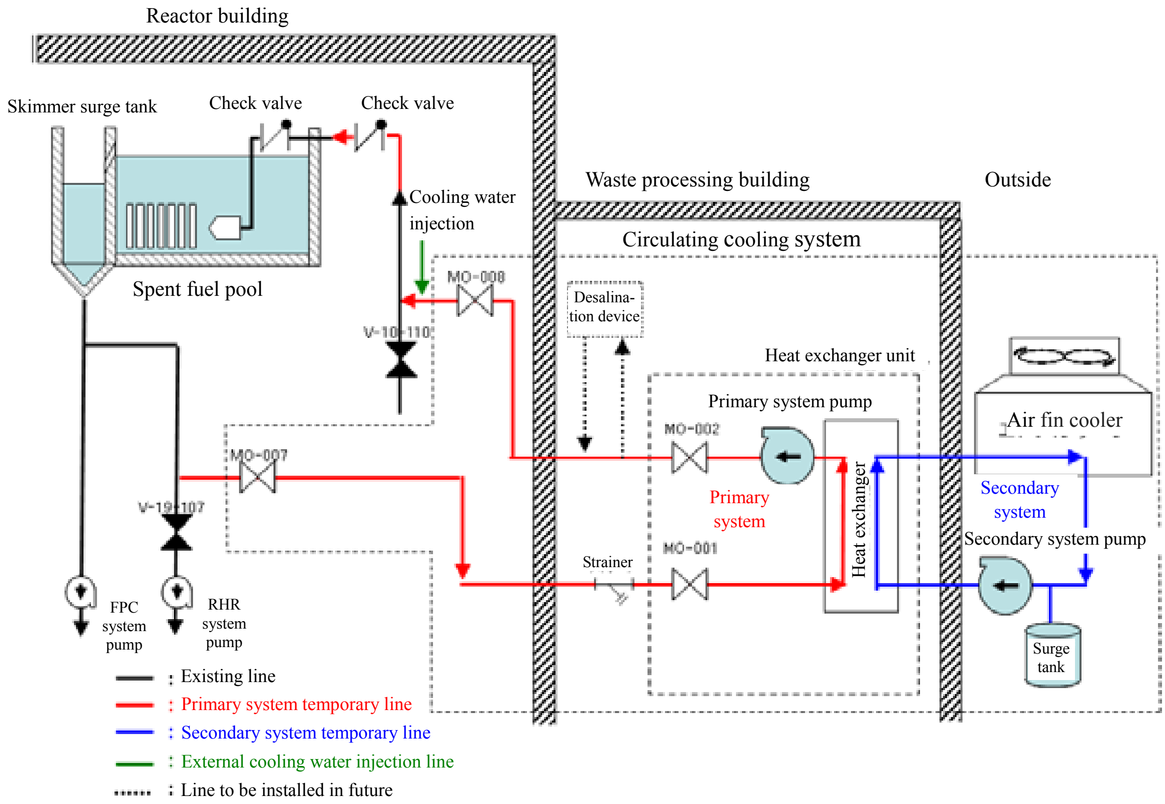


Figure 1 Alternate cooling system diagram

Chart 2 Unit 4 SFP cooling water injection record

As of 9:00 8/12

		Cooling water injection volume total	(Maximum) Approx. 6,242(t)
Date/Time	Measure	Type	Cooling water injection volume (t)
3/20 8:21-9:40	SDF high pressure water truck	Fresh water	80
3/20 Around 18:30-19:46	SDF high pressure water truck	Fresh water	80
3/21 6:37-8:41	SDF high pressure water truck	Fresh water	90
3/21 8:38-8:41	US military high pressure water truck	Fresh water	2.2
3/22 17:17-20:32	TEPCO concrete pump truck (58m class)	Seawater	150
3/23 10:00-13:02	TEPCO concrete pump truck (58m class)	Seawater	125
3/24 14:36-17:30	TEPCO concrete pump truck (58m class)	Seawater	150
3/25 6:05-10:20	FPC	Seawater	21
3/25 19:05-22:07	TEPCO concrete pump truck (58m class)	Seawater	150
3/27 16:55-19:25	TEPCO concrete pump truck (58m class)	Seawater	125
3/30 14:04-18:33	TEPCO concrete pump truck (58m class)	Fresh water	140
4/1 8:28-14:14	TEPCO concrete pump truck (58m class)	Fresh water	180
4/3 17:14-22:16	TEPCO concrete pump truck (58m class)	Fresh water	180
4/5 17:35-18:22	TEPCO concrete pump truck (62m class)	Fresh water	20
4/7 18:23-19:40	TEPCO concrete pump truck (62m class)	Fresh water	38
4/9 17:07-19:24	TEPCO concrete pump truck (62m class)	Fresh water	90
4/13 0:30-6:57	TEPCO concrete pump truck (62m class)	Fresh water	195
4/15 14:30-18:29	TEPCO concrete pump truck (62m class)	Fresh water	140
4/17 17:39-21:22	TEPCO concrete pump truck (62m class)	Fresh water	140
4/19 10:17-11:35	TEPCO concrete pump truck (62m class)	Fresh water	40
4/20 17:08-20:31	TEPCO concrete pump truck (62m class)	Fresh water	100
4/21 17:14-21:20	TEPCO concrete pump truck (62m class)	Fresh water	140

4/22 17:52-23:53	TEPCO concrete pump truck (62m class)	Fresh water	200
4/23 12:30-16:44	TEPCO concrete pump truck (62m class)	Fresh water	140
4/24 12:25-17:07	TEPCO concrete pump truck (62m class)	Fresh water	165
4/25 18:15 ～4/26 0:26	TEPCO concrete pump truck (62m class)	Fresh water	210
4/26 16:50-20:35	TEPCO concrete pump truck (62m class)	Fresh water	130
4/27 12:18-15:15	TEPCO concrete pump truck (62m class)	Fresh water	85
4/28 11:43-11:54	TEPCO concrete pump truck (62m class)	Fresh water	(water level measurement)
4/28 11:55-12:07	TEPCO concrete pump truck (62m class)	Fresh water	(sampling)
4/29 10:29 (water level measurement) 10:35 (temperature measurement)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
4/30 10:14-10:28 (water level and temperature measurements)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
5/1 10:32-10:38(water level and temperature measurements)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
5/2 10:10-10:20(water level and temperature measurements)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
5/3 10:15-10:23(water level and temperature measurements)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
5/4 10:25-10:35 (water level and temperature measurements)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements)
5/5 11:55-12:05 (water level and temperature measurements) 12:19-20:46 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements) 270
5/6 12:16 (water level and temperature measurements) 12:38-17:51 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	(water level and temperature measurements) 180
5/7 11:00 (water level measurement, underwater video, sampling) 14:05-17:30 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	(water level measurement, underwater video, sampling) 120
5/9 16:05-19:05 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	100
5/11 16:07-19:38 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	120

5/13 16:04-19:04 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	100
5/15 16:25-20:25 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	140
5/17 16:14-20:06 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	120
5/19 16:30-19:30 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	100
5/21 16:00-19:56 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	130
5/23 16:00-19:09 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	100
5/25 16:36-20:04 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	121
5/27 17:05-20:00 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	100
5／28 17:56-19:45 (water sprayed)	TEPCO concrete pump truck (62m class)	Fresh water	60
6/3 14:35-21:15 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	210
6/4 14:23-19:45 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	180
6/6 15:56-18:35 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	90
6/8 16:12-19:41 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	120
6/13 16:36-21:00 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	150
6/14 16:10-20:52 (water sprayed)	TEPCO concrete pump truck (58m class)	Fresh water	150
6/16 13:14-15:44 (water sprayed)	Temporary water spraying equipment	Fresh water	75
6/18 16:05-19:23 (water sprayed)	Temporary water spraying equipment	Fresh water	99
6/22 14:31-16:38 (water sprayed)	Temporary water spraying equipment	Fresh water	56
6/29 11:47-12:01(water sprayed)	Temporary water spraying equipment	Fresh water	7 (leak check)
6/30 11:30-11:55 (water sprayed)	Temporary water spraying equipment	Fresh water	13
7/31 8:47-9:38 (water sprayed)	Temporary water spraying equipment	Fresh water	25
7/31 10:08 (alternate cooling system activated)	SFP circulation cooling device	Fresh water	—

2. Items verified through the investigation

(1) Unit 4 SFP water sampling

Unit 4 SFP water was sampled using a concrete pump truck on April 12th, April 28 and May 7, 2011. Furthermore, SFP water that had overflowed into the skimmer surge tank was sampled from FPC piping on August 20, 2011. The sampled SFP water was analyzed for radioactive material nuclear species (analysis date: April 13, April 29, May 8, August 20). Chart 3 shows the analysis results.

Chart 3 Unit 4 SFP water analysis results

Nuclear species	Half-life	Concentration (Bq/cm^3)					
		Unit 4 SFP water					(Reference) Unit 3 turbine building basement puddles (3/24)
		Sampled 4/12	Sampled 4/28	Sampled 5/7	Sampled 8/20	(reference) sampled 3/4	
Cs-134	Approx. 2 years	88	49	56	44	Below detectable limits	31
Cs-137	Approx. 30 years	93	55	67	61	0.13	32
I-131	Approx. 8 days	220	27	16	Below detectabl e limits	Below detectable limits	360

The following is an evaluation based on these analysis results.

-All three samples indicate higher concentrations of radioactive materials than those taken prior to the accident (March 4), but the absolute value is not large. Therefore, it is estimated that most of the fuel inside the SFP is intact and that a systematic extensive amount of damage has not occurred.

However, since the Unit 4 R/B was damaged the possibility that some fuel was damaged by debris falling into the SFP cannot be denied.

- Unit 4 was stopped on November 30, 2010 for periodic inspection, and since even fuel removed from reactor with the shortest cooling period would take at least more than four months to cool, it is unlikely that I-131 (half-life: 8 days) could have been discharged from the fuel stored in the SFP and it is more likely that it originated from the Unit 1-3 reactors.

- In regard to the discharge path of radioactivity originating from the reactor, it is highly possible that radioactive materials discharged during PCV venting and radioactivity contained in seawater sprayed on the unit had an impact.

-Evaluation values that take into consideration nuclear species decay and changes in water volume are approximately the same as measurements, as shown in Chart 4, so the relationship between the three measurement results is adequate.

Chart 4 Unit 4 SFP water analysis results

	Sampled 4/28		Sampled 5/7	
	Evaluation value*	Measurement value	Evaluation value*	Measurement value
Cs-134	54	49	56	56
Cs-137	58	55	61	67
I-131	35	27	17	16

*: Evaluation value refers to values that consider dilution due to differences in decay and SFP volume based on sampling data from April 12.

(2) Unit 4 SFP water level evaluation

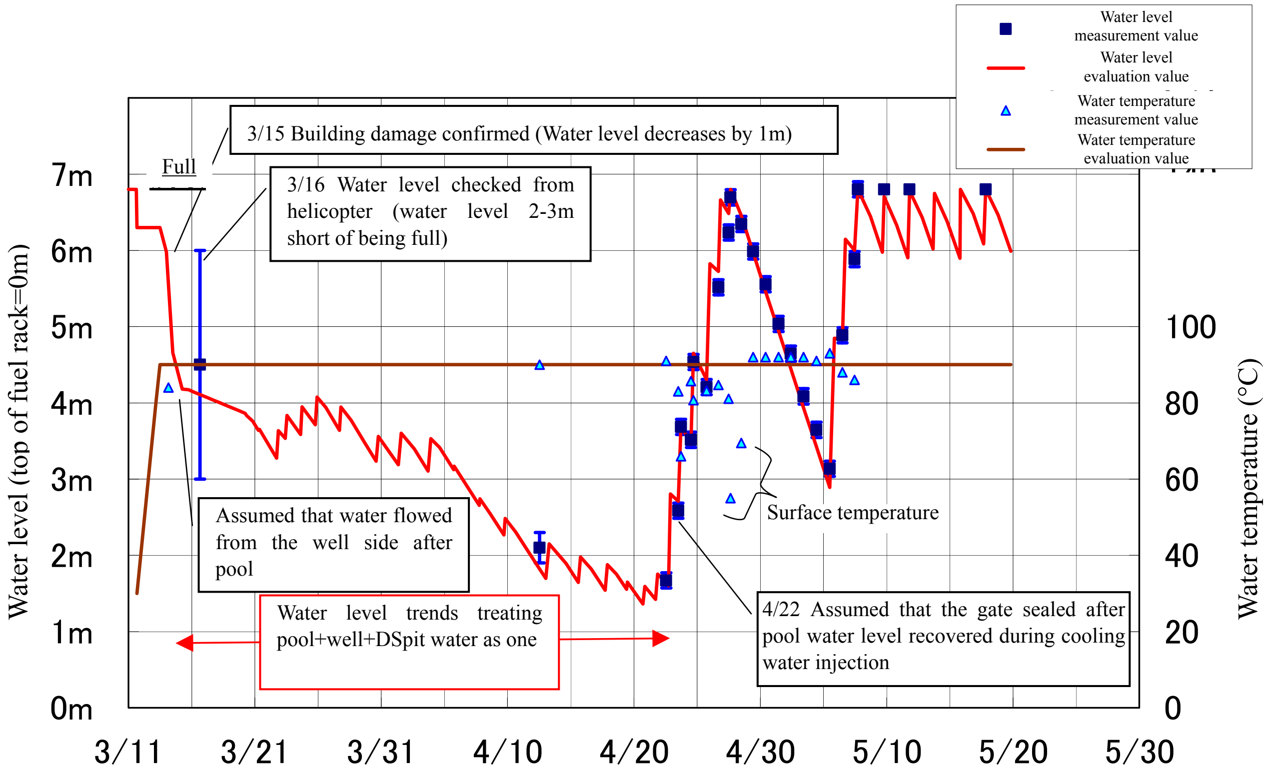
Figure 2 shows the Unit 4 SFP evaluation results along with actual measurements.

Evaluation results assume that the water level decreased as a result of the explosions and sloshing caused by the earthquake, and decreased thereafter due to evaporation. Attempts were made to restore water level through cooing water injection after March 20 however around April 20 the speed of evaporation exceeded the amount of cooling water being injected and the water level fell to +1.5m above the fuel racks. After the pool was complete filled with water through concentrated efforts to inject cooling water between April 22 and April 27 cooling water injection was suspended until May 5 when water level started to decrease again. Thereafter the pool was once again filled to capacity through concentrated cooling water injection. This process of water level decrease followed by cooling water injection has been repeated ever since to maintain water level at near full capacity. Furthermore, since it is assumed that the actual amounts of water initially sprayed on the SFP using a water truck, injected into the SFP using concrete pump trucks, and injected using FPC piping differ, yield rates have been set for each method.

Water level measurements taken frequently since the middle of April by

lowering a thermocouple from a concrete pump truck, closely match evaluation values.
In the water level evaluation, prior to April 22 when the overall SFP water level shows decreasing tendencies the water in the SFP and that in the reactor well are taken as one, while thereafter following the implementation of concentrated cooling water injection the SFP water is independent of the reactor well. It was estimated at the beginning of May that the reactor well water level was stable at approximately 2m above the top of the fuel racks, which closely matches evaluation values.

As with Unit 2, the Unit 4 SFP was confirmed to be full by checking fluctuations in the water gauge of the skimmer surge tank following cooling water injection. However, examination of water level measurement records has revealed that the SFP was mistaken for being full from the mid-March through mid-April. This mistake was made because during cooling water injection some of the cooling water found its way to the skimmer surge tank side and as a result caused fluctuations in the water gauge even though the SFP was not completely filled with water thereby causing personnel to mistakenly think that the SFP was full of water. Compared with the large fluctuations that became apparent after the end of April these initial level fluctuations were sluggish and small. This is why water level continues to decrease and does not recover from the middle of March through the middle of April even though cooling water was being injected.
Water temperature was measured by lowering a thermocouple from a concrete pump truck at which time water level was also measured. Many of the measurement results were around 90°C, which is high compared to the measurement result of 70°C for Unit 2, however this is because the decay heat of the fuel in the Unit 4 SFP is high which causes the quasi-stationary temperature to be on the high side. There are a few measurements in Figure 2 that are below 70°C but this is assumed to be because water was sampled from the surface of the SFP.



*Water level evaluation considers that water flowed from the well/DSPit side to the pool side since the reactor well side was completely full of water at the time the earthquake occurred.

Figure 2　Unit 4 SFP evaluation results

Since actual water level measurements almost match evaluation values is assumed that there are no leaks that will affect maintaining SFP water level.

Water level measurements taken using a concrete pump truck thereafter closely match evaluation values and on April 28, 2003 an underwater camera was used to confirm that the majority of the fuel and fuel racks in the SFP are sound.

These facts have led the to the conclusion that from the time the earthquake occurred until the present there has been no damage that will affect maintaining SFP water level, water level is being maintained through cooling water injection and that the fuel was not exposed.

(3) Pool gate structure

As shown in Figure 3, the pool gate is constructed to seal off the junction between the SFP and the reactor well from the SFP side and watertightness is maintained by the water pressure of the SFP. During operation a great amount of water pressure acts on the pool gate since there is no water in the reactor well. However, Unit 4 was undergoing periodic inspection so water was stored in the reactor well side which means that after FPC cooling function was lost the water on the SFP side began to evaporate thereby causing the water level on the reactor well side to be higher than the water level on the SFP side. As shown in Figure 4 and Figure 5, in this case water pressure was acting on the pool gate from the opposite side than normal which caused the pool gate to fail to remain watertight due to its construction and for water to flow from the reactor well side until water levels on both sides were equal. The water level behavior evaluation shown in (2) indicates a gradual decrease in SFP water level because it assumes the effect of this migrating water. However, SFP water level recovered after the cooling water injection of April 22, and it is estimated that as a result reactor well side water level fell below the water level on the SFP side thereby enabling the pool gate to regain watertightness. The results of an evaluation performed based on this hypothesis closely match measurement results.

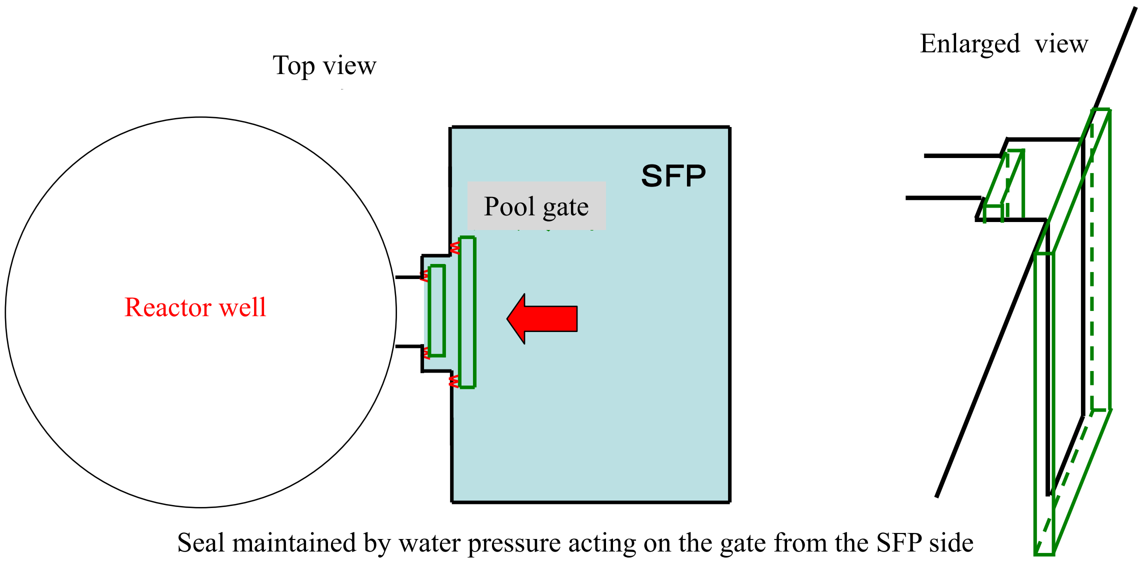


Figure 3　Pool gate structure

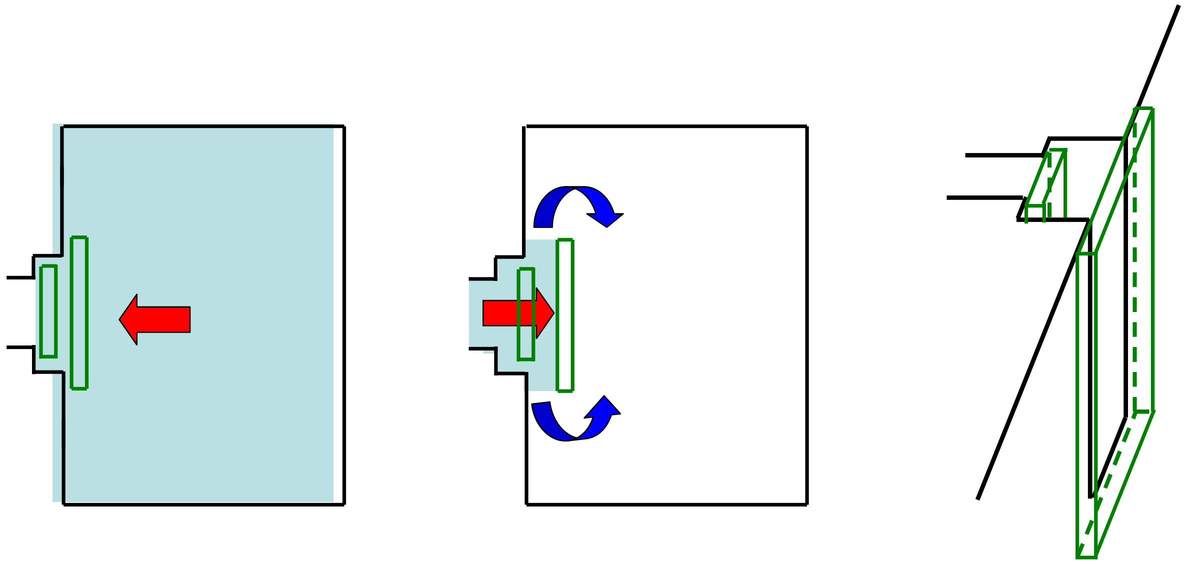


Figure 4　Mechanism of water flowing from the pool gate (1)

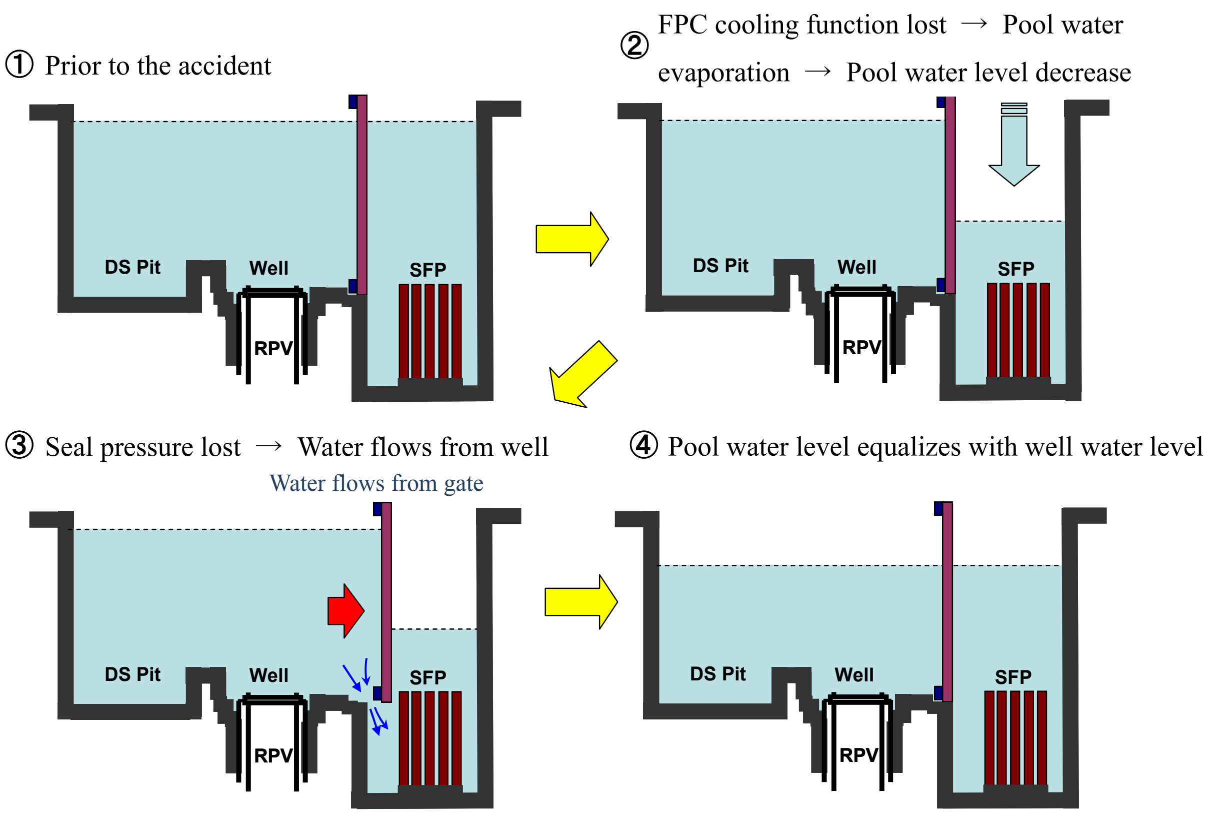


Figure 5 Mechanism of water flowing from the pool gate (2)

(4) Conditions under SFP water

On May 7 sampling of the SFP water was recorded on video. Images that were taken are shown in Figure 6, Figure 7, Figure 8 and Figure 9. Large and small sized debris have fallen into the SFP, but the fuel stored in the SFP is still in the racks and it was confirmed that there is not a lot of fuel damage.

Figure 6 Conditions within Unit 4 SFP (1)

Figure 7 Conditions within Unit 4 SFP (2)

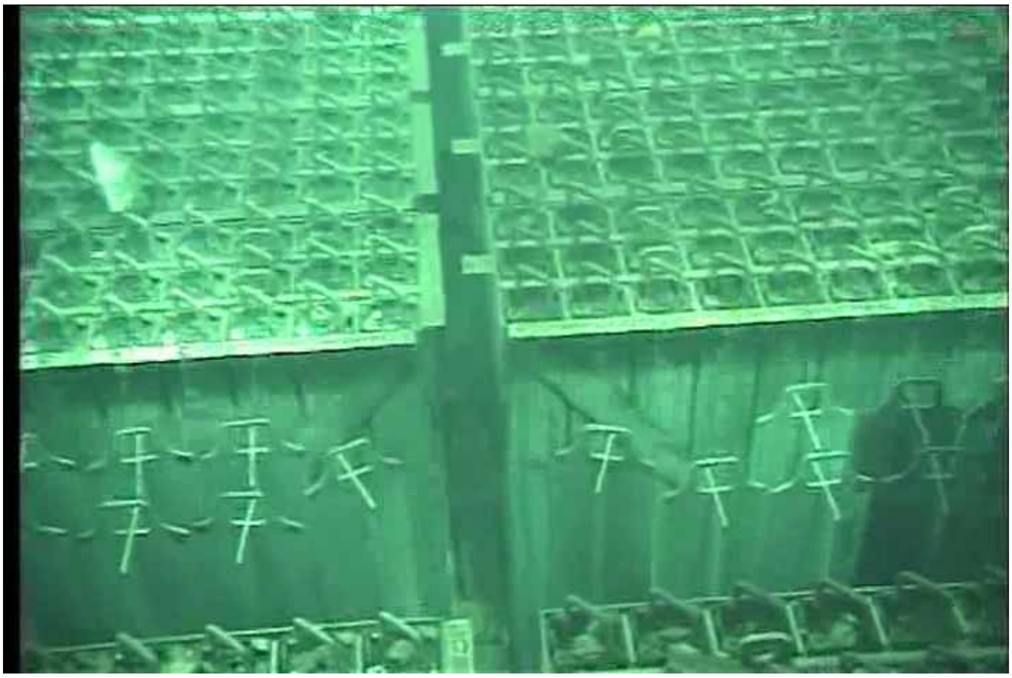


Figure 8 Conditions within Unit 4 SFP (3)

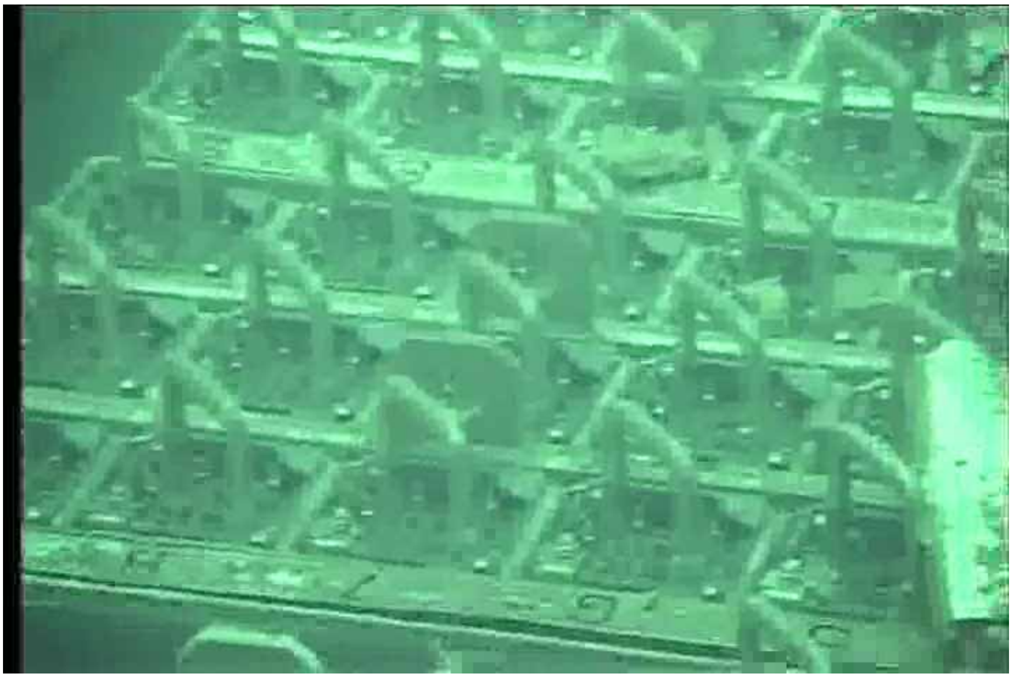


Figure 9 Conditions within Unit 4 SFP (4)

(5) Methods of measuring SFP water level and water temperature

The temperature of the water was measured when sampling the Unit 4

SFP water. As shown in Figure 10, the water was measured by marking the water level over fixed intervals and by using a concrete pump truck to lower a thermocouple attached to a cable from the upper structure of the building. Water level was marked by measuring the length of the cable between a reference point, such as the fuel charger railing, etc., and the surface of the water. The cable was deemed to have reached the surface of the water when the thermocouple indicated a temperature change at which time the length of the lowered cable was measured. It is for this reason that measurement results are assumed to contain an approximate 10cm degree of error. The temperature changes recorded during water level measurement are the temperatures for the surface of the SFB water. Therefore, in some cases the thermocouple was lowered further into the water and the water temperature was measured at a depth which is deemed to indicate the average temperature of the SFP water.

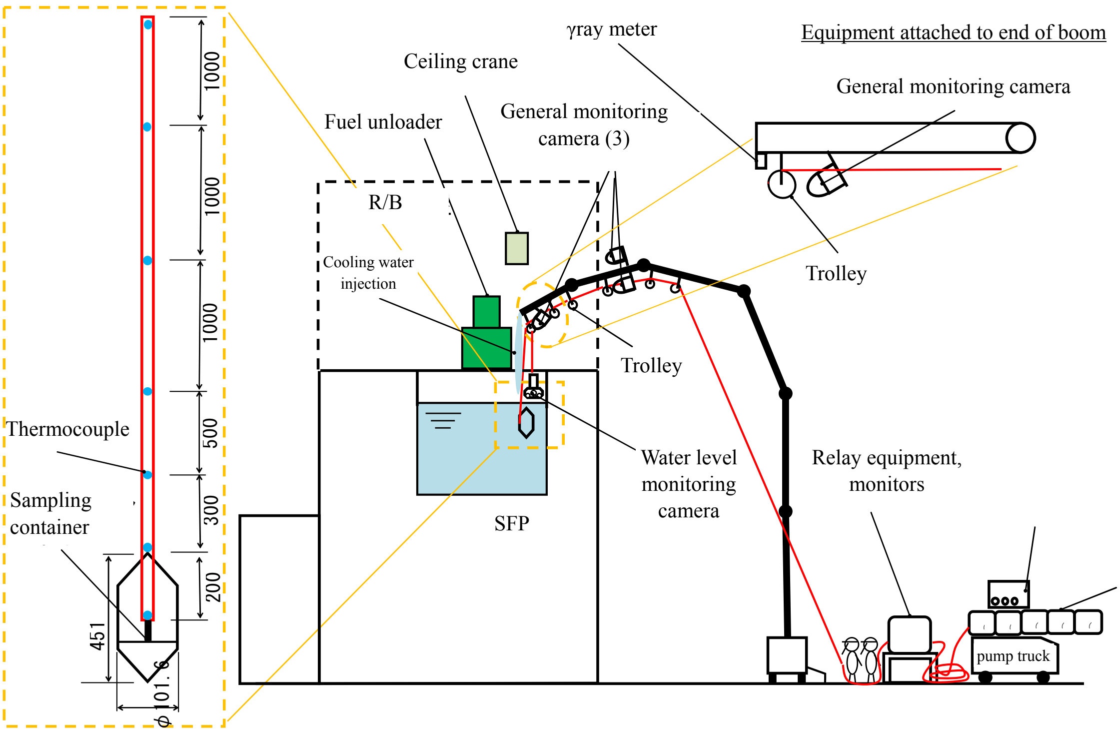


Figure 10 Method for measuring SFP water level and water temperature using a concrete pump truck

Results of Fukushima Daiichi Unit 5 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 946 assemblies of spent fuel and 48 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 5. Decay heat has been evaluated to be 1.01MW as of March 11, and 0.76MW as of June 11. Chart 1 shows the number of fuel assemblies that were stored in the Unit 5 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck, all AC power sources were lost and SW pump function was lost, thereby causing a loss of SFP cooling and filling function.

SFP water temperature continued to rise and at 5:00 on March 19th the RHR pump was manually started and SFP cooling commenced in emergency heat load mode, thereby stopping the rise in water temperature at a maximum of 68.8°C. After cooling commenced it was possible to maintain cooling in a stable manner. Since the RHR is also used to cool fuel in the reactor the system was switched back and forth between the two. When it was switched SFP water temperature rose and remained between approximately 30 to 50°C.

Furthermore, it became possible to maintain cooling in an even more stable manner after June 25 when cooling using the FPC became possible, and SFP water temperature stabilized at around 30°C.

Chart 1 Number of fuel assemblies stored in the Unit 5 SFP

8x8	27
STEP2	487
STEP3-B	432
Total spent fuel	946
New fuel (STEP3-B)	48
Total fuel	994

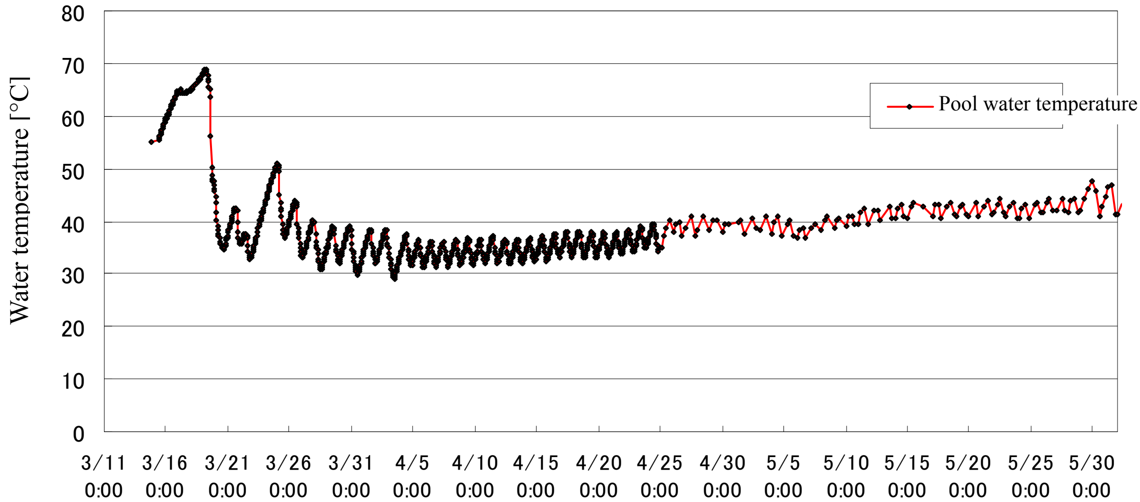


Figure 1 Unit 5 SFP water temperature trend

Results of Fukushima Daiichi Unit 6 Spent Fuel Pool (SFP) Status Investigation

1. SFP Status

As of March 11, 2011, 876 assemblies of spent fuel and 64 assemblies of new fuel were stored in the SFP of the Fukushima Daiichi Nuclear Power Station Unit 6. Decay heat has been evaluated to be 0.87MW as of March 11, and 0.73MW as of June 11. Chart 1 shows the number of fuel assemblies that were stored in the Unit 6 SFP.

When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck, all AC power sources were lost and SW pump function was lost (however, D/G 6B function was maintained), thereby causing a loss of SFP cooling function.

SFP water temperature continued to rise and at 22:14 on March 19 the RHR pump was manually started and SFP cooling commenced in emergency heat load mode thereby stopping the rise in water temperature at a maximum of 67.5°C. After cooling commenced it was possible to maintain cooling in a stable manner. Since the RHR is also used to cool fuel in the reactor, the system was switched back and forth between the two. When it was switched SFP water temperature rose and remained between approximately 20 to 40°C.

Thereafter increases in air temperature, etc. caused SFP water temperature to stabilize at between 30 to 50°C.

Chart 1 Number of fuel assemblies stored in the Unit 6 SFP

8x8	144
STEP2	316
STEP3-B	416
Total spent fuel	876
New fuel (STEP3-B)	64
Total fuel	940

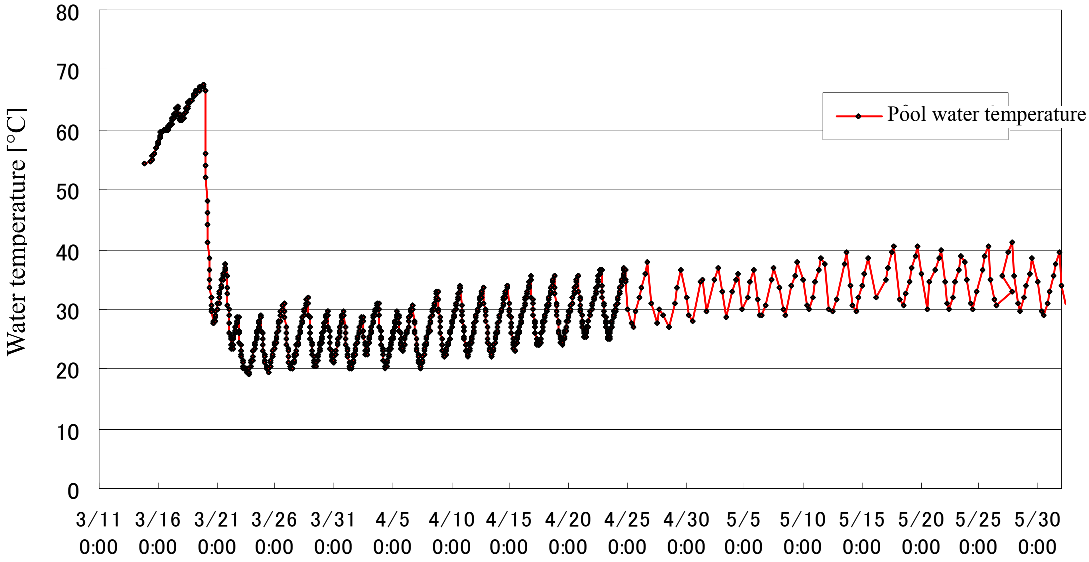


Figure 1 Unit 6 SFP water temperature trend

Results of Fukushima Daiichi Common Pool Status Investigation

1. Common Pool Status

   As of March 11, 2011, 6,375 assemblies of spent fuel were stored in the Fukushima Daiichi Nuclear Power Station common pool. Decay heat has been evaluated to be 1.13MW as of March 11, and 1.12MW as of June 11. Chart 1 shows the number of fuel assemblies that are stored in the common pool.

   When the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 struck, all AC power sources were lost thereby causing a loss of common pool cooling and filling function.

   On March 18 the common pool was inspected and water level was confirmed to be maintained.

   Thereafter common pool water temperature continued to rise. In conjunction with the restoration of off-site power, power was supplied to the common pool via temporary power facilities and at 18:00 on March 24 temporary cooling equipment was put in service so the rise in water temperature reached a maximum of 73°C and it became possible to maintain cooling in a stable manner. (Refer to Figure 1)

   Thereafter water temperature stabilized at between 30 to 40°C.

Chart 1 Number of fuel assemblies stored in the common pool

8x8	5,153
STEP2	1,222
Spent fuel total	6,375

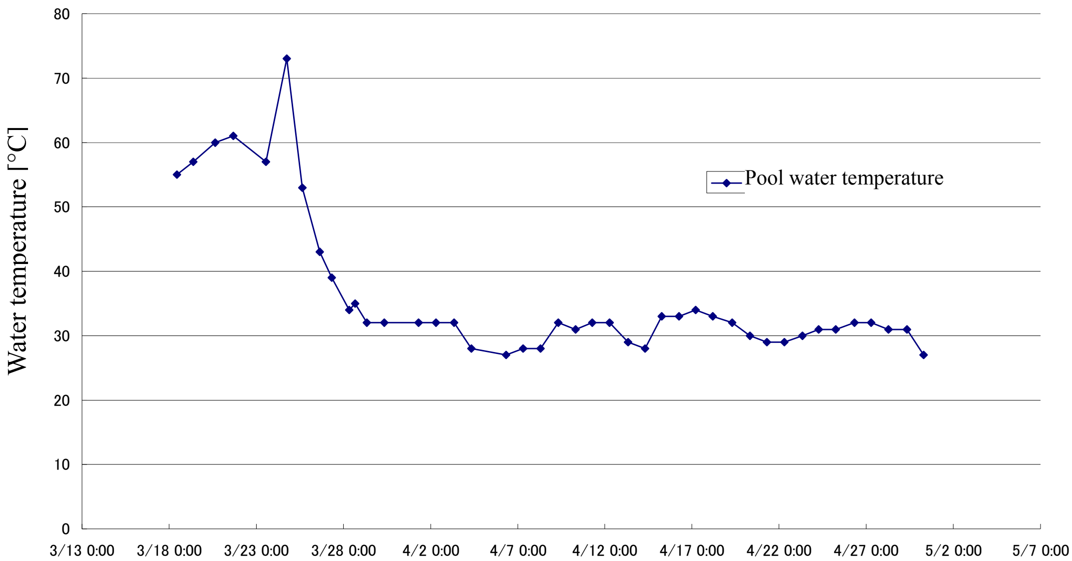


Figure 1 Common pool water temperature trend

2. Items verified through the investigation

(1) Common pool water sampling

On May 13, 2011 common pool water was sampled by scooping it up from the operating floor using a ladle. The sampled common pool water was analyzed for radioactive material nuclear species (analysis date: May 14). Chart 2 shows the analysis results.

Chart 2 Common pool water analysis results

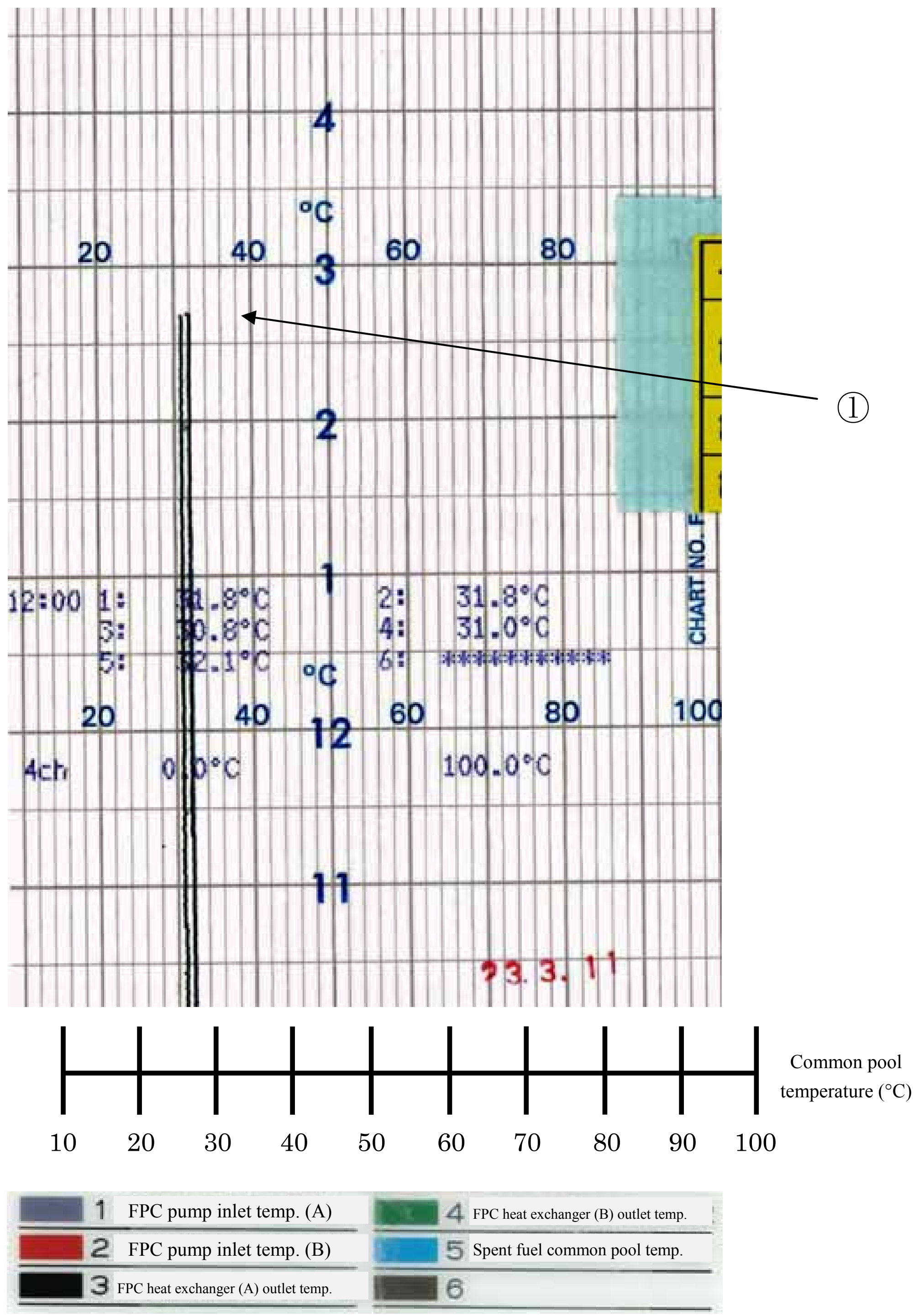
Nuclear species	Half-life	Concentration (Bq/cm^3) Common pool water Sampled 5/13	Concentration (Bq/cm^3) Common pool water (reference) sampled 2/10
Cs-134	Approx. 2 years	0.17	Below detectable limits
Cs-137	Approx. 30 years	1.2	Below detectable limits
I-131	Approx. 8 days	Below detectable limits	Below detectable limits

The following is an evaluation based on these analysis results.

・The absolute value of the radioactivity detected from the common pool water sampled on May 13 is low and common pool water level has been maintained since the accident, so it is estimated that the possibility of damage to fuel assemblies in the common pool is low.

Common pool data chart

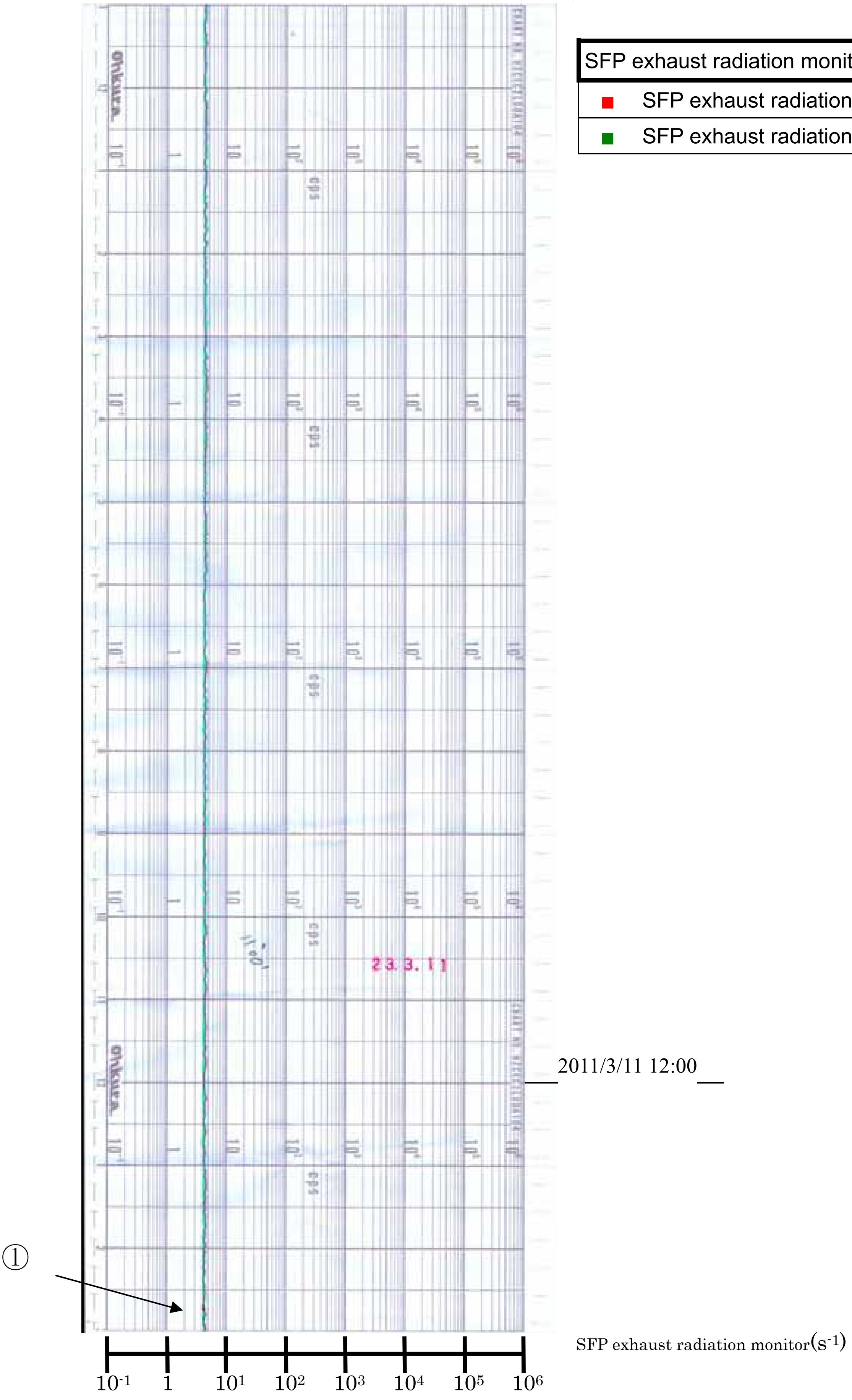
[Common pool temperature]



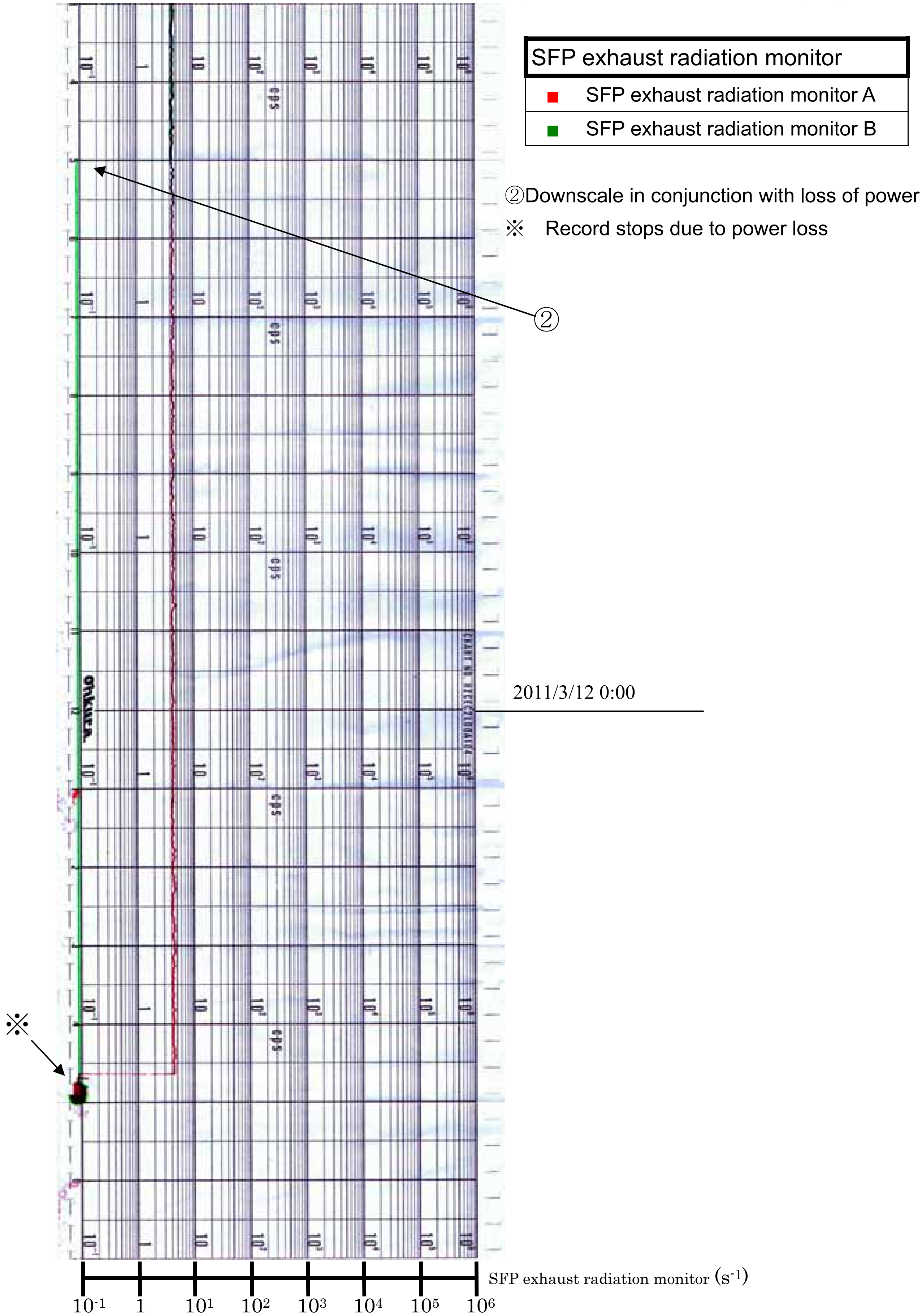
① 14:46 Earthquake occurs
(Record stops due to power loss)

【Common pool　Spent fuel pool (SFP) exhaust radiation monitor (1/2)】

SFP exhaust radiation monitor
■ SFP exhaust radiation monitor A
■ SFP exhaust radiation monitor B

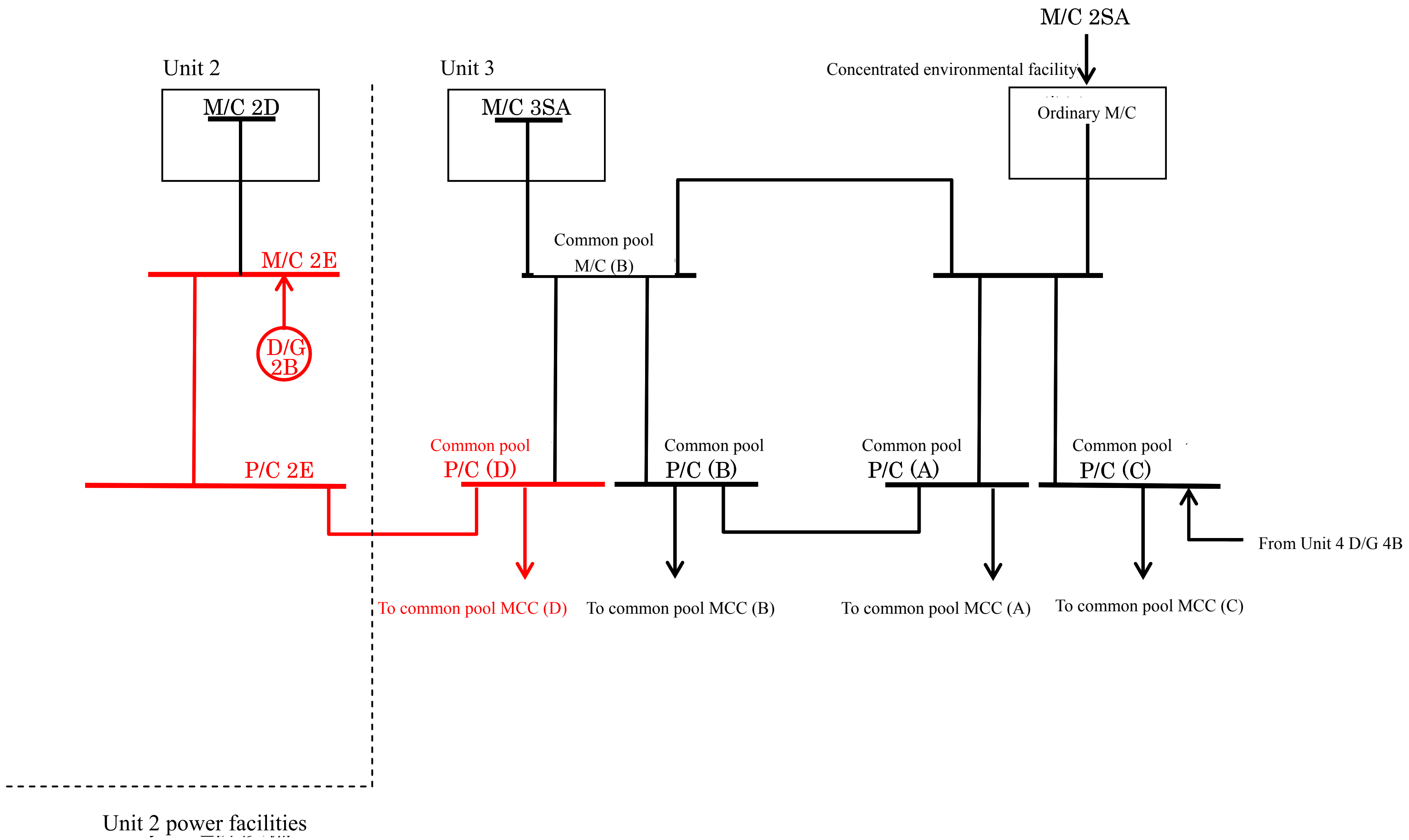


【Common pool　Spent fuel pool (SFP) exhaust radiation monitor (2/2)】

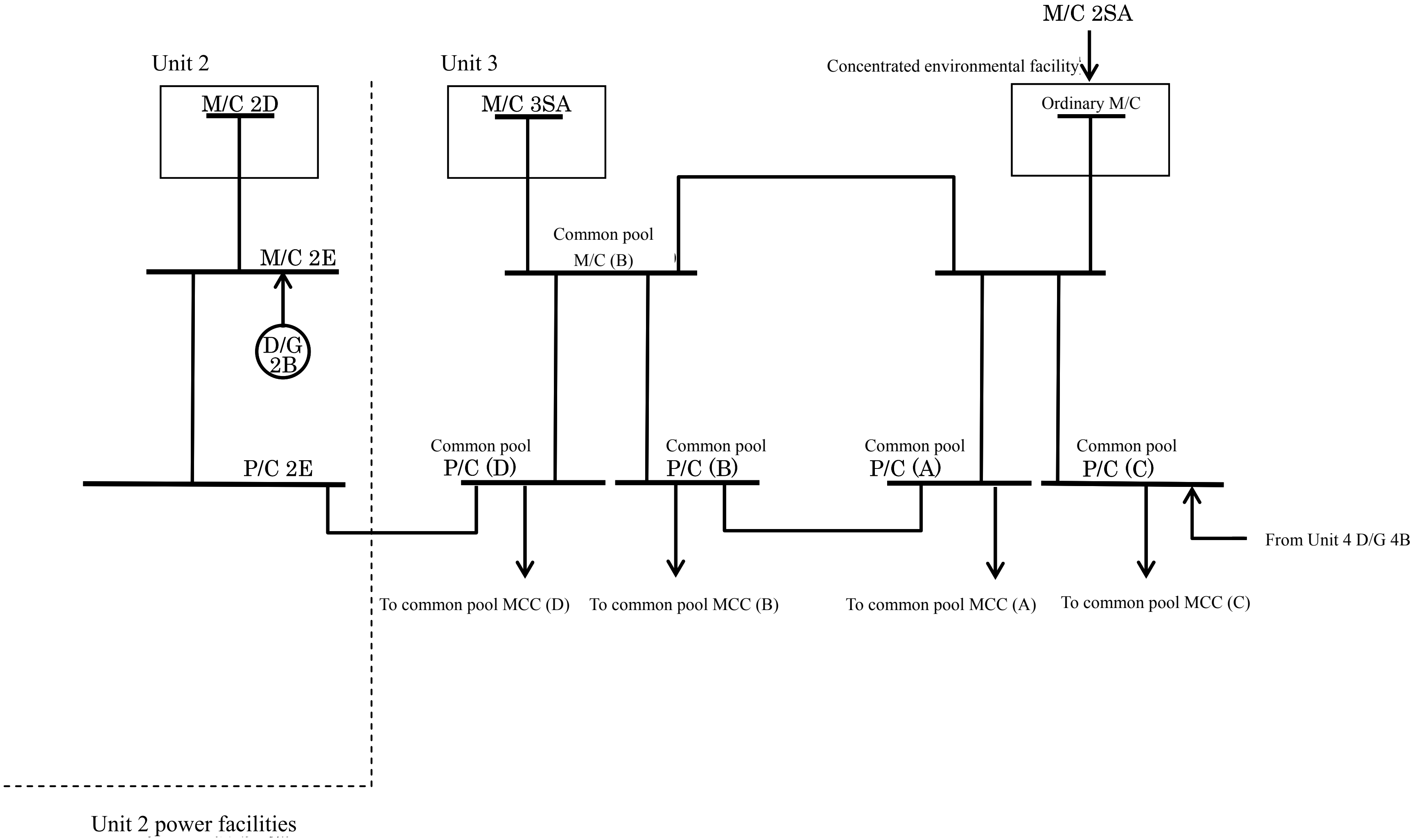


Common Pool Electrical Power Distribution System Diagram (Post-earthquake)

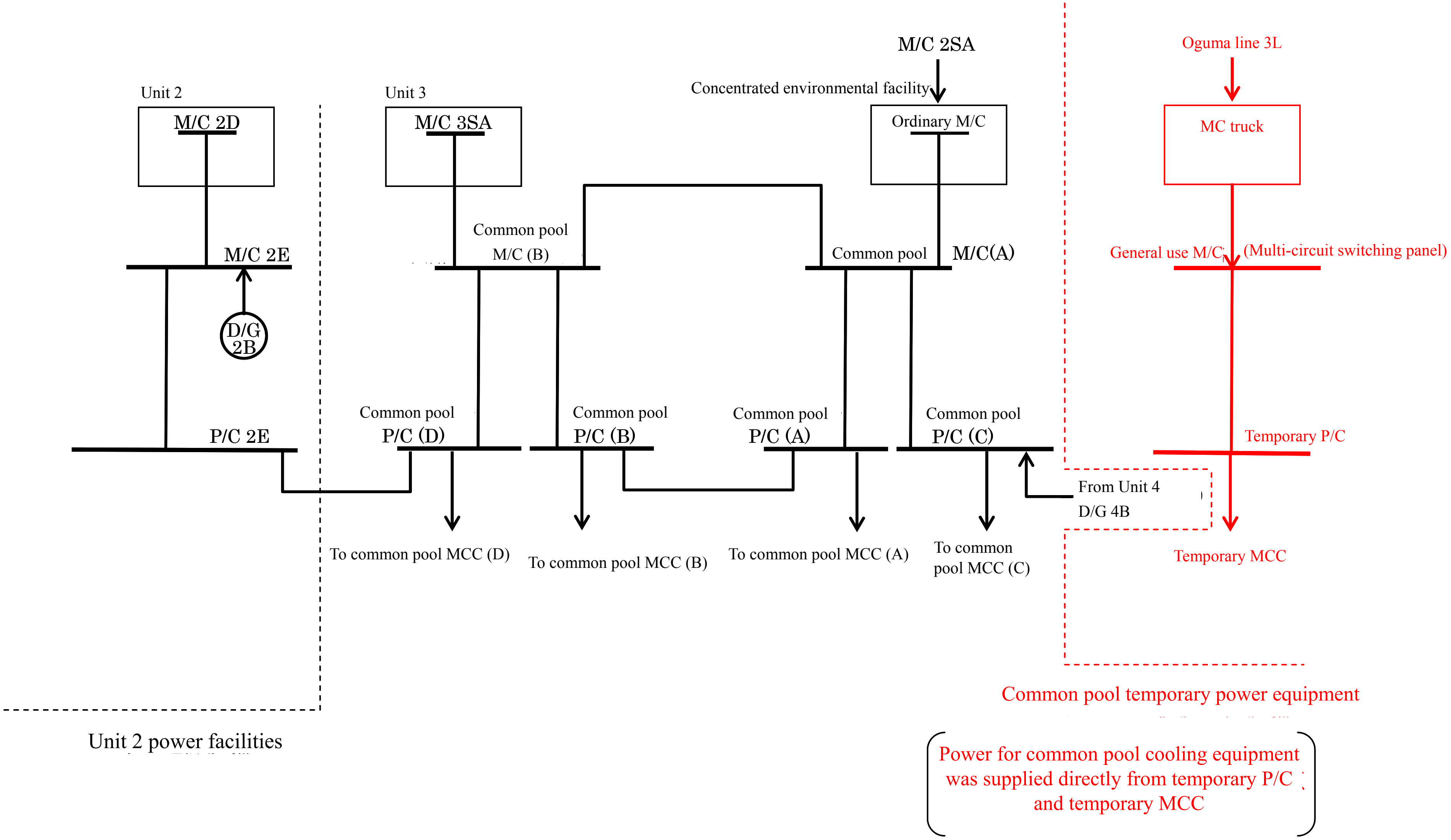
(Black letters: Loss of power and inability to switch electrical power distribution system, Red letters: Power flow from D/G)



Common Pool Electrical Power Distribution System Diagram (Post-tsunami onslaught)
(Black letters: D/G also stops resulting in total power loss)



Common Pool Electrical Power Distribution System Diagram (after installation of temporary power facilities)
(Black letters: Loss of power, Red letters: Power from temporary power sources)



Common pool temporary cooling equipment

On March 23, 2011, the common pool was filled with water from the suppression pool water surge tank (A) using a fire engine via a temporary tank.
On March 24 debris scattered by the hydrogen explosion at the Unit 3 R/B was removed and the existing are fan cooler (AFC) A1 was started up. The spent fuel pool clean up water system (FPC) subsystem-A is used for circulation on the common poolside, and the spent fuel pool auxiliary unit cooling system pump (FPC) subsystem-A is used on the AFC side for circulation via the FPC heat exchanger (equipment uses temporary power sources) (Figure 1).

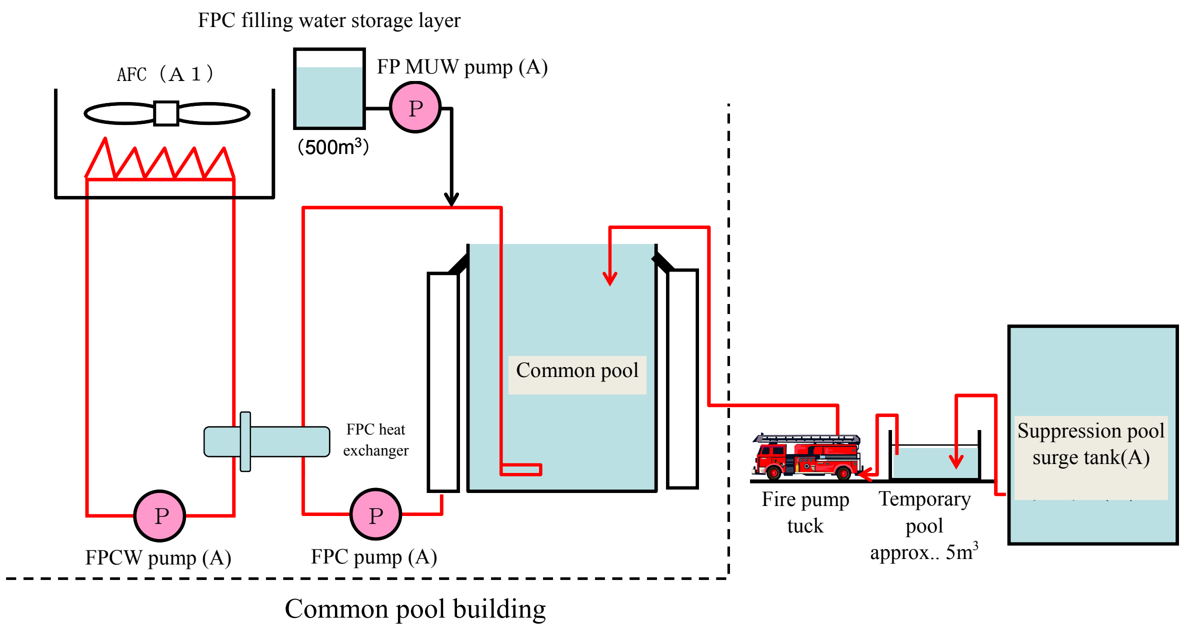


Figure 1 Common pool cooling water injection and cooling

Fukushima Daiichi Nuclear Power Station (NPS) Dry Storage Cask Storage Building Status Investigation Results

1. Dry storage cask storage building status

   The dry storage cask storage building is located between Units 1 to 4 and Units 5/6. (Refer to Figure 1) Dry storage refers to placing the spent fuel into dry storage casks, as shown in Figure 2, and storing them in a cask storage warehouse. Dry storage casks are designed to be cooled through natural convection. This method of storage started to be used at the Fukushima Daiichi NPS in August 1995.

   As of March 11, 2011, a total of 408 spent fuel assemblies were stored in five large dry storage casks (each cask containing 52 fuel assemblies), and four medium-sized dry storage casks (each cask containing 37 fuel assemblies).

   The impact of the tsunami caused by the Tohoku-Chihou-Taiheiyo-Oki Earthquake that occurred at 14:46 on March 11 caused a total loss of AC power. The dry storage cask storage building was inundated with a large amount of sea water, sand, and scattered debris.

   The dry storage cask storage building was inspected multiple times after March 17. The building had been flooded with water up to the dry storage cask storage area floor, and the louvers and doors were damaged. However, the flow of air needed to cool the casks through natural convection was not hindered and it was confirmed that there were no problems with cooling.

   Even though scattered debris pushed into the building by the tsunami has adhered to the dry storage casks, the casks themselves are bolted to the foundation and did not move from their original position, and visual inspections have revealed no problem with soundness.

   Furthermore, compared with background radiation levels, the radiation levels within the dry storage casks storage building (~several tens of μSv/h) are not abnormal. Dry storage casks have excellent airtight performance because they are constructed to maintain airtightness with a primary and secondary lid. It is assumed that this airtight performance is being maintained. However, since direct confirmation through leak tests has yet to be obtained the dry storage casks will be carried out from the dry storage cask storage building and airtight performance will be verified directly. Figure 3 is a picture of the conditions inside the dry storage cask storage building.

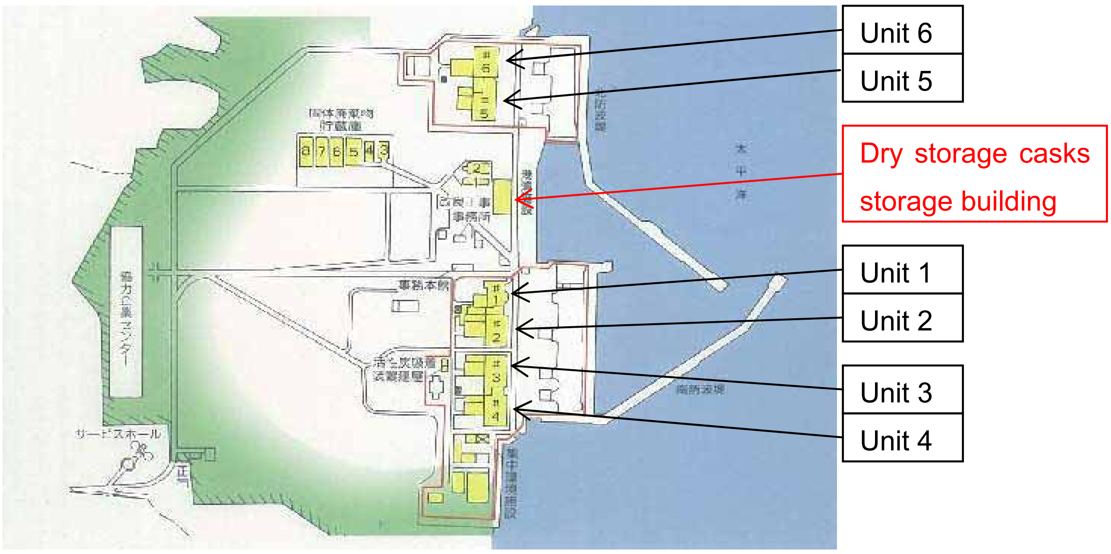


Figure 1 Dry storage casks storage building location

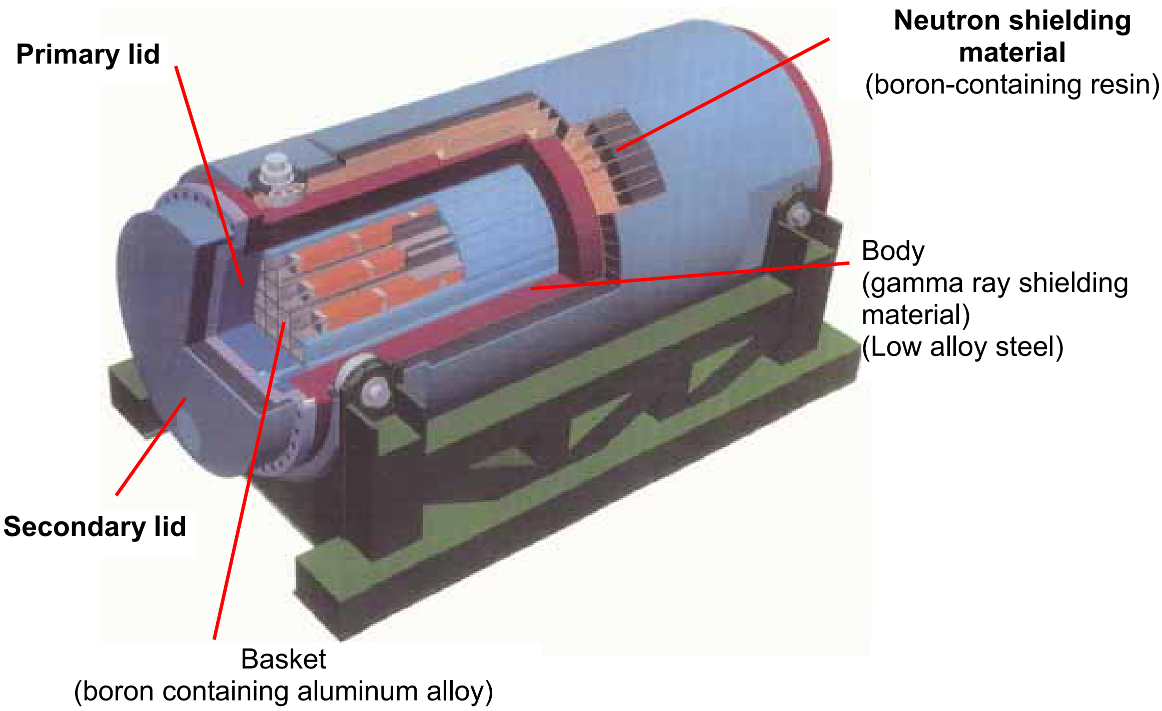


Figure 2 Dry storage cask structure

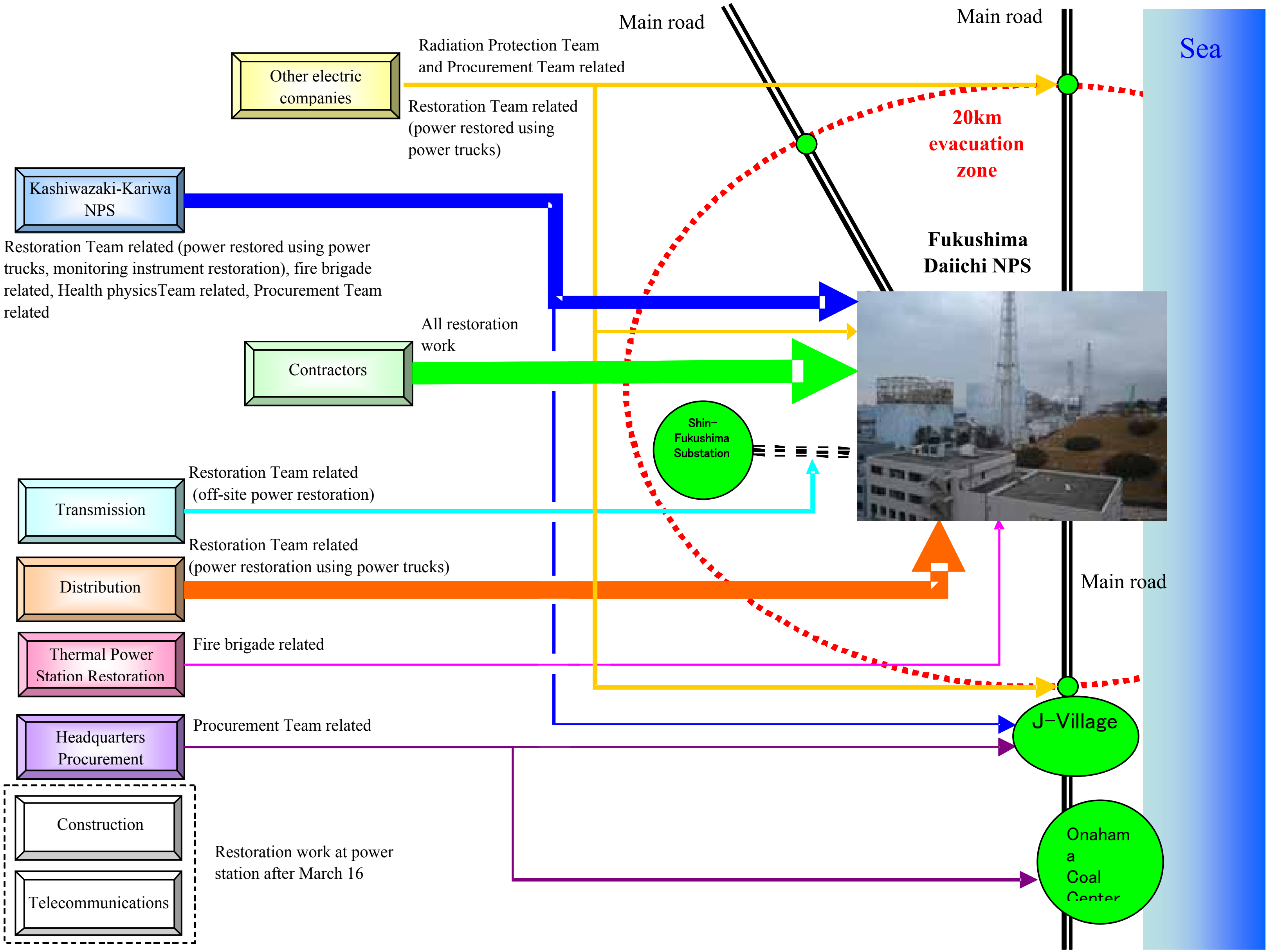
Figure 3 Conditions inside the dry storage cask storage building

Support personnel dispatched to Fukushima Daiichi NPS between March 11 and March 15

Support Provider				March 11th	March 12th	March 13th	March 14th	March 15th
TEPCO related	Kashiwazaki-Kariwa	Employee	Health Physics	0	25	25	42	42
			Restoration	0	1	11	36	34
			Fire Brigade	0	0	0	0	0
			Transportation	0	7	3	5	8
		Subtotal		0	33	39	83	84
		Contractors	Health Physics	0	0	0	0	0
			Restoration	0	0	0	0	0
			Fire Brigade	0	6	6	6	6
			Transportation	0	17	17	2	0
		Subtotal		0	23	23	8	6
		Employees and contractors	Health Physics	0	25	25	42	42
			Restoration	0	1	11	36	34
			Fire Brigade	0	6	6	6	6
			Transportation	0	24	20	7	8
		Total		0	56	62	91	90
	Other offices	Distribution team	Employees	142	215	265	261	152
			Contractors	35	64	98	115	40
			Other electric companies	58	0	0	0	0
			Subtotal	235	279	363	376	192
		Transmission team	Employees	10	9	0	0	15
			Contractors	0	43	0	27	31
			Subtotal	10	52	0	27	46
		Thermal Power Station Restoration team	Employees	0	0	0	0	0
			Contractors	0	4	0	15	25
			Subtotal	0	4	0	15	25
		Headquarters Procurement Team	Employees	0	0	0	2	2
			Contractors	11	63	32	29	45
			Subtotal	11	63	32	31	47
		Total	Employees	152	224	265	263	169
			Contractors	46	174	130	186	141
			Other electric companies	58	0	0	0	0
			Employees + contractors + other electric companies	256	398	395	449	310
	Sum Total		Employees	152	257	304	346	253
			Contractors	46	197	153	194	147
			Other electric companies	58	0	0	0	0
			Employees + contractors + other electric companies	256	454	457	540	400
Other electric companies	Surveys, decontamination, Logistics, etc. (Dispatched in accordance with Cooperative Agreement Between Nuclear Operating Companies during times of Nuclear Emergency)			0	0	41	116	120

Field of service of dispatched support personnel		March 11th	March 12th	March 13th	March 14th	March 15th
	Restoration	245	332	374	439	272
	Fire brigade	0	10	6	21	31
	Health Physics	0	25	66	158	162
	Procurement	11	87	52	38	55

Summary of support personnel dispatched to Fukushima Daiichi NPS during initial response



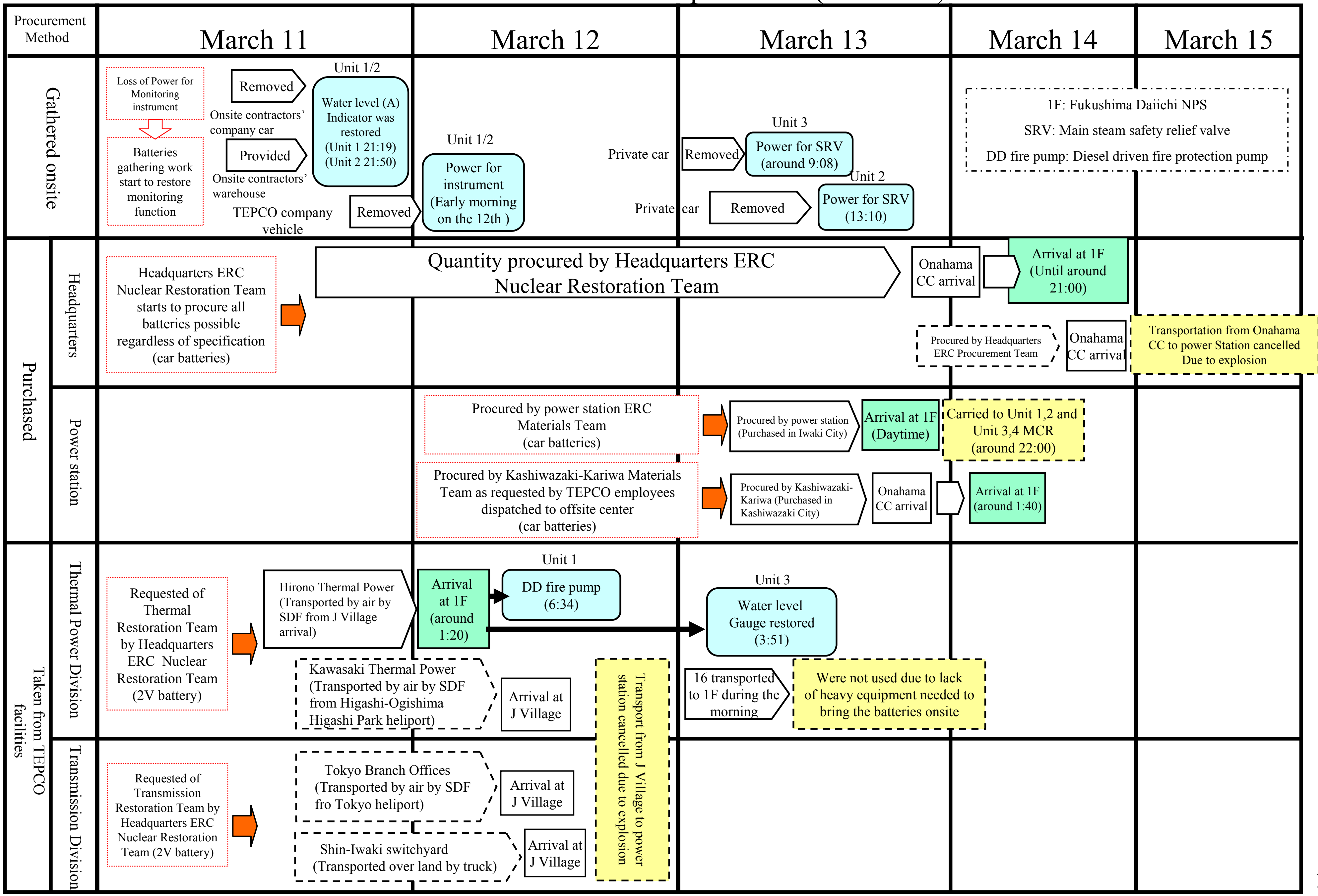
Attachment 10-1 (2)

List of Battery Procurement

Supplier	Date of Procurement (Date of arrival at Fukushima Daiichi)	Specifications	Weight (kg)	Quantity	Transportation Means
Onsite contractors' company bus	March 11 After dusk	12V (For car battery)	Approx. 40	2	Procured by power station restoration team
Onsite contractors' warehouse	March 11 After dusk	6V (For communications and control)	Approx. 20	4	Procured by power station restoration team
TEPCO company vehicle	March 11 around 23:00	12V (For car battery)	Approx. 20	3	Removed by power station restoration team
TEPCO employee's Private car	March 13 between around 7:00 to around 10:00	12V (For car battery)	Approx. 20	20	Removed by car owners
Headquarters Restoration Team (Plant manufacturer)	March 14 around 0:00* (Arrival at Onahama coal center)	12V (For car battery)	17~41.5	1000	Transported by land as arranged by manufacturer (to Onahama coal center)
Fukushima Daiichi Restoration Team (Plant manufacturer)	March 17 around 2:00 (Arrival at Onahama coal center)	12V (For car battery)	17~41.5	Approx. 1000	Transported by land as arranged by manufacturer (to Onahama coal center)
Headquarters Procurement Team	March 14 (Arrival at Onahama coal center)	12V (For car battery)	Approx. 20	20	Transported by land as arranged by Headquarters Procurement Team
Fukushima Daiichi Procurement Team	March 13 During the day	12V (For car battery)	Approx. 10	8	Transported by land by power station Procurement team
Kashiwazaki-Kariwa Procurement Team	March 14 Around 1:40	12V (For car battery)	Approx. 10	20	Transported by land by supporters from Kashiwazaki-Kariwa
Hirono Thermal Power Station	March 12 Around 1:20	2V (From Existing station equipment)	12.5	50	Transported by air by Self-Defense Force
Kawasaki Thermal Power Station	March 12 Between around 9:00~11:00 (Arrival at J Village)	2V (From Existing station equipment)	143	100	Transported by air by Self-Defense Force (To J-Village)
Tokyo Branch Office	March 12 During the day (Arrival at J Village)	2V (From Existing Office equipment)	12~33	132	Transported by air by Self-Defense Force (To J-Village)
Shin-Iwaki Switching Station	March 12 Afternoon (Arrival at J Village)	2V (From Existing station equipment)	21	52	Transported by air by Self-Defense Force (To J-Village)

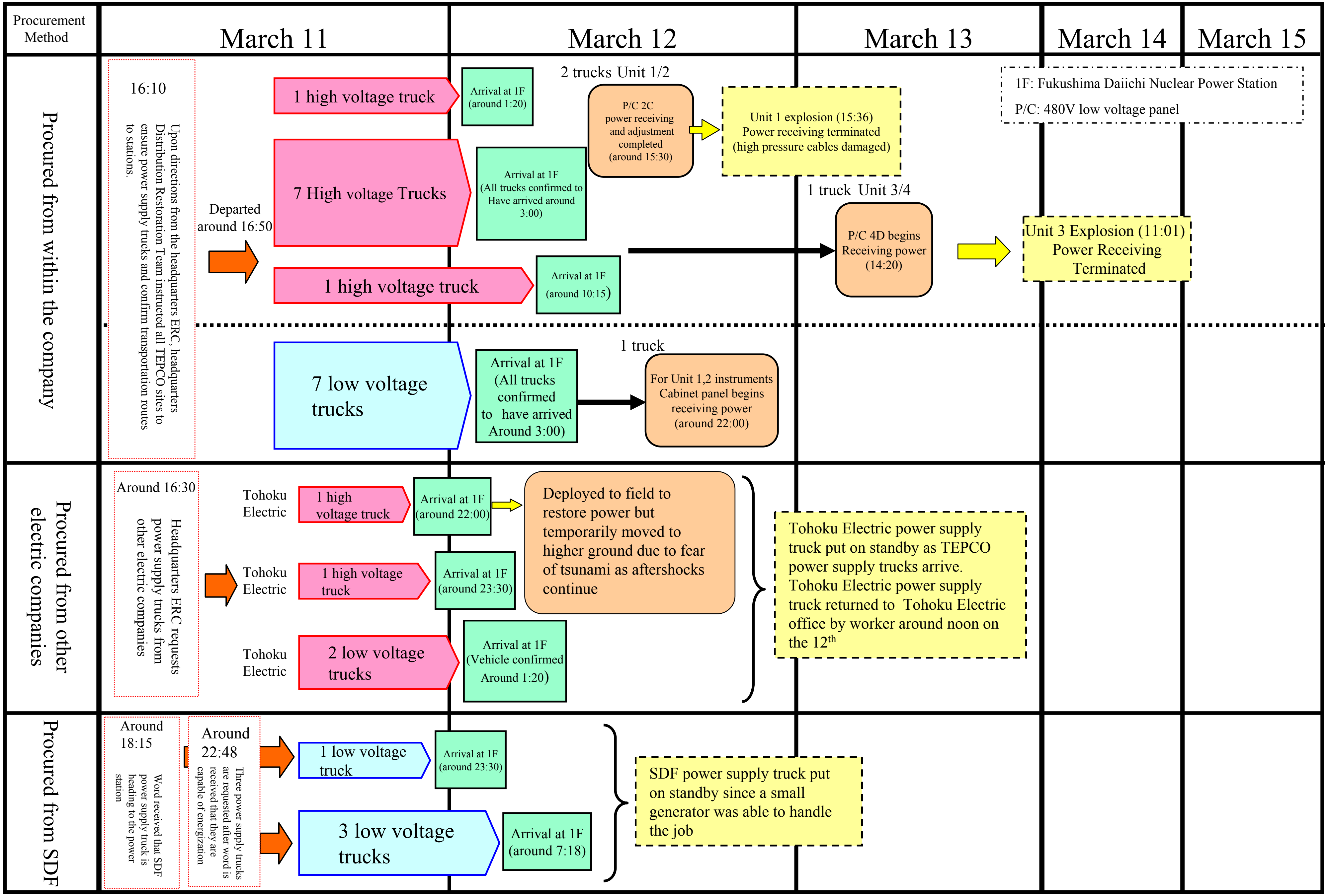
*1 TEPCO employees transported the batteries by land after arrival at the Onahama coal center after which they arrived at the power station after March 14th.

Status of Materials Transportation (Batteries)



Attachment 10-2 (2)

Status of Materials Transport (Power Supply Truck)



Attachment 10-3

Fire Truck Procurement Status

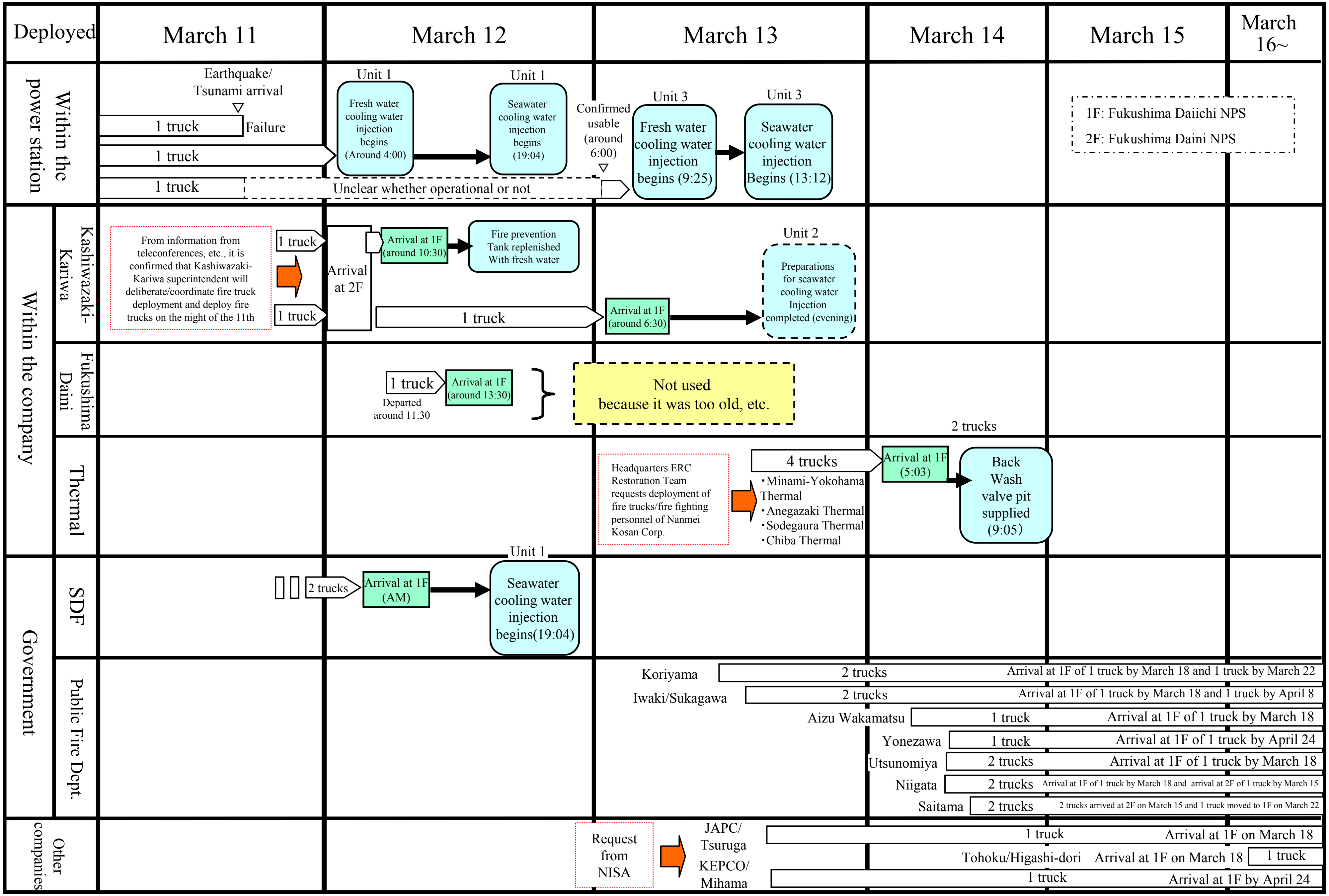
Procured from:	Date of Procurement (Date of arrival at Fukushima Daiichi)	Quantity	Transportation Means
Self-Defense Force (SDF)	March 12 AM	2	SDF (assumed)
Kashiwazaki-Kariwa NPS ①	March 12 around 10:30	1	Japan Nuclear Securitysystem Corp. at Kashiwazaki-Kariwa
Fukushima Daini NPS	March 12 around 13:30	1	Nanmei Kosan Corp. at Fukushima Daini
Kashiwazaki-Kariwa NPS ②	March 13 around 6:30	1	Nanmei Kosan Corp. at Kashiwazaki-Kariwa/Fukushima Daini
Thermal power stations (Chiba, Minami-Yokohama, Sodegaura, Anezaki)	March 14 at 5:03	4	Nanmei Kosan Corp. at Thermal power station
Japan Atomic Power Company Tsuruga NPS	March 18 before noon	1	Japan Atomic Power employees and contractors
Tohoku Electric Higashi-dori NPS	March 18 around noon	1	Contractors (Tohoku Electric transportation contractor) and headquarter employees
Kansai Electric Mihama NPS	Arrived by April 24	1[*1]	Kansai Electric employees and contractors
Iwaki Fire Dept. Uchigo Fire Station	Arrived by March 18	1[*1]	Inawashiro power station employee from fire station to offsite center
Koriyama Fire Dept. Tamura Fire Station	Arrived by March 18	1[*1]	Inawashiro power station employee from fire station to offsite center
Koriyama Fire Dept. Koriyama Fire Station	Arrived by March 22	1[*1]	Contractor from fire station to offsite center
Niigata Fire Dept. Nishi Fire Station	Arrived by March 18 (1)	2[*1*2]	TEPCO Kashiwazaki-Kariwa NPS employee from Local office of Nishi fire Station to J Village
Saitama Fire Dept. Chuo Fire Station	Arrived on March 22 (1)	2[*2]	TEPCO Logistics Corp. from fire station to J Village (accompanied by TEPCO Saitama branch office employee)
Utsunomiya Fire Dept. Chuo Fire Station	Arrived by March 18	2[*1]	TEPCO Tochigi branch office employee from fire station to J Village

Aizu Wakamatsu Fire Dept. Aizu Wakamatsu Fire Station	Arrived by March 18	1[*1]	TEPCO Inawashiro power station employee from fire station to J Village
Sukagawa Fire Dept. Ishikawa Fire Dept. Furudono Station House	Arrived by April 8	1[*1]	Contractor from fire Dept. to offsite center
Yonezawa Fire Dept.	Arrived by April 24	1[*1]	TEPCO Inawashiro power station employee from fire dept. to Onahama coal center

*1: It is assumed that transportation from the offsite center, J Village and Onahama coal center to the Fukushima Daiichi power station was carried out by TEPCO employees or contractors.

*2: One fire truck from the Niigata Fire Dept. and two trucks from the Saitama Fire Dept. were transported by March 15 by Nanmei Kosan Corp. at Fukushima Daini and brought from J Village to Fukushima Daini.

Status of Materials Transport(Fire Trucks)



Attachment 10-4 (2)

Diagram of Reactor Cooling Water Injection using Fire Trucks

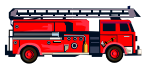
<Legend>

: Water supplied (solid blue line)

: Hoses laid only (water not supplied) (dashed blue line)

: Fire truck water tanks filled (blue arrow)

: Fire truck moved (orange arrow)



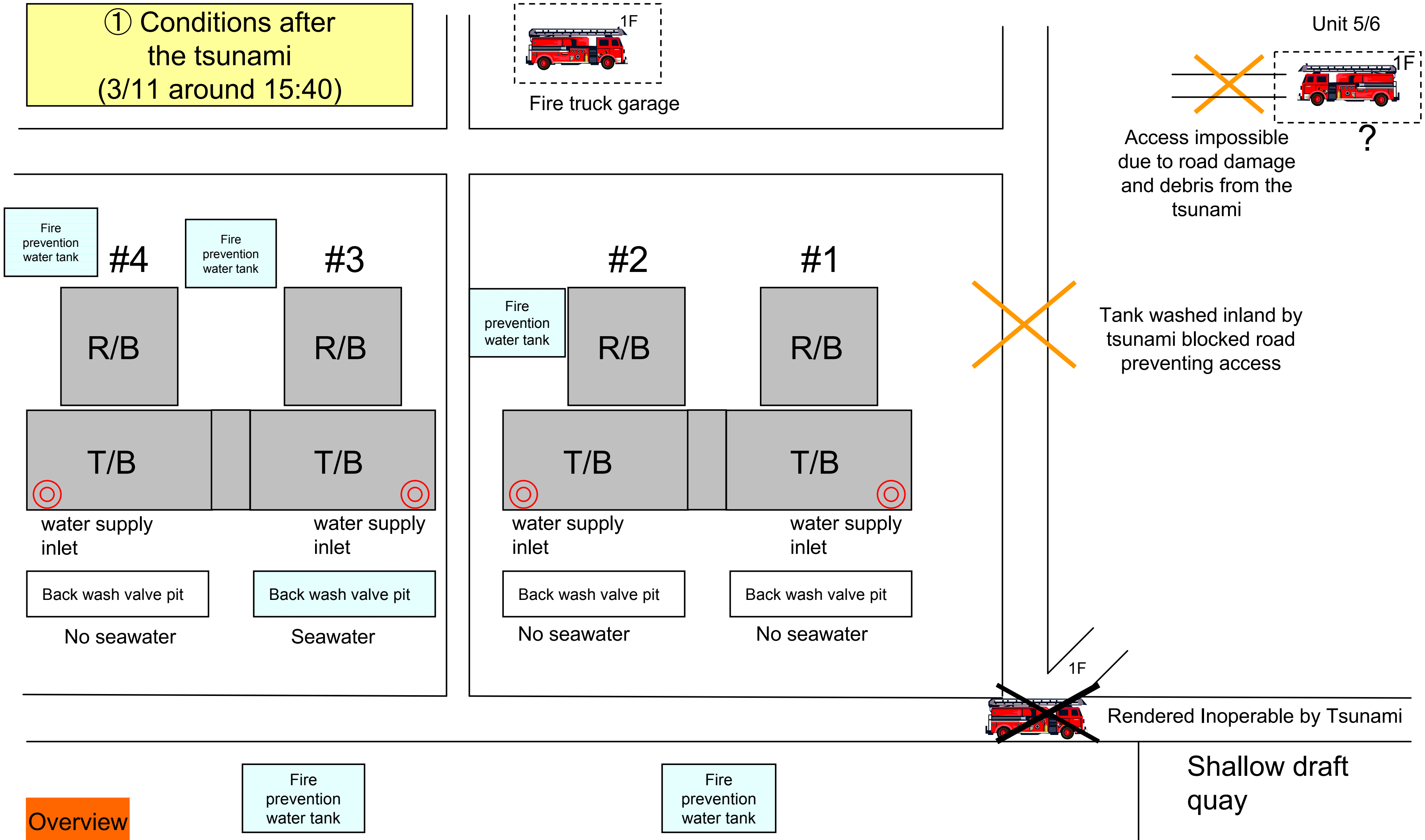
○○ : Indicates fire truck owner

1F : Fukushima Daiichi NPS
2F : Fukushima Daini NPS
KK : Kashiwazaki-Kariwa NPS
SDF: Self-Defense Force
Public: Public fire dept.

T/B : Turbine Building

R/B : Reactor Building

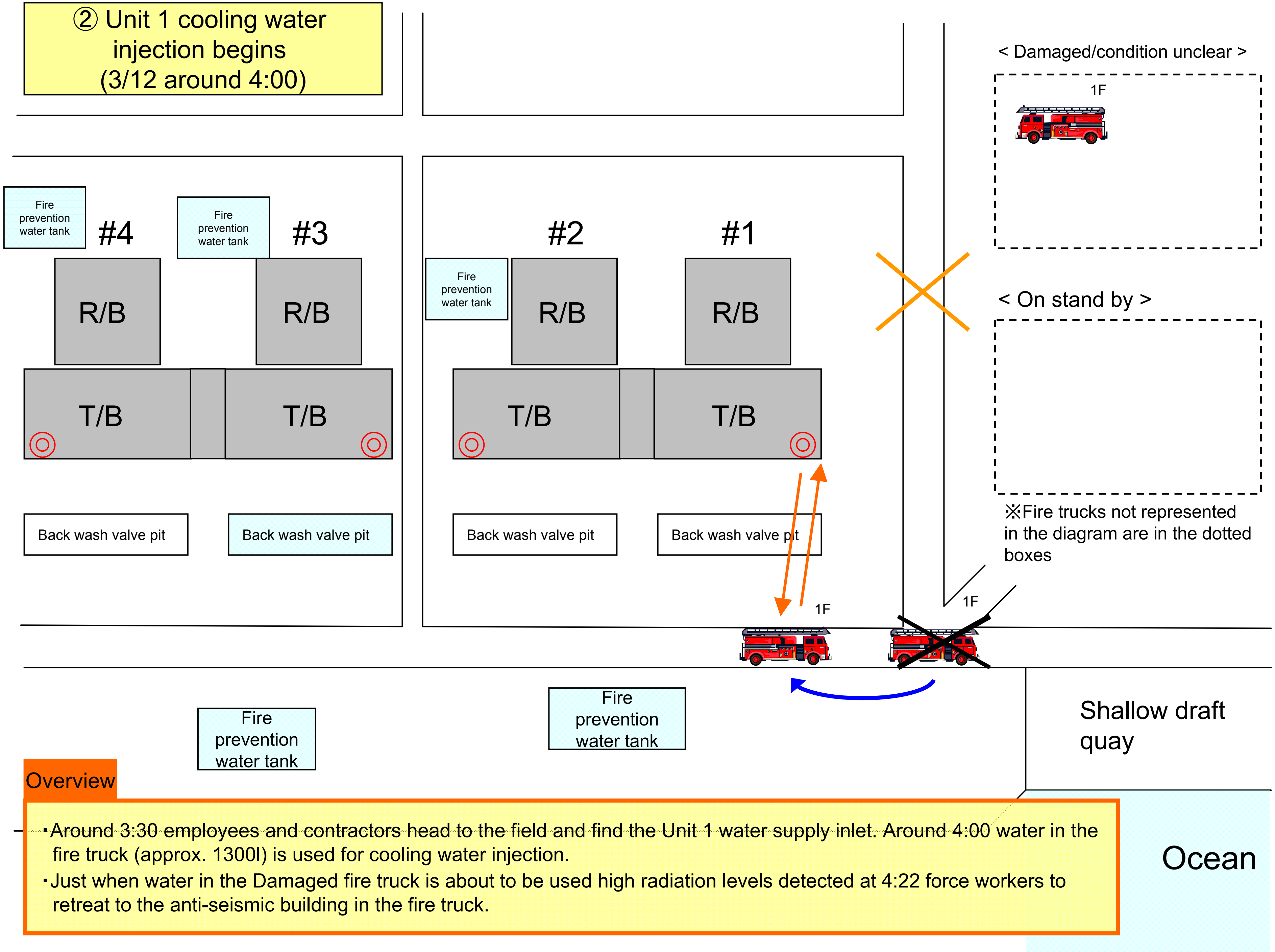
① Conditions after the tsunami (3/11 around 15:40)



Overview

- Condition of 3 fire trucks deployed at power station:
  - 1 truck is in a garage on high ground and operational.
  - 1 truck was near the protection office on the Unit 1-4 side and rendered inoperable by the tsunami.
  - 1 truck is on the Unit 5/6 side but is cut off due to road damage and debris from the tsunami, there is also information that it got washed away by the tsunami and is therefore unavailable.

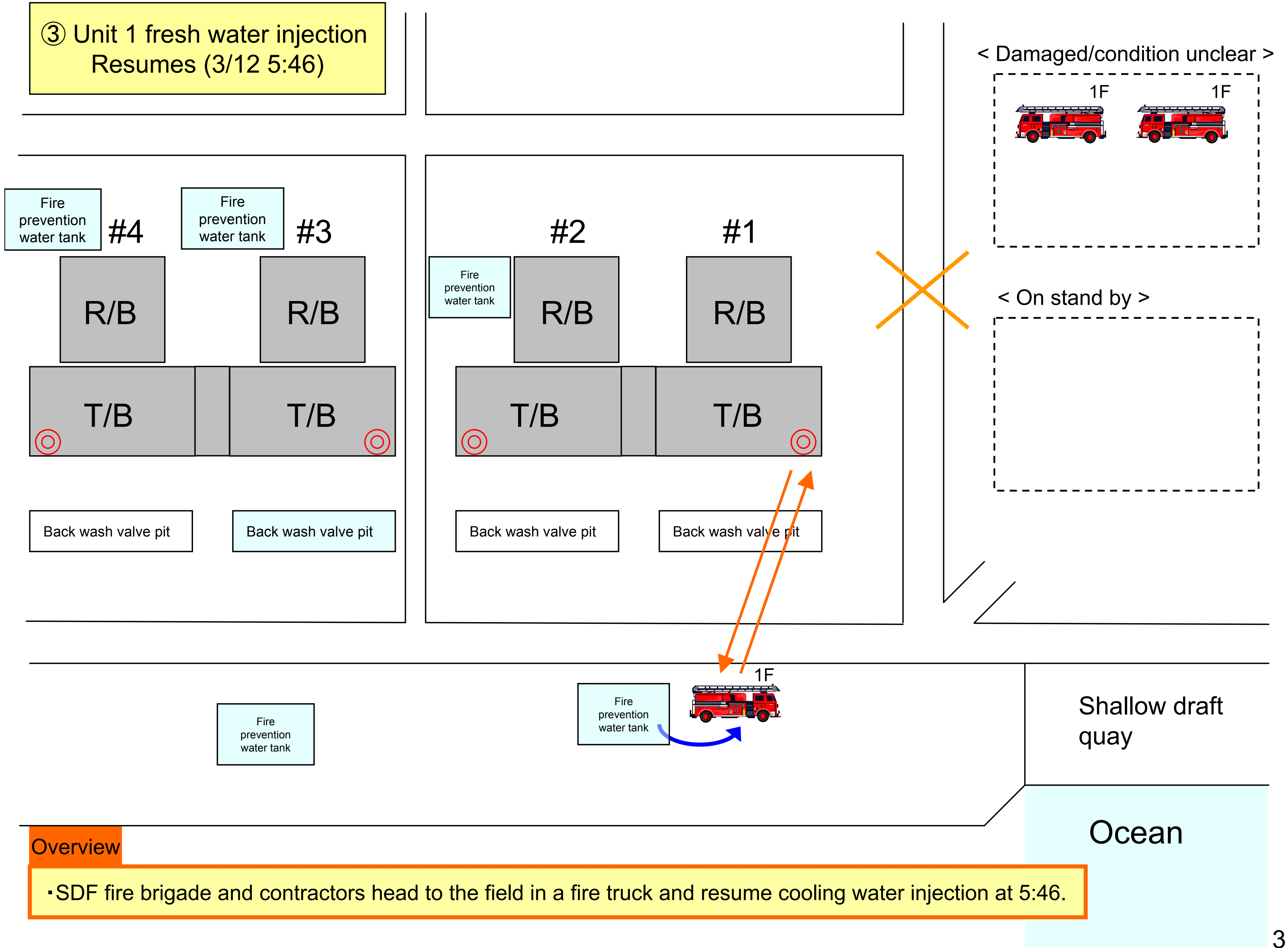
② Unit 1 cooling water injection begins (3/12 around 4:00)



Overview

- Around 3:30 employees and contractors head to the field and find the Unit 1 water supply inlet. Around 4:00 water in the fire truck (approx. 1300l) is used for cooling water injection.
- Just when water in the Damaged fire truck is about to be used high radiation levels detected at 4:22 force workers to retreat to the anti-seismic building in the fire truck.

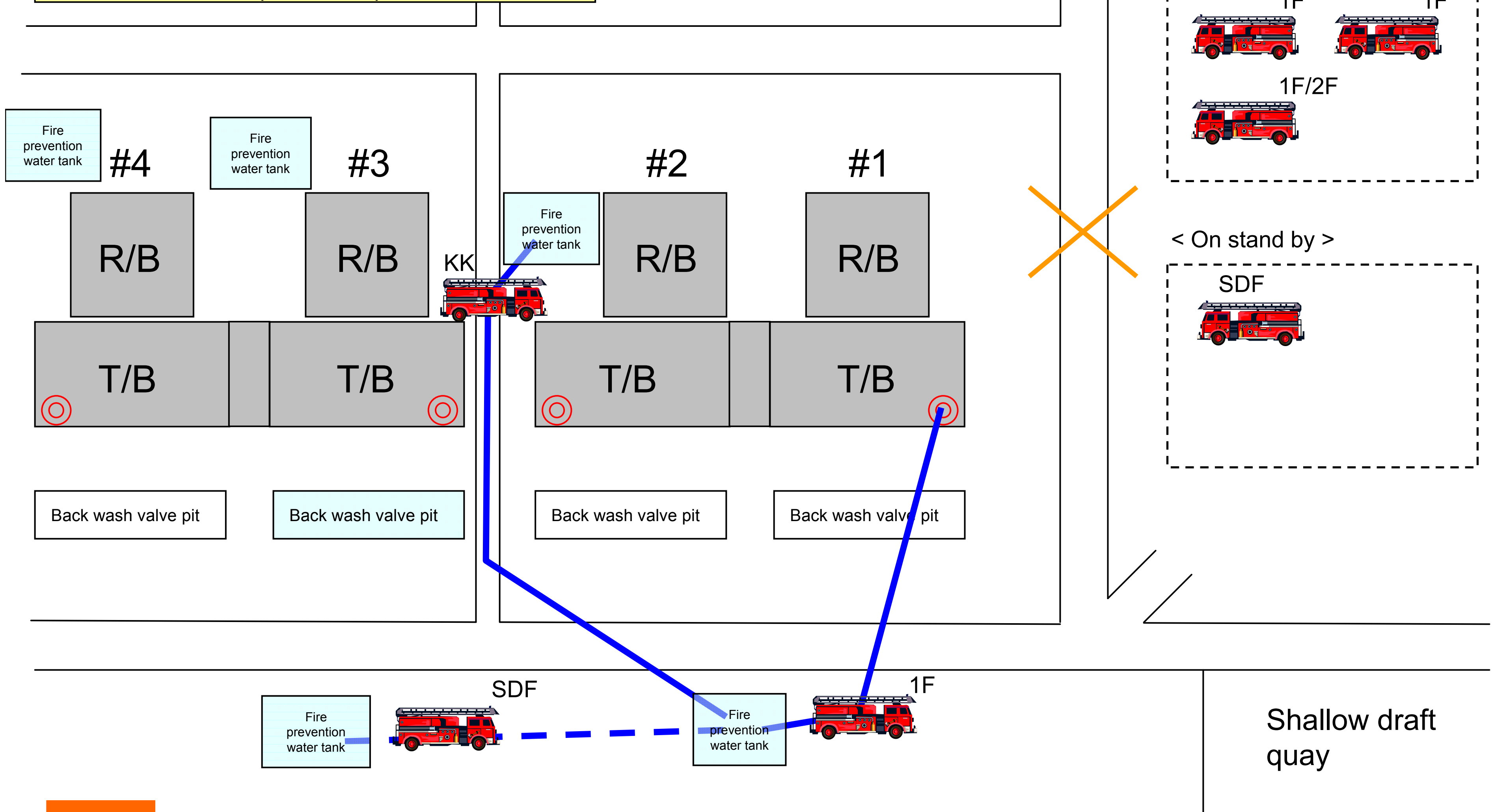
③ Unit 1 fresh water injection Resumes (3/12 5:46)



Overview

・SDF fire brigade and contractors head to the field in a fire truck and resume cooling water injection at 5:46.

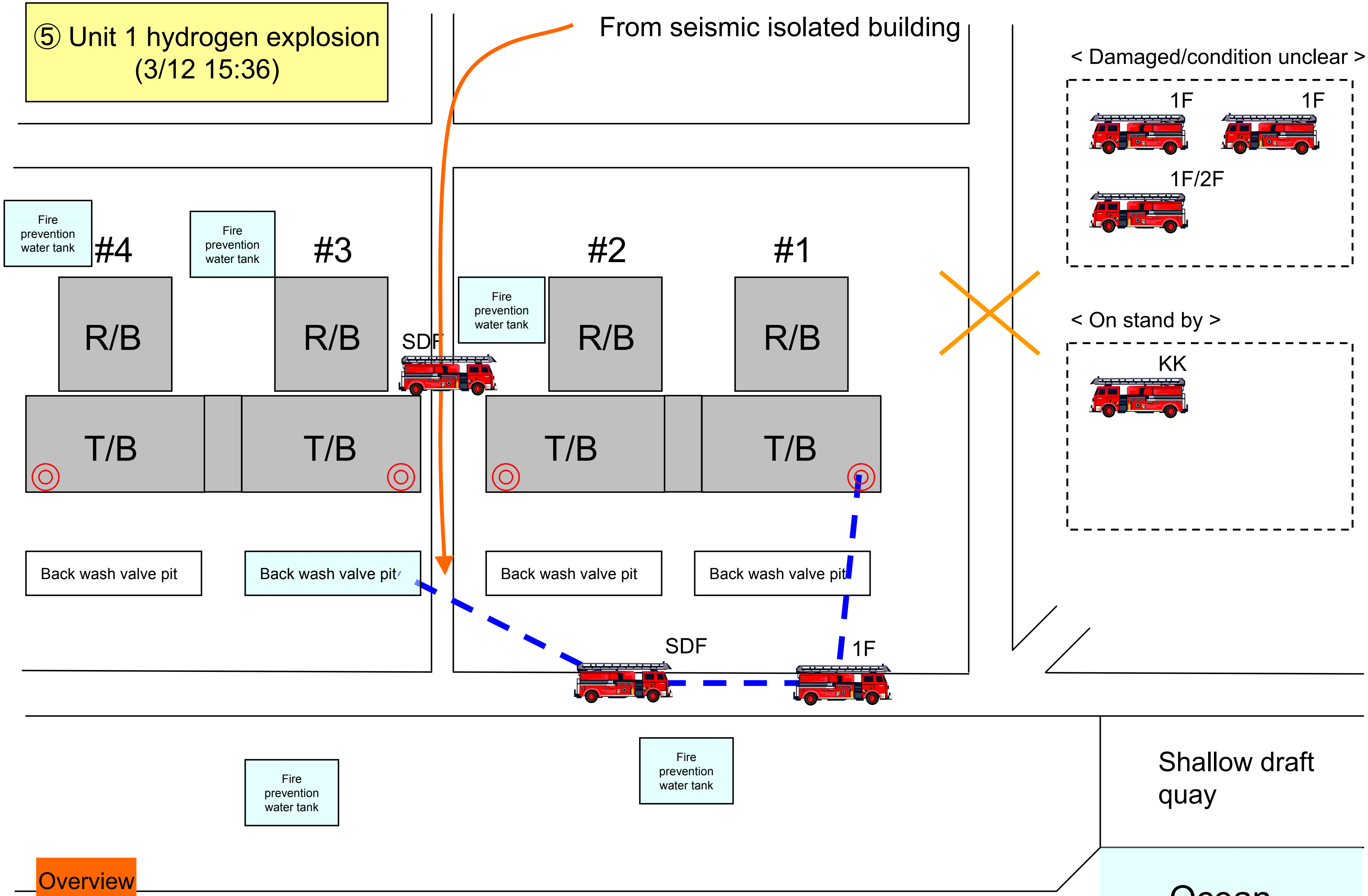
④ Continuous cooling water injection begins, support fire trucks arrive (3/12 AM)



Overview

- Cooling water injected through continuous cooling water injection line configured between fire prevention water tank and water supply inlet.
- Around 10:30 KK fire truck arrives, and SDF fire truck arrives during morning. Unit 1 side fire prevention tank filled with water from surrounding fire prevention water tanks.
- Other: 1 chemical fire truck shared by 1F and 2F heads to scene from 2F. (ultimately not used because it was too old)

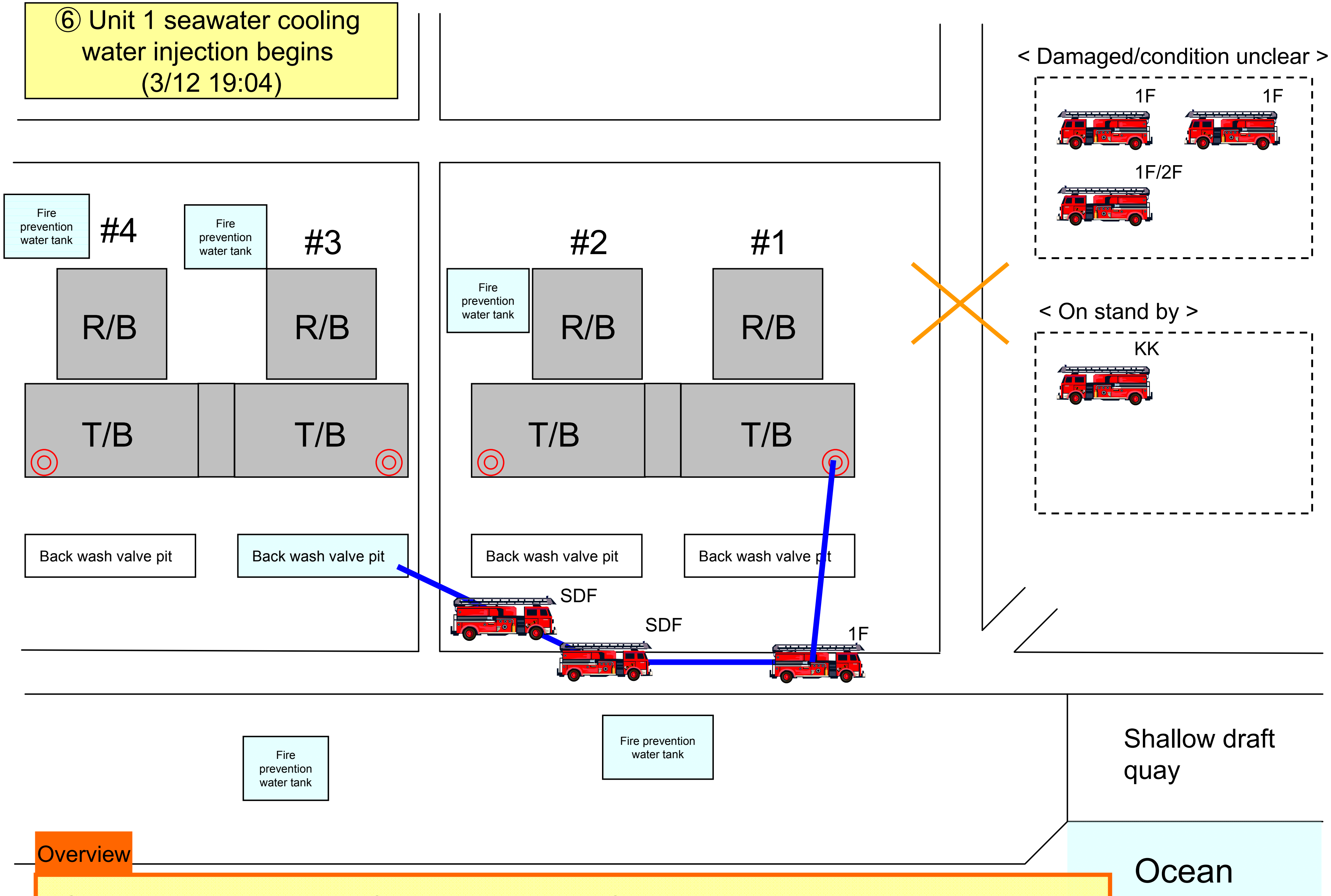
⑤ Unit 1 hydrogen explosion (3/12 15:36)



Overview

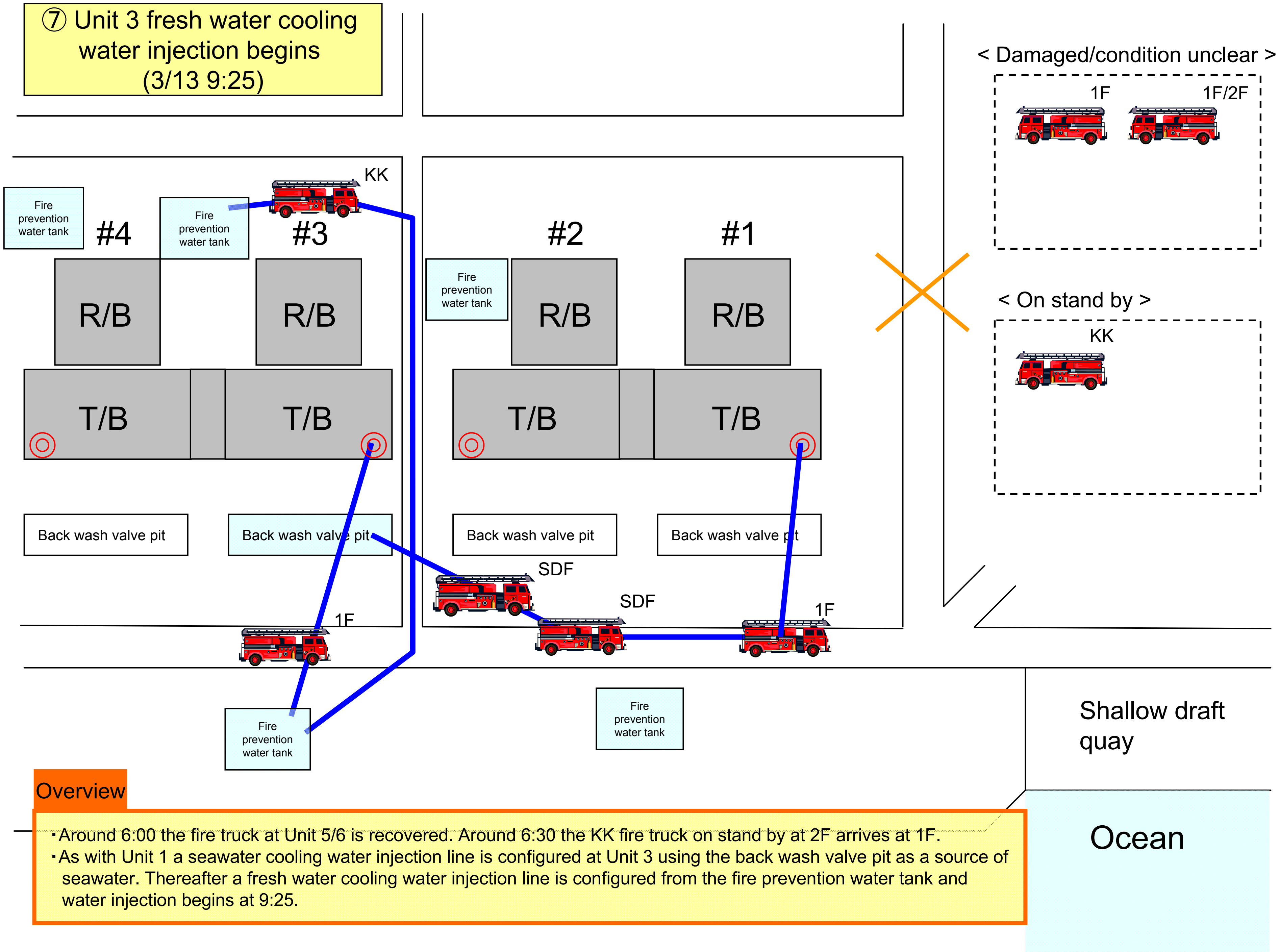
- After the explosion all workers retreated to the seismic isolated building.
- Hoses prepared for seawater cooling water injection damaged by explosion and rendered unusable.

⑥ Unit 1 seawater cooling water injection begins (3/12 19:04)



Overview

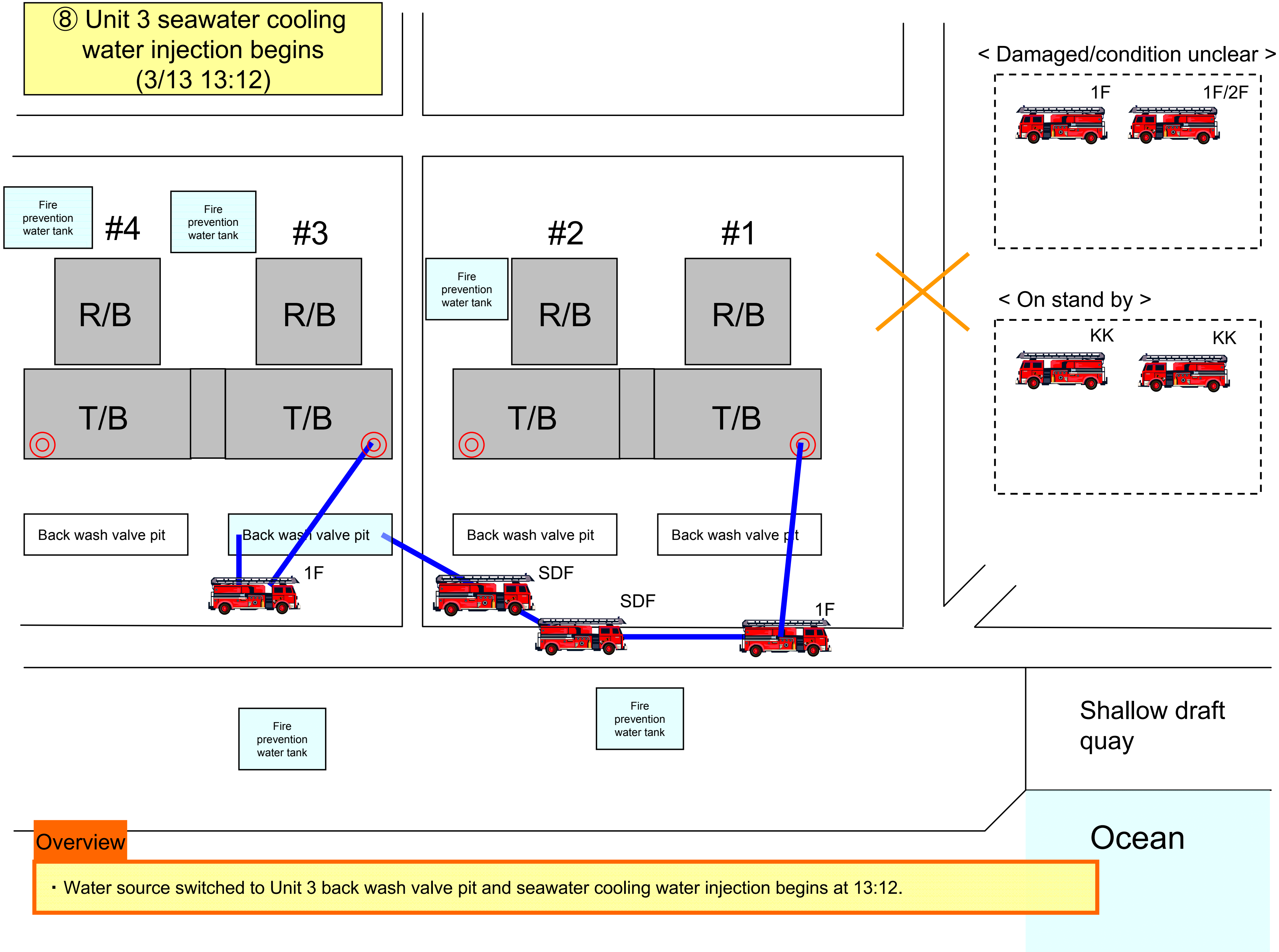
・Cooling water injection line configured by connecting 3 fire trucks in series and using the back wash valve pit as a water source. Unit 1 seawater cooling water injection begins at 19:04.



Overview

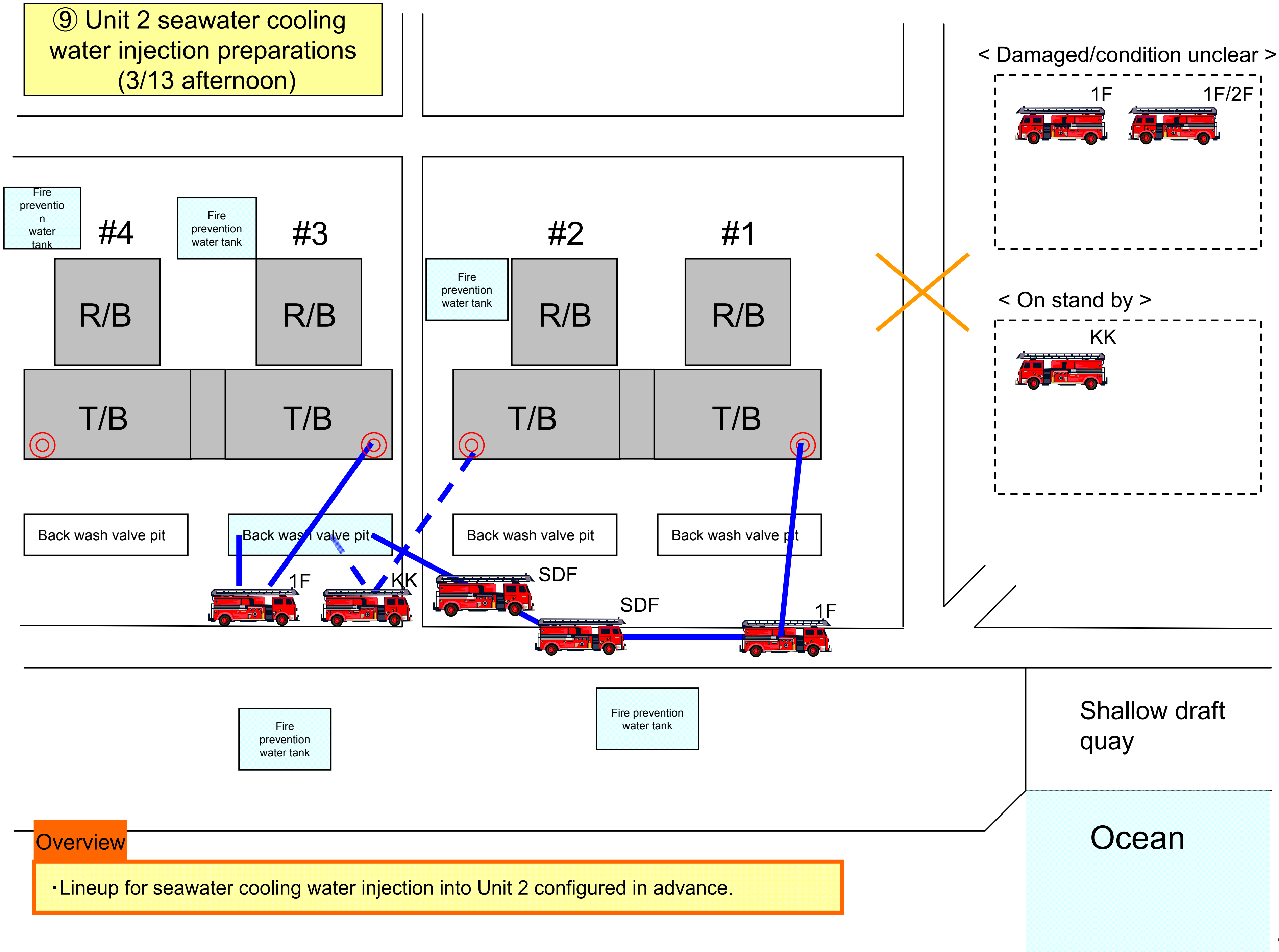
- Around 6:00 the fire truck at Unit 5/6 is recovered. Around 6:30 the KK fire truck on stand by at 2F arrives at 1F.
- As with Unit 1 a seawater cooling water injection line is configured at Unit 3 using the back wash valve pit as a source of seawater. Thereafter a fresh water cooling water injection line is configured from the fire prevention water tank and water injection begins at 9:25.

⑧ Unit 3 seawater cooling water injection begins (3/13 13:12)



Overview

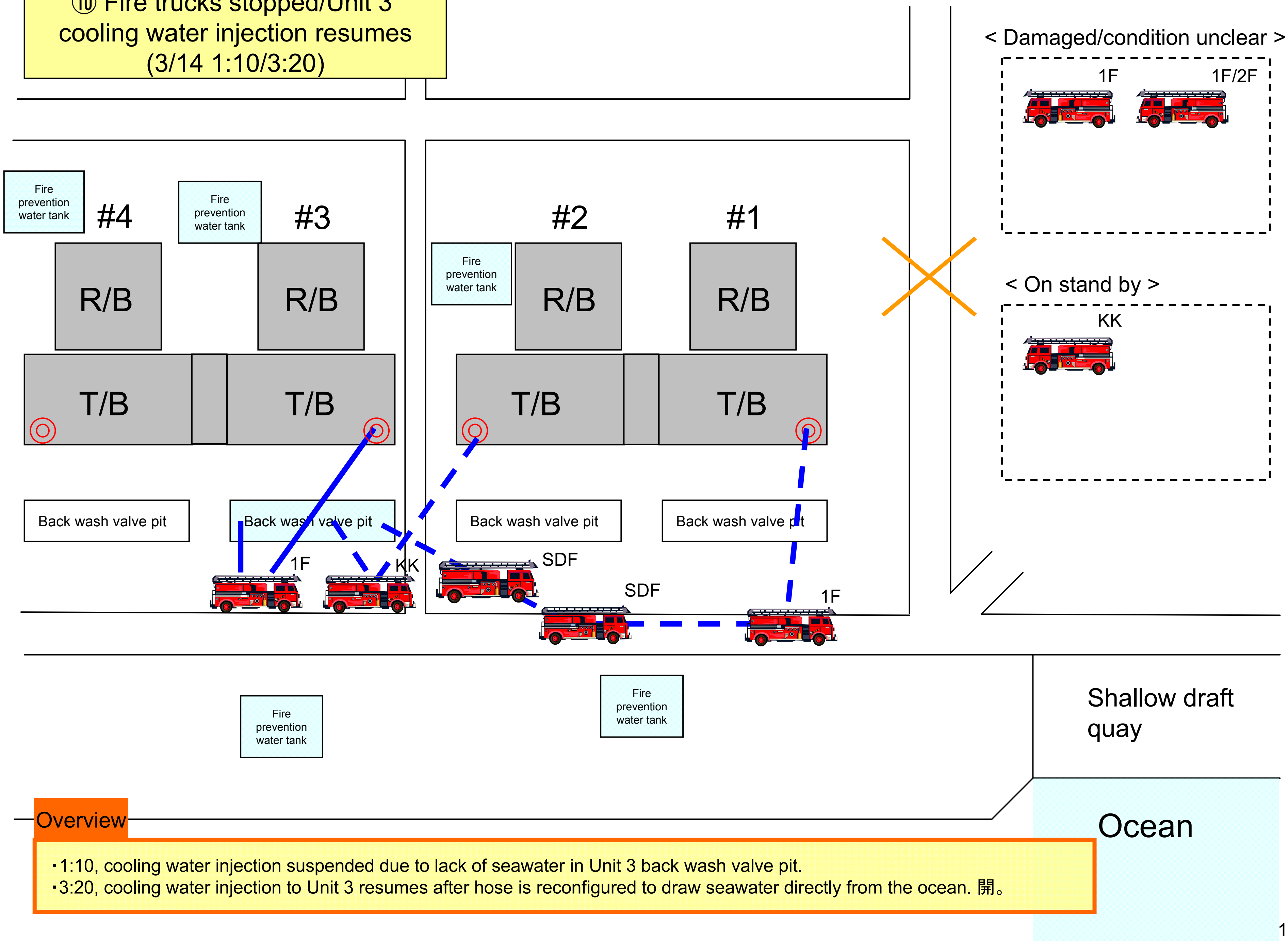
・Water source switched to Unit 3 back wash valve pit and seawater cooling water injection begins at 13:12.



Overview

・Lineup for seawater cooling water injection into Unit 2 configured in advance.

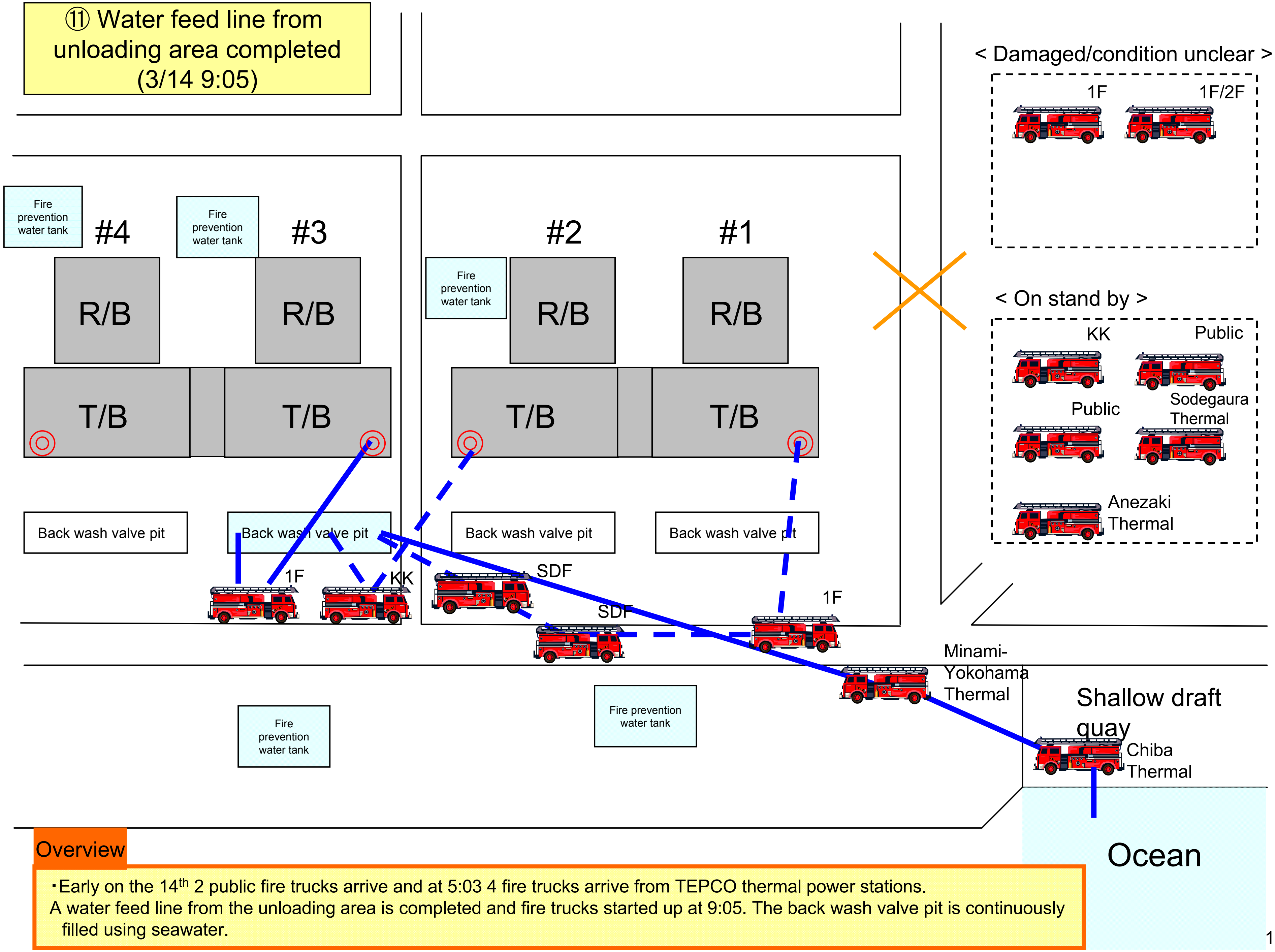
⑩ Fire trucks stopped/Unit 3 cooling water injection resumes (3/14 1:10/3:20)



Overview

・1:10, cooling water injection suspended due to lack of seawater in Unit 3 back wash valve pit.
・3:20, cooling water injection to Unit 3 resumes after hose is reconfigured to draw seawater directly from the ocean. 開。

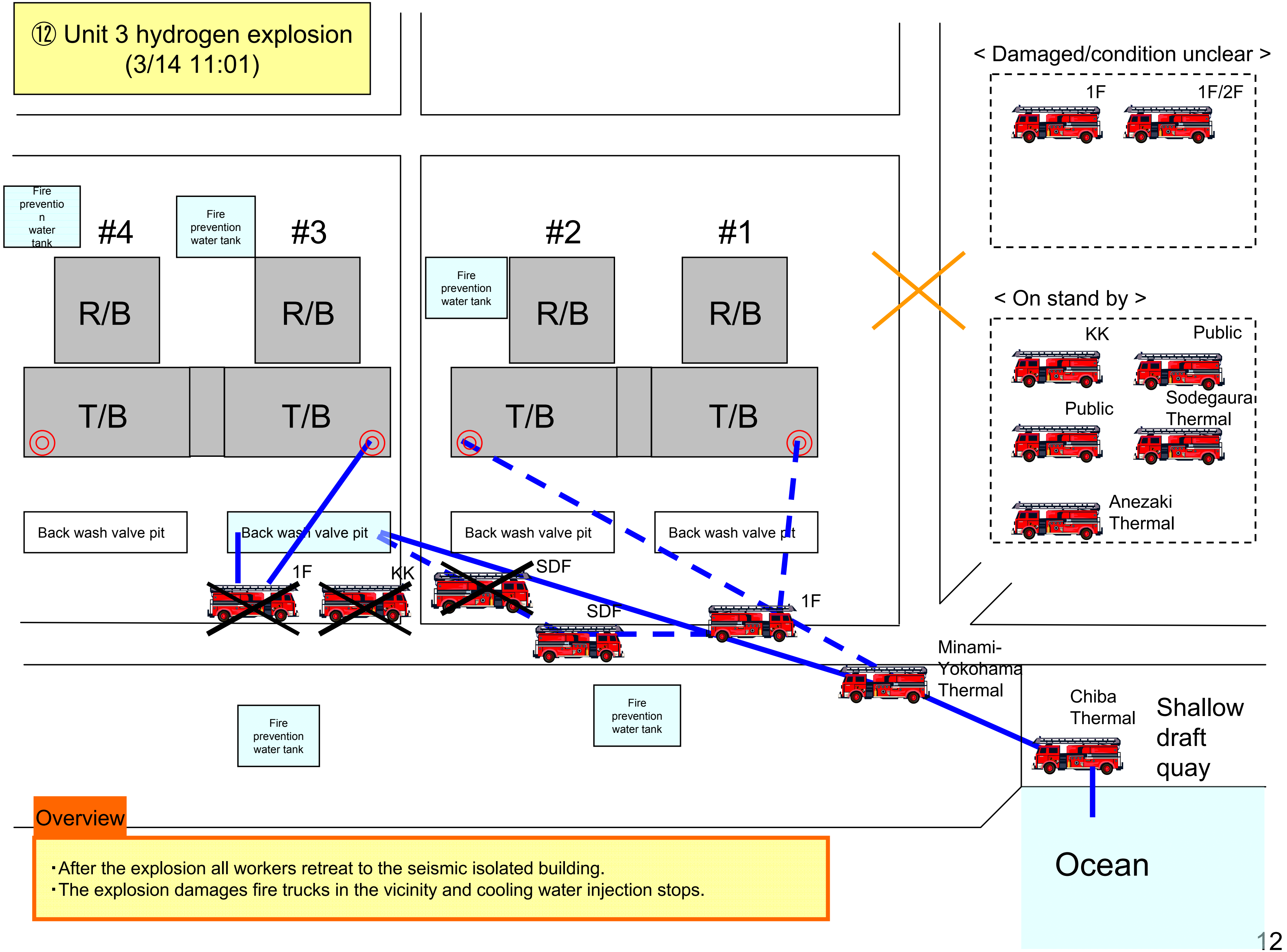
⑪ Water feed line from unloading area completed (3/14 9:05)



Overview

・Early on the 14th 2 public fire trucks arrive and at 5:03 4 fire trucks arrive from TEPCO thermal power stations.
A water feed line from the unloading area is completed and fire trucks started up at 9:05. The back wash valve pit is continuously filled using seawater.

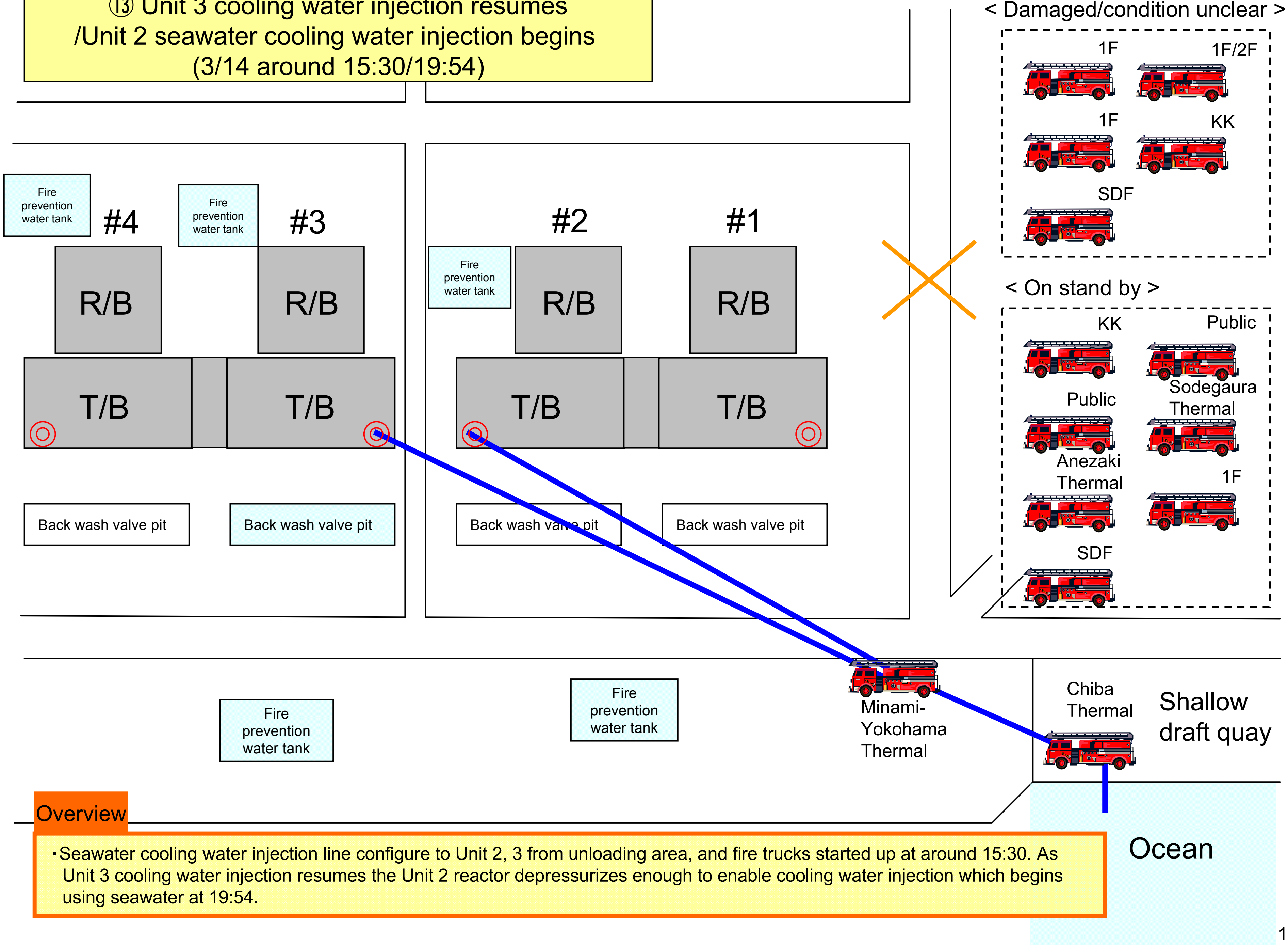
⑫ Unit 3 hydrogen explosion (3/14 11:01)



Overview

・After the explosion all workers retreat to the seismic isolated building.
・The explosion damages fire trucks in the vicinity and cooling water injection stops.

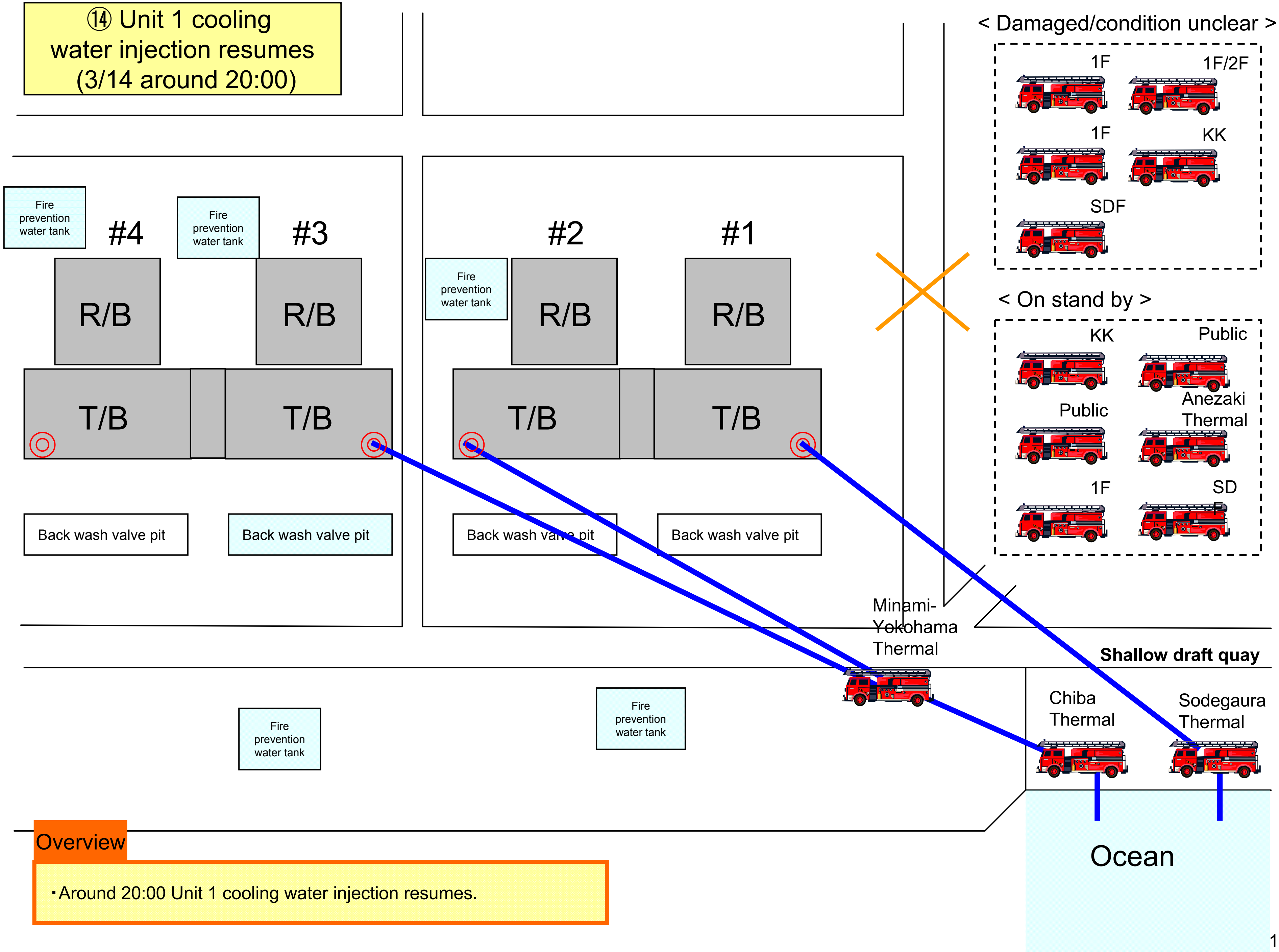
⑬ Unit 3 cooling water injection resumes /Unit 2 seawater cooling water injection begins (3/14 around 15:30/19:54)



Overview

・Seawater cooling water injection line configure to Unit 2, 3 from unloading area, and fire trucks started up at around 15:30. As Unit 3 cooling water injection resumes the Unit 2 reactor depressurizes enough to enable cooling water injection which begins using seawater at 19:54.

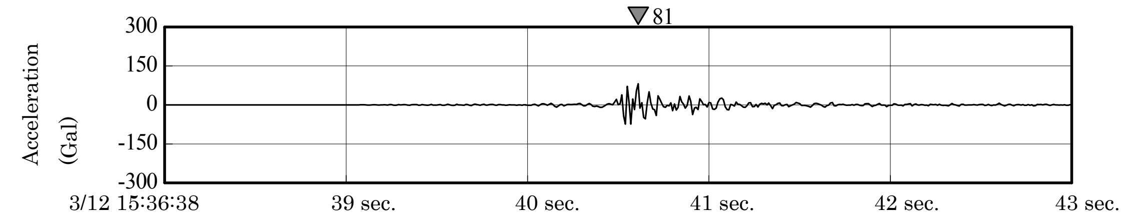
⑭ Unit 1 cooling water injection resumes (3/14 around 20:00)



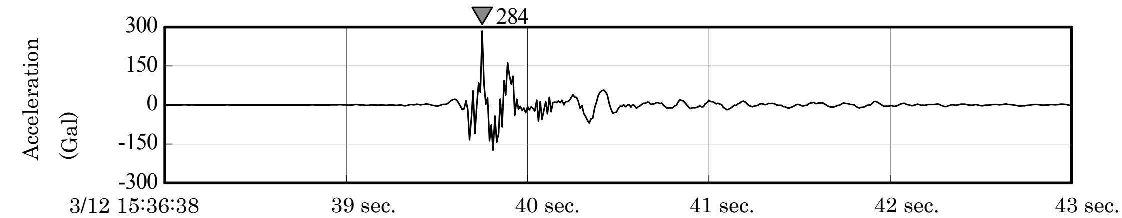
Overview

・Around 20:00 Unit 1 cooling water injection resumes.

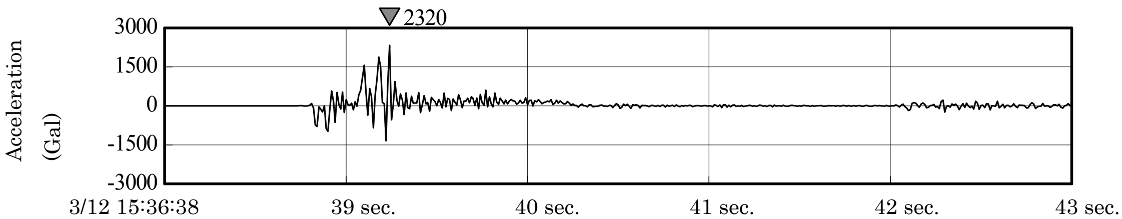
Observation Point A



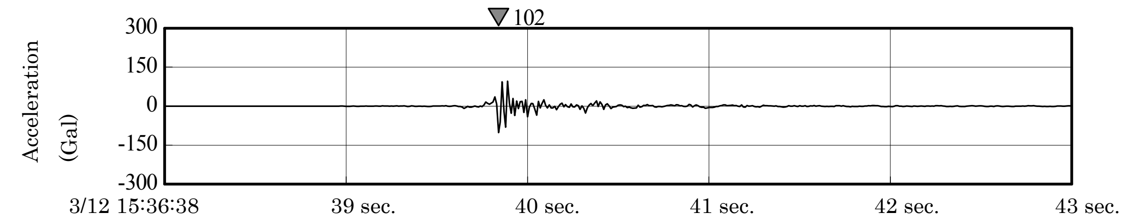
Observation Point B



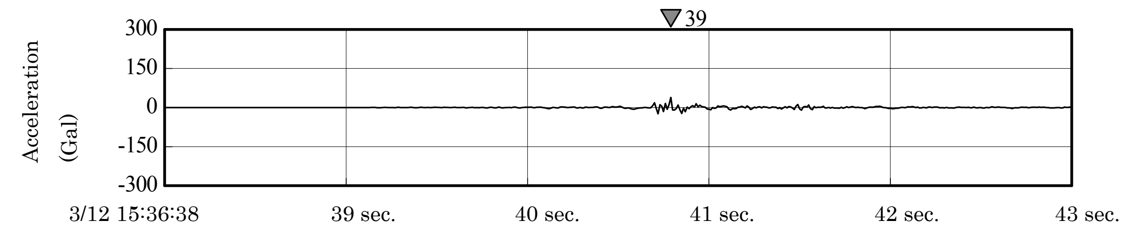
Observation Point C ※Reference value since sensor capacity (2000Gal) was exceeded.



Observation Point D

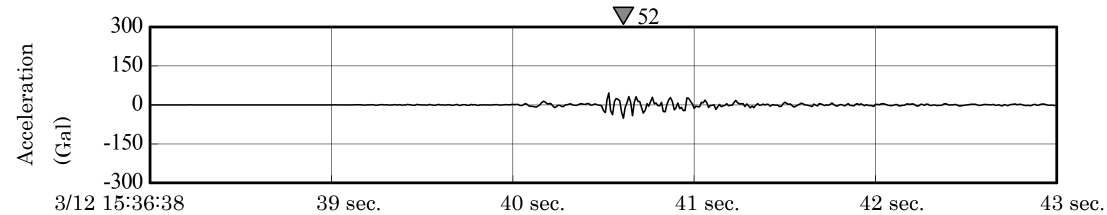


Observation Point E

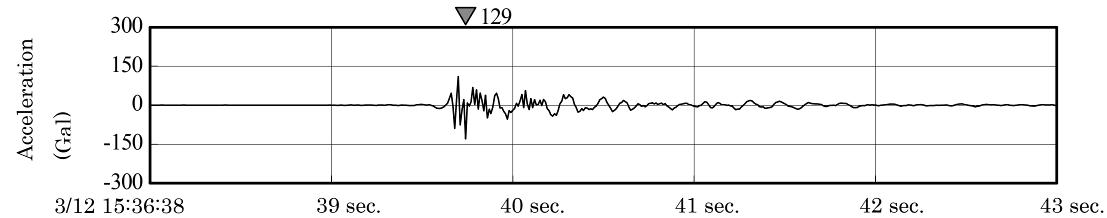


Acceleration wave for Unit 1 explosion (NS direction)

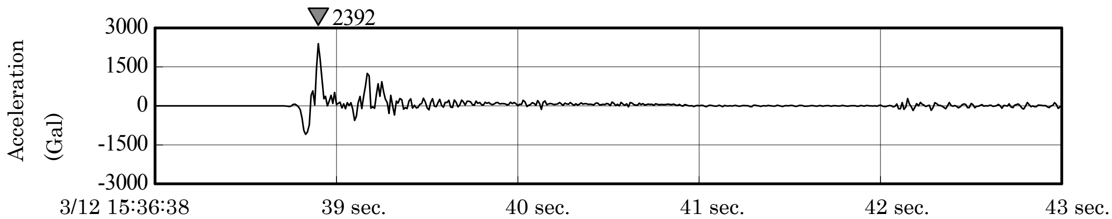
Observation Point A



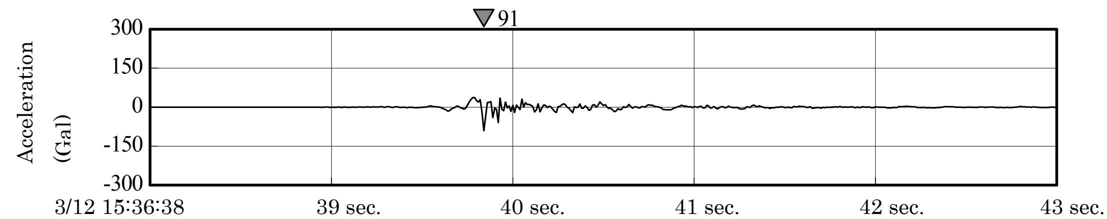
Observation Point B



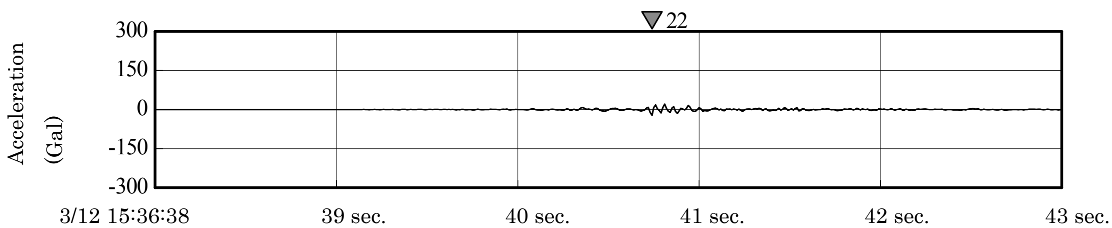
Observation Point C ※Reference value since sensor capacity (2000Gal) was exceeded.



Observation Point D

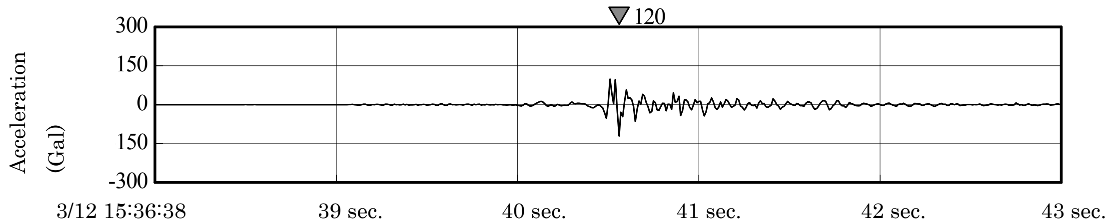


Observation Point E

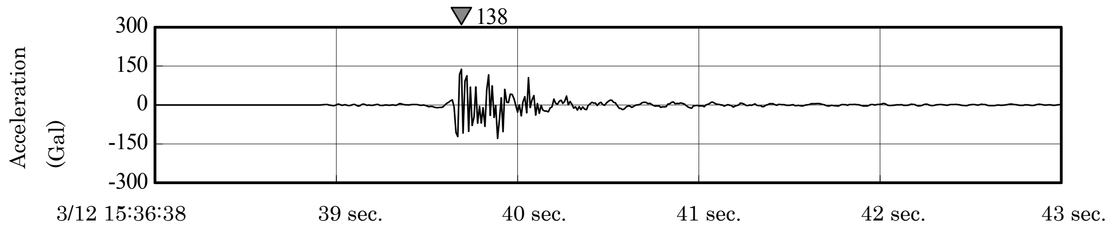


Acceleration wave for Unit 1 explosion (EW direction)

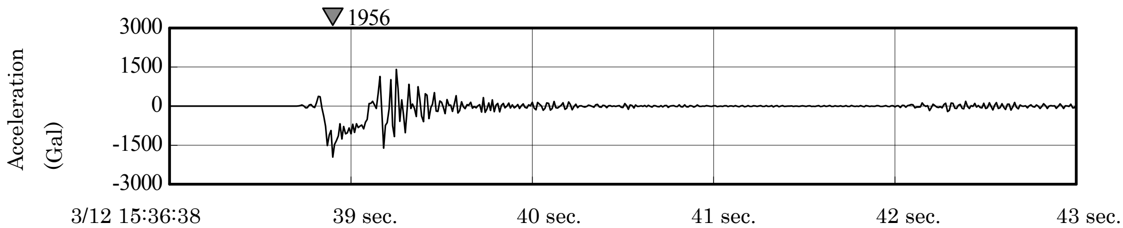
Observation Point A



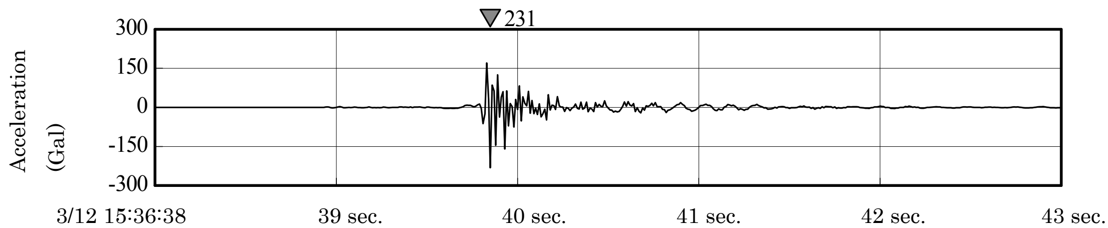
Observation Point B



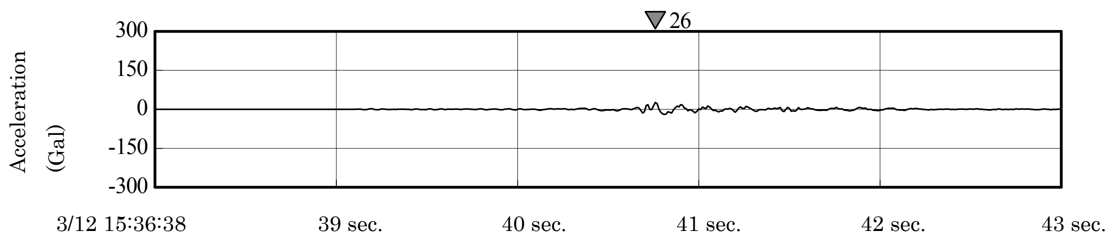
Observation Point C



Observation Point D

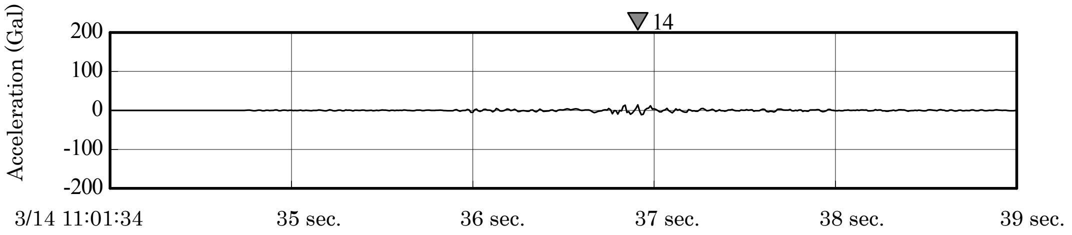


Observation Point E

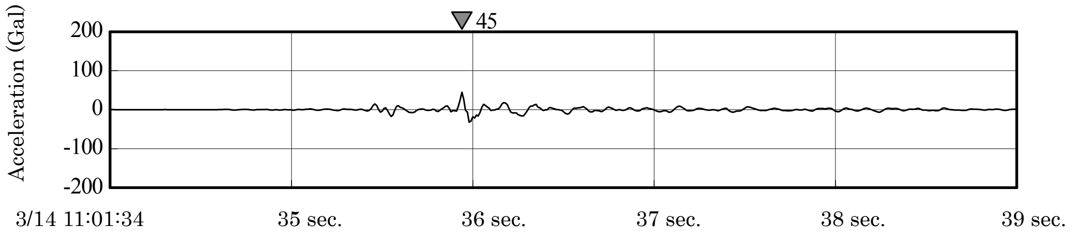


Acceleration wave for Unit 1 explosion (UD direction)

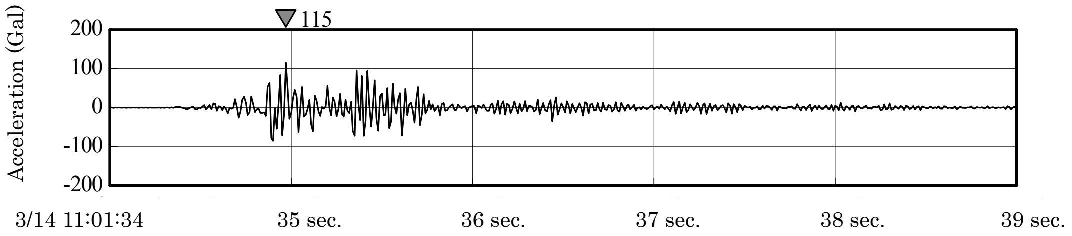
Observation Point A



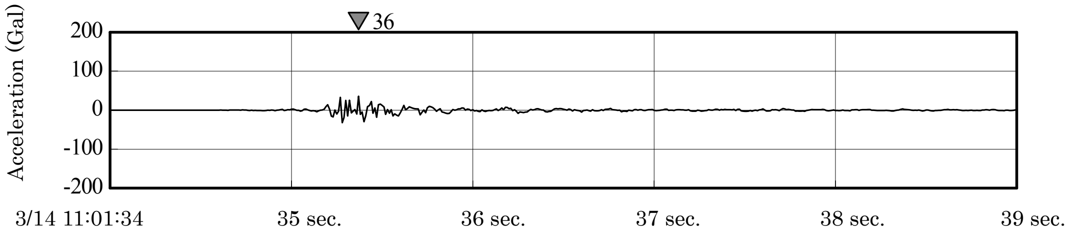
Observation Point B



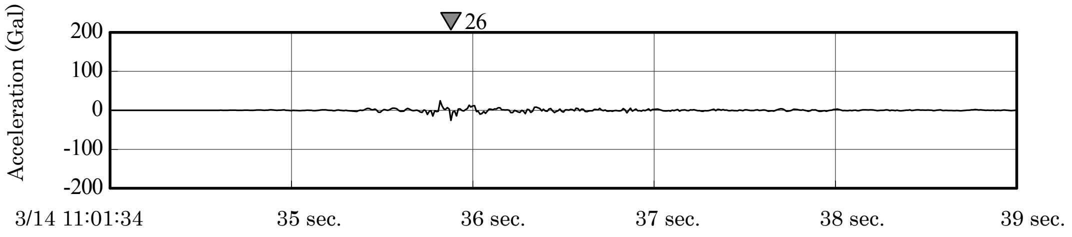
Observation Point C



Observation Point D

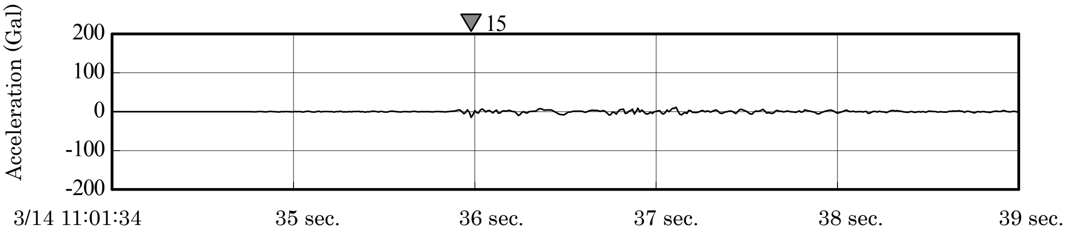


Observation Point E

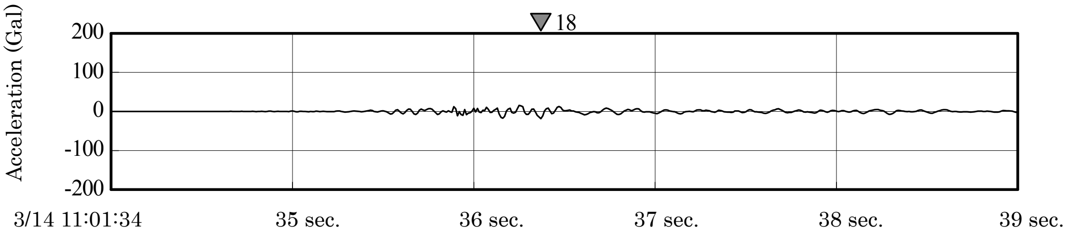


Acceleration wave for Unit 3 explosion (NS direction)

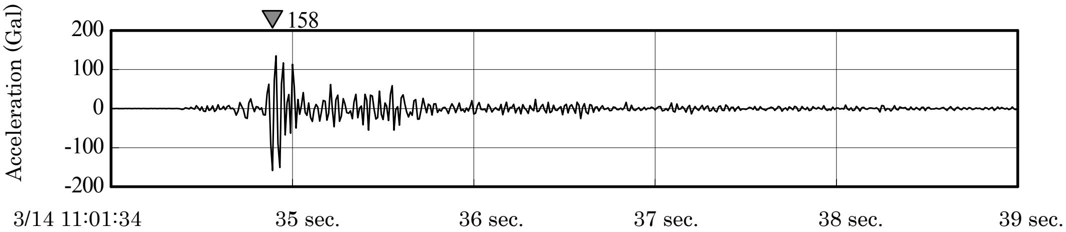
Observation Point A



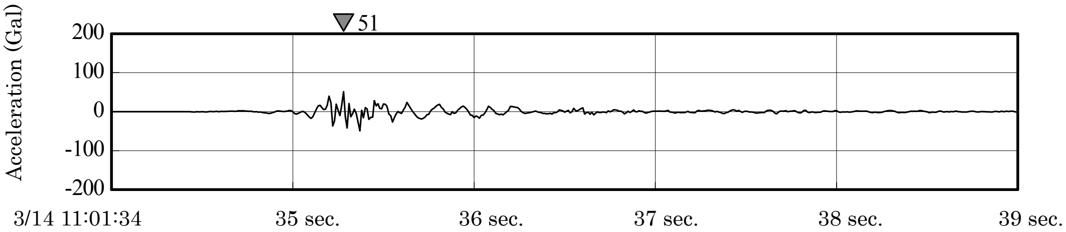
Observation Point B



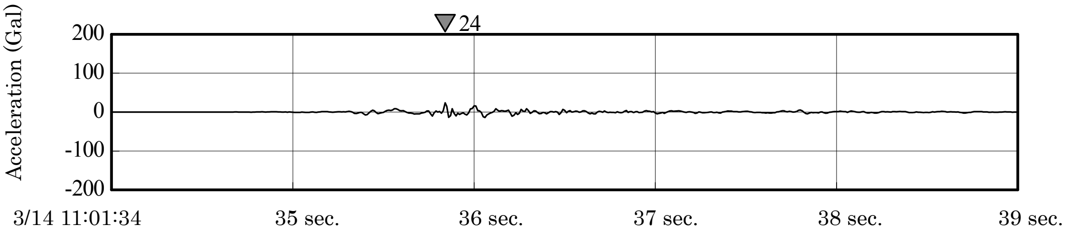
Observation Point C



Observation Point D

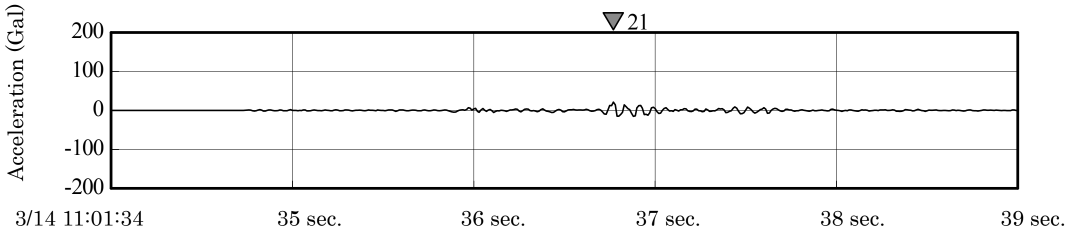


Observation Point E

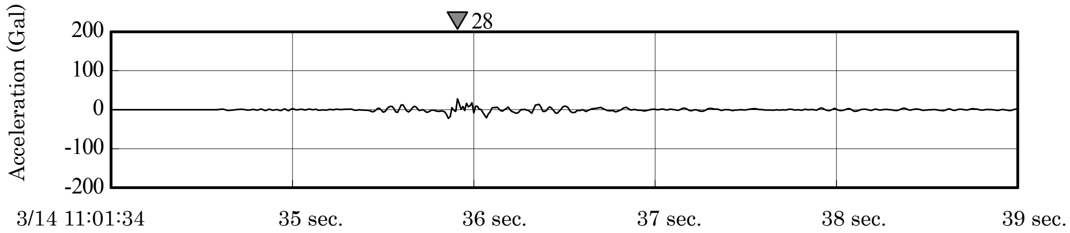


Acceleration wave for Unit 3 explosion (EW direction)

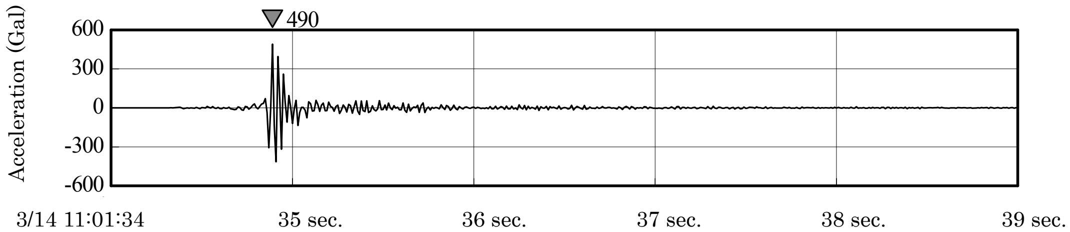
Observation Point A



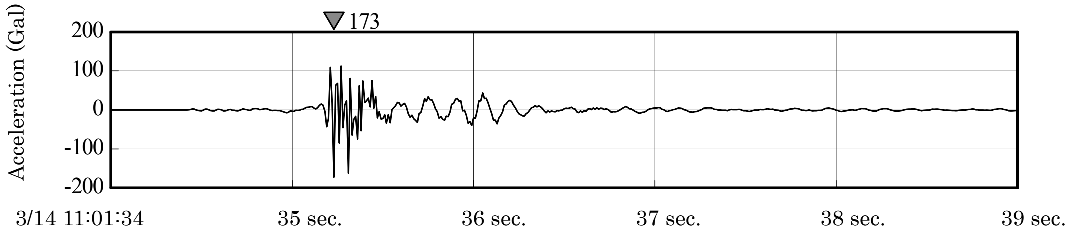
Observation Point B



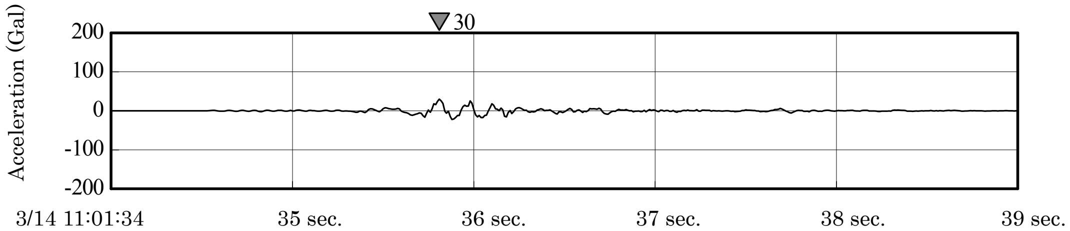
Observation Point C



Observation Point D

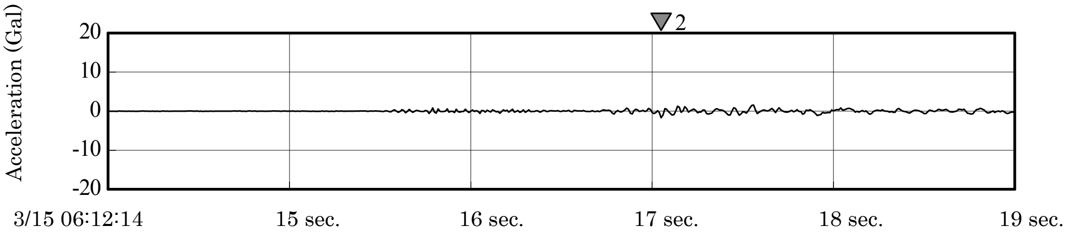


Observation Point E

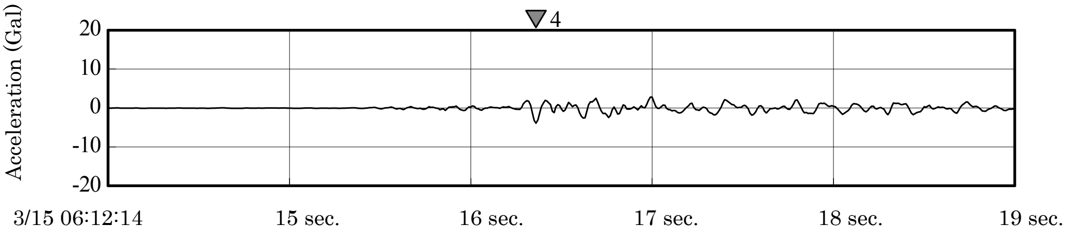


Acceleration wave for Unit 3 explosion (UD direction)

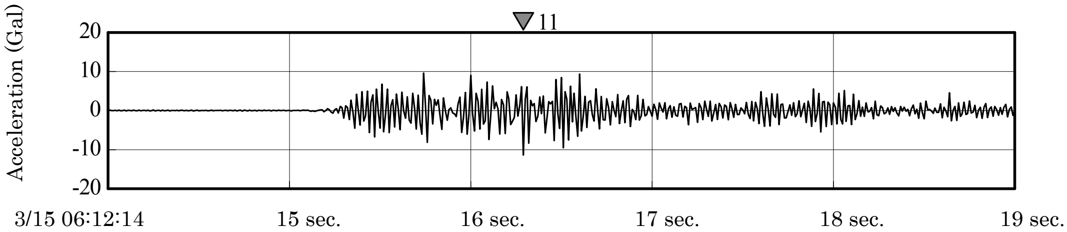
Observation Point A



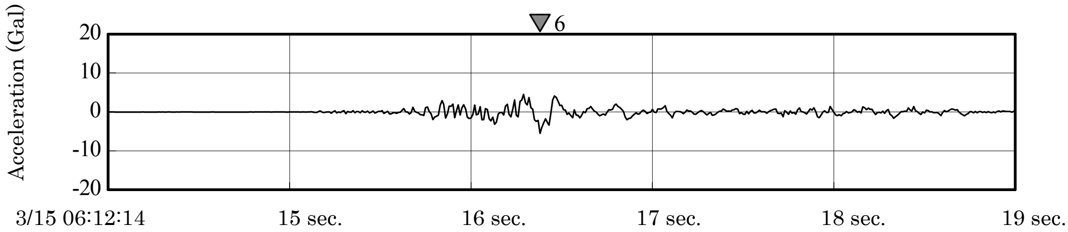
Observation Point B



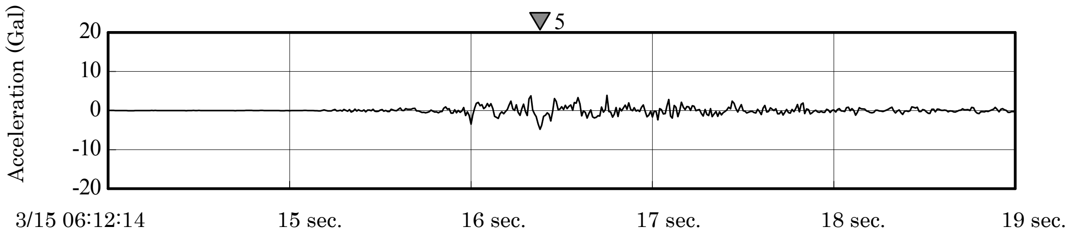
Observation Point C



Observation Point D

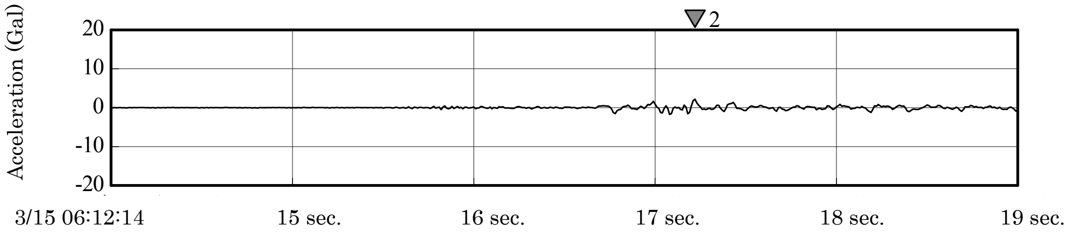


Observation Point E

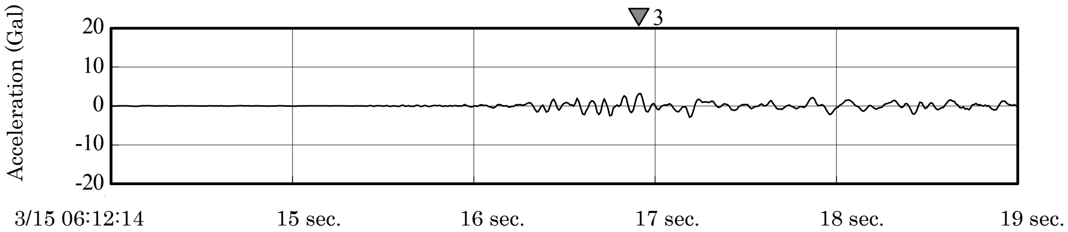


Acceleration wave at time when it is estimated that the Unit 4 explosion occurred (NS direction)

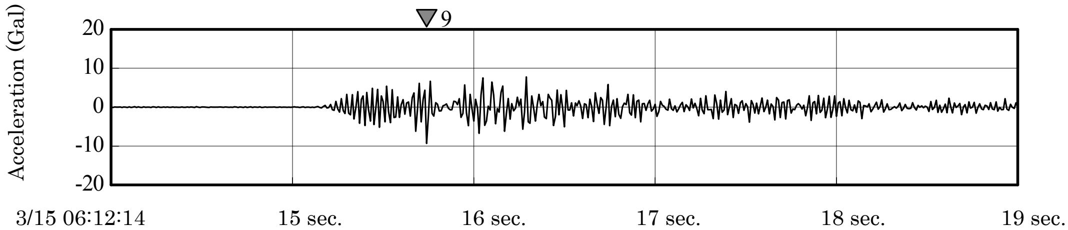
Observation Point A



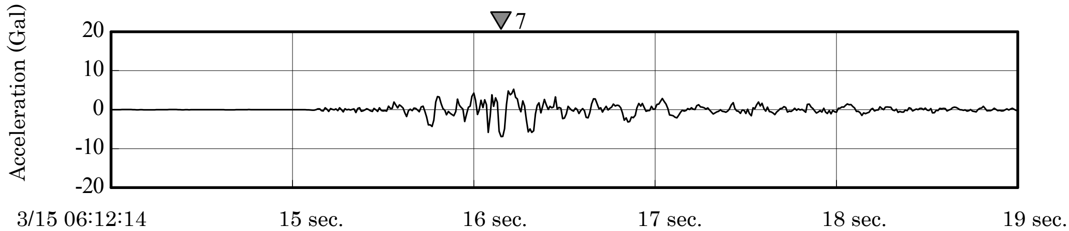
Observation Point B



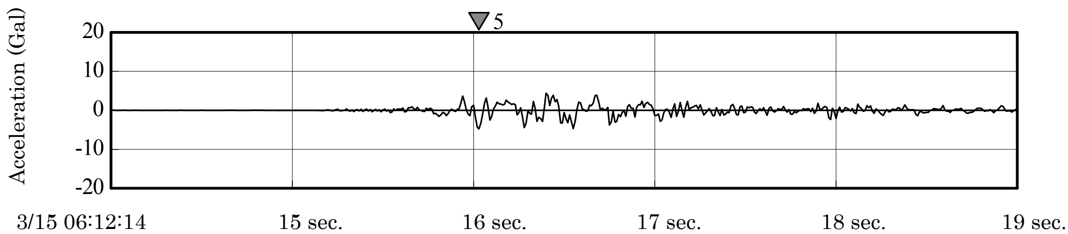
Observation Point C



Observation Point D

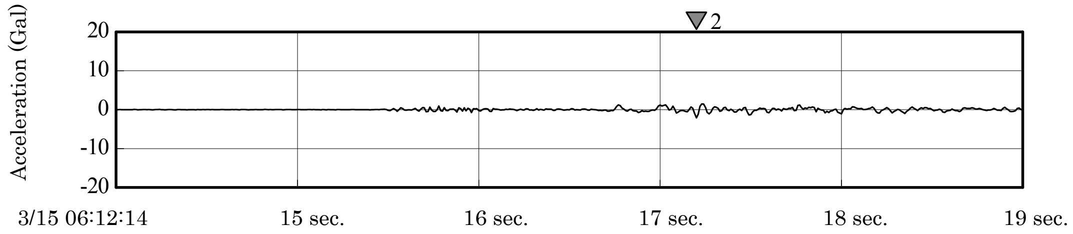


Observation Point E

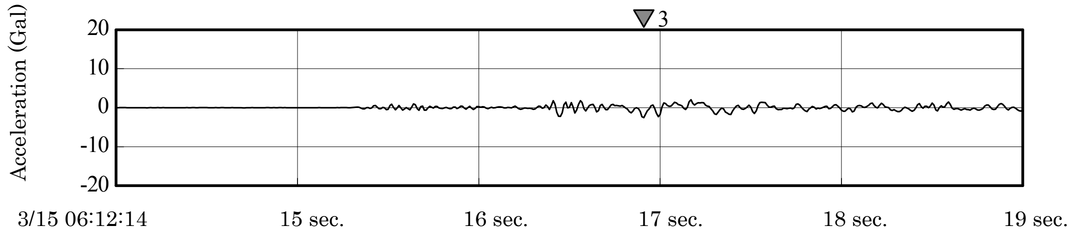


Acceleration wave at time when it is estimated that the Unit 4 explosion occurred (EW direction)

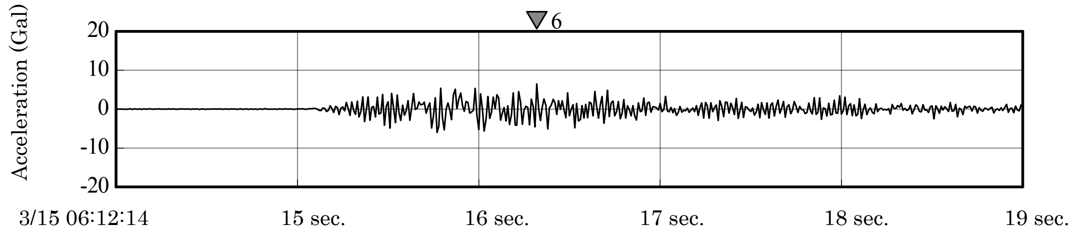
Observation Point A



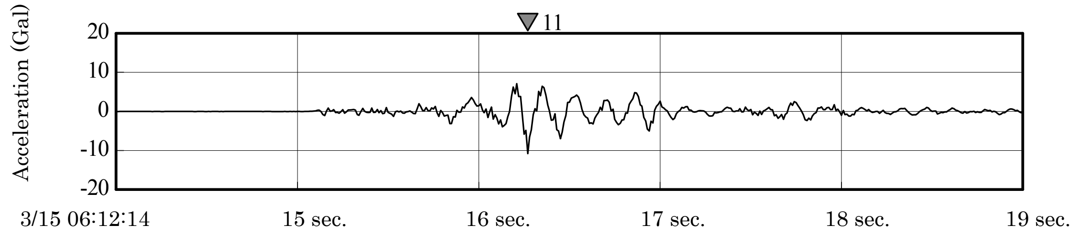
Observation Point B



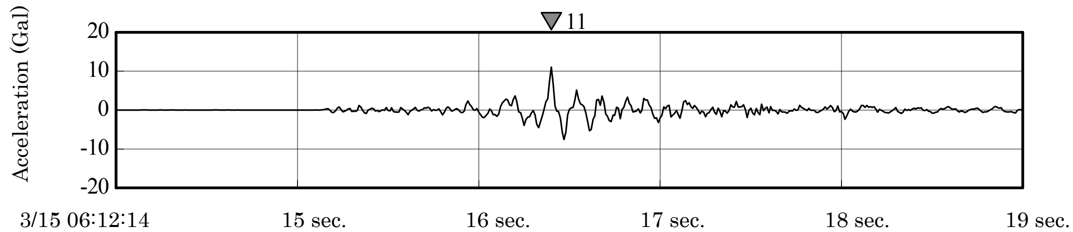
Observation Point C



Observation Point D



Observation Point E



Acceleration wave at time when it is estimated that the Unit 4 explosion occurred (UD direction)

Percentage of Fukushima Daiichi Unit 3 Venting Flow that Entered the Unit 4 Reactor Building (R/B)

1. Objective

It is estimated that it is possible that the hydrogen explosion that occurred at the Unit 4 reactor building was caused by vent gases that contained hydrogen flowing into the Unit 4 side during venting of the Unit 3 PCV since the Unit 4 standby gas treatment system (SGTS) exhaust pipes merge with the Unit 3 SGTS exhaust pipes right before the main stack. Therefore in regards to the percentage of Unit 3 vent flow that flowed in Unit 4 a general evaluation of the volume of hydrogen flow into Unit 4 from Unit 3 with considering the pressure losses in the pipes was performed.

2. Evaluation conditions and model

The evaluation model assumes that the pressure at the main stack outlet and within the Unit 4 reactor building is the same (equal to atmospheric pressure) and the relationship between the pressure losses on the main stack side and on the Unit 4 side are given using the following equation from corresponding pipe length and pipe diameter. Table 1 shows the primary evaluation conditions.

$$\frac{\Delta P_1}{\Delta P_2} = \frac{\frac{1}{2}\lambda \frac{L_1}{D_1} v_1^2}{\frac{1}{2}\lambda \frac{L_2}{D_2} v_2^2} \cong \frac{\frac{L_1}{D_1}\left(\frac{Q_1}{A_1}\right)^2}{\frac{L_2}{D_2}\left(\frac{Q_2}{A_2}\right)^2} = 1$$

In this equation,

v_1 : Flow speed within main stack (m/s)
v_2 : SGTS piping internal flow speed (m/s)
Q_1 : Main stack side flow volume (m^3)
Q_2 : Unit 4 side flow volume (m^3)
ΔP_1 : Main stack pressure loss (Pa)
ΔP_2 : Unit 4 Heating, Ventilating and Air Conditioning System, Standby gas treatment system (SGTS) pressure loss (Pa)
L_1 : Main stack side corresponding pipe length (m)
L_2 : Unit 4 side corresponding pipe length (m)
D_1 : Main stack side pipe diameter (mm)
D_2 : Unit 4 side pipe diameter (mm)
A_1 : Main stack piping internal cross-sectional area (mm^2)

A_2 : SGTS piping cross-sectional area (mm^2)
λ : Pipe friction coefficient

3. Evaluation results

It has been evaluated that approximately 40% of the volume that flowed into the main stack from the venting of Unit 3 flowed into the Unit 4 side.

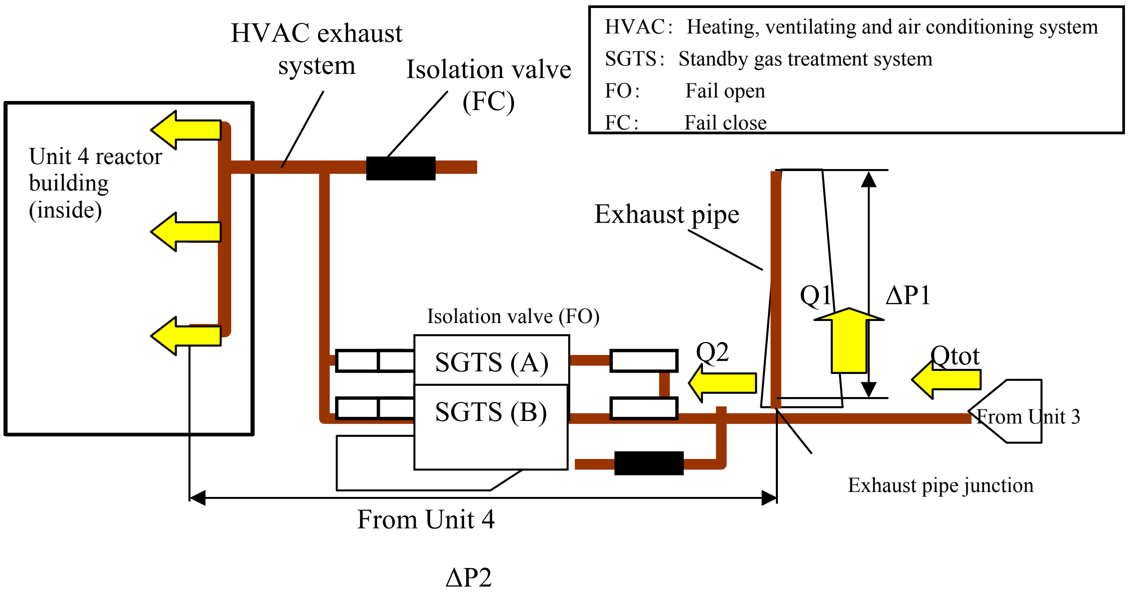
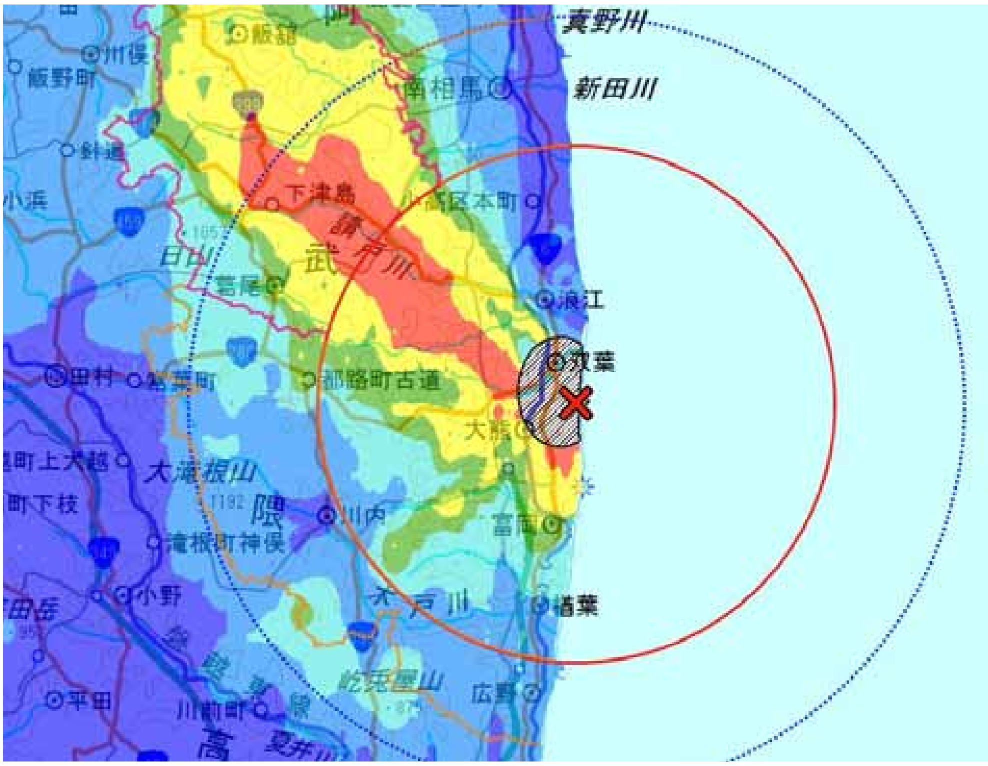


Figure 1 Evaluation model

Table 1 Evaluation conditions

Item	Value
D[1]: Main stack side pipe diameter (mm)	381.0
L[1]: Main stack side corresponding pipe length (m)*1	144
D[2]: Unit 4 side pipe diameter (mm)	333.4
L[2]: Unit 4 side corresponding pipe length (m)*2	481

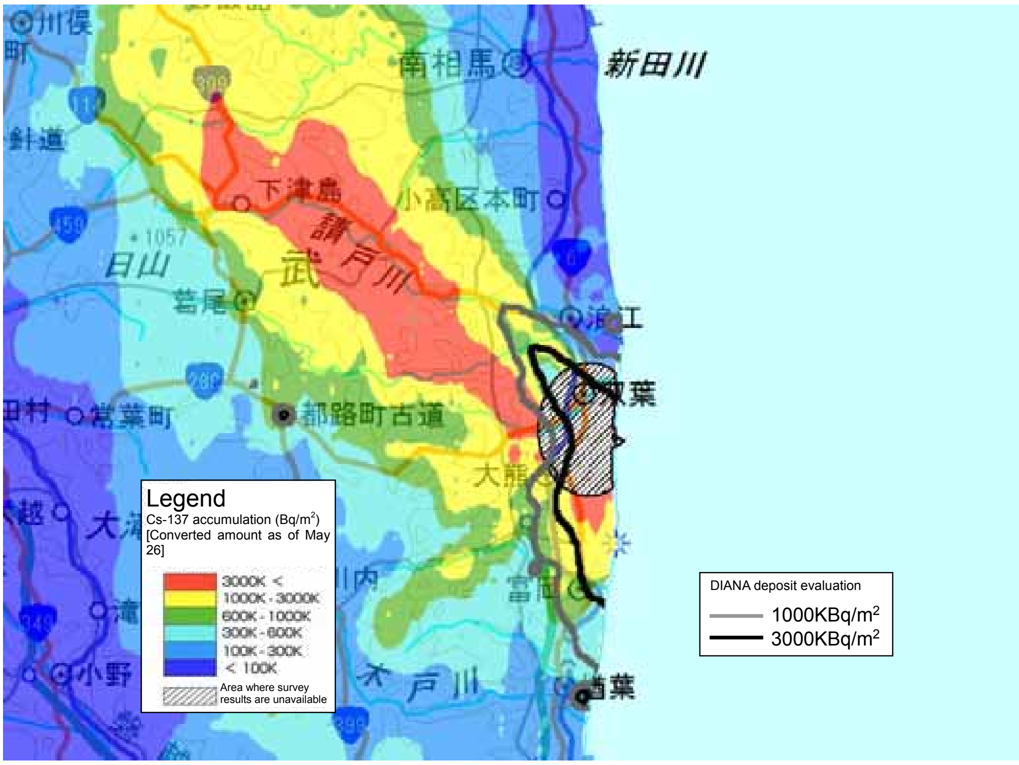
*1: Main stack side pipe length (m) = [Main stack height] + [Pipe length from junction to main stack tip] + [Corresponding length of elbow joint]
[Main stack height]: 120m
[Pipe length from junction to main stack tip]: 12m
[Corresponding length of elbow joint]: 12m
*2: Unit 4 side corresponding pipe length(m) = [SGTS pipe length] + [Corresponding length of valves, elbow joints, branching T's]
[SGTS pipe length]: 164m
[Corresponding length of valves, elbow joints, branching T's]: 317m



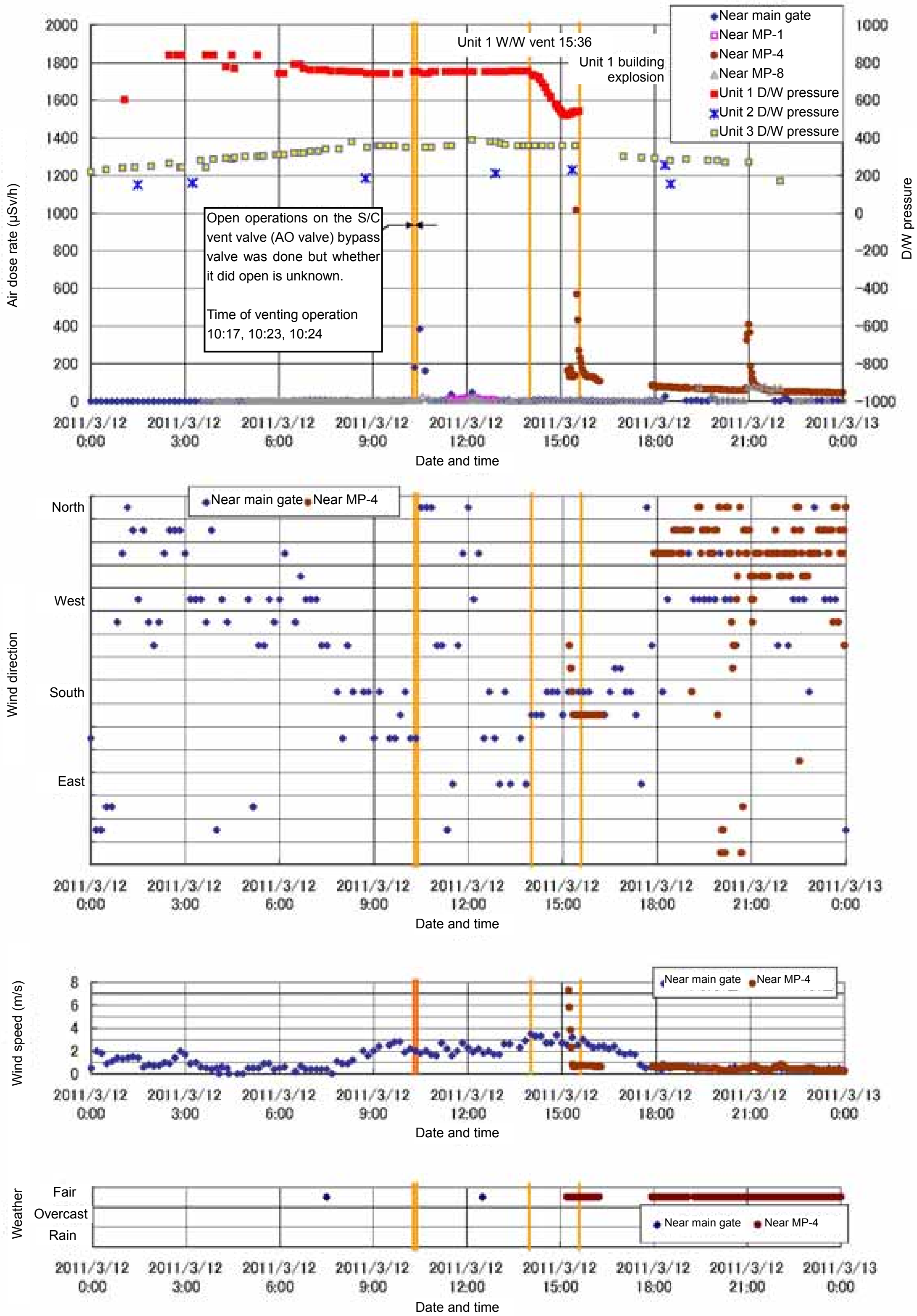
Soil sampling data

(Source: Radiation Dose Map HP http://ramap.jaea.go.jp/map/

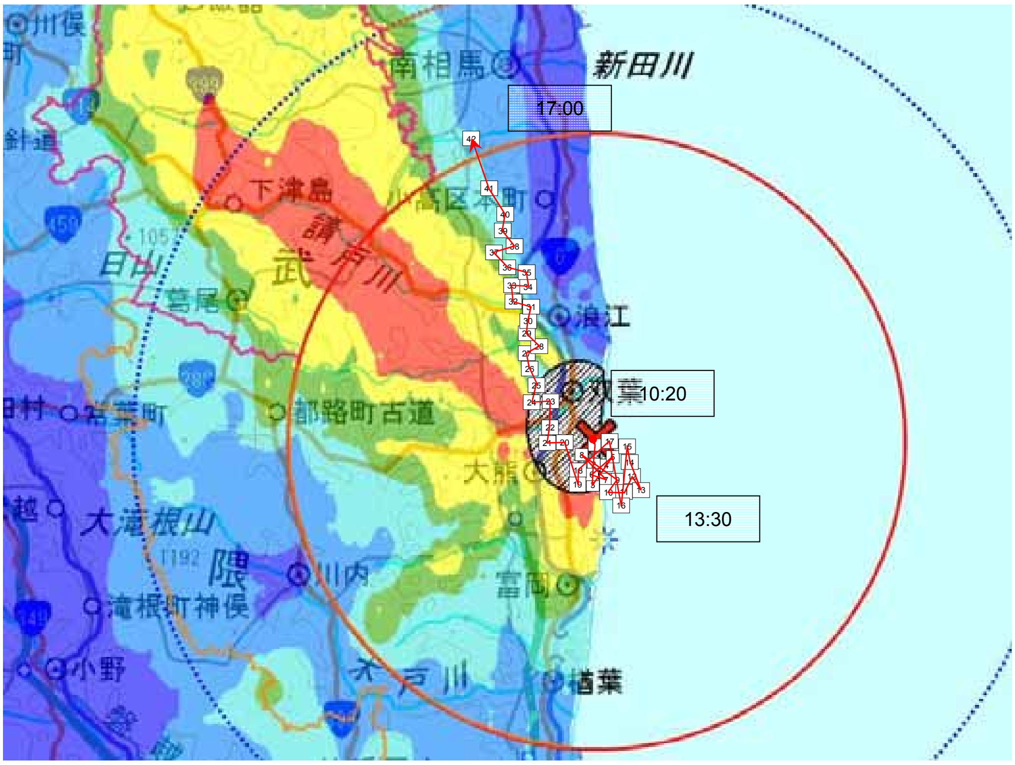
Ministry of Education, Culture, Sports, Science and Technology)



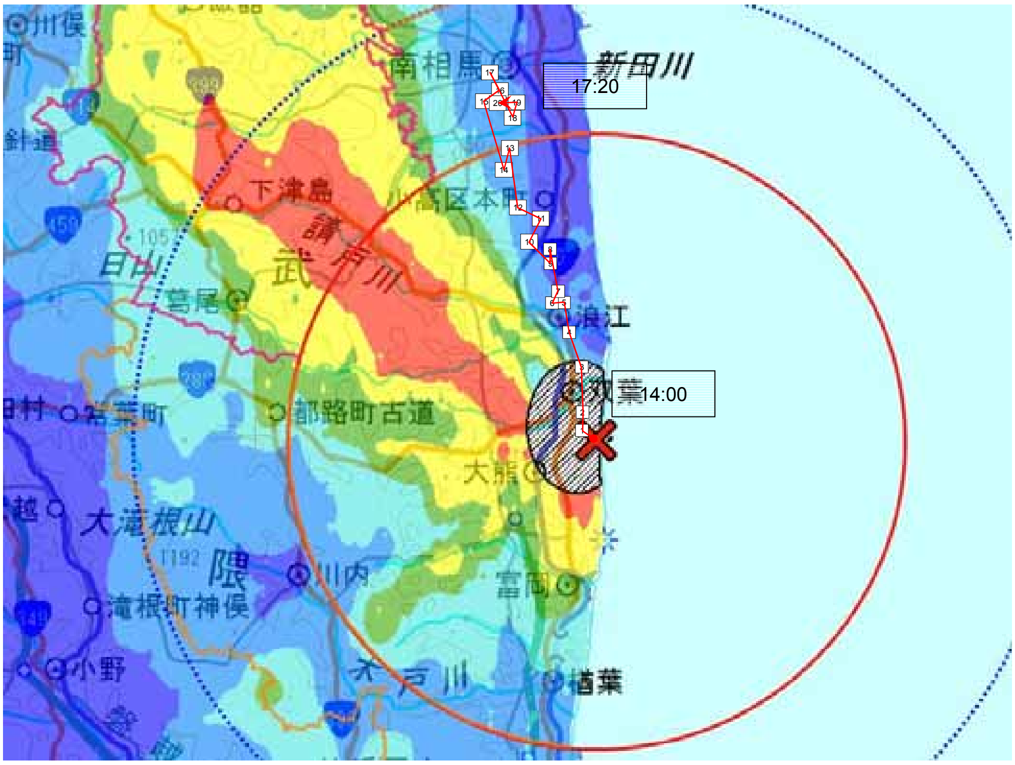
Comparison of DIANA evaluation results and MEXT survey results (Cs137 deposit status)



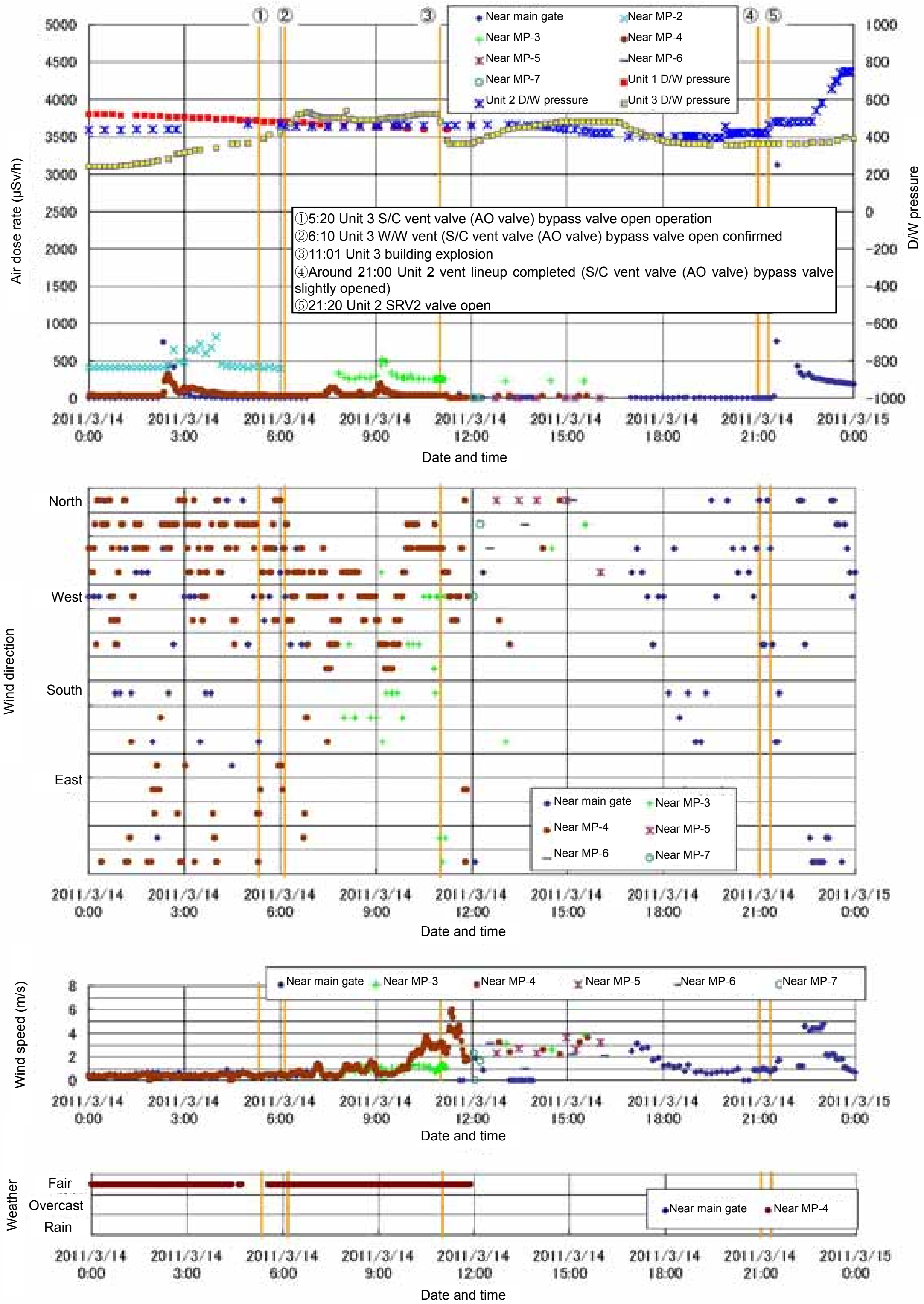
Monitoring data and trend data of wind direction (March 12)



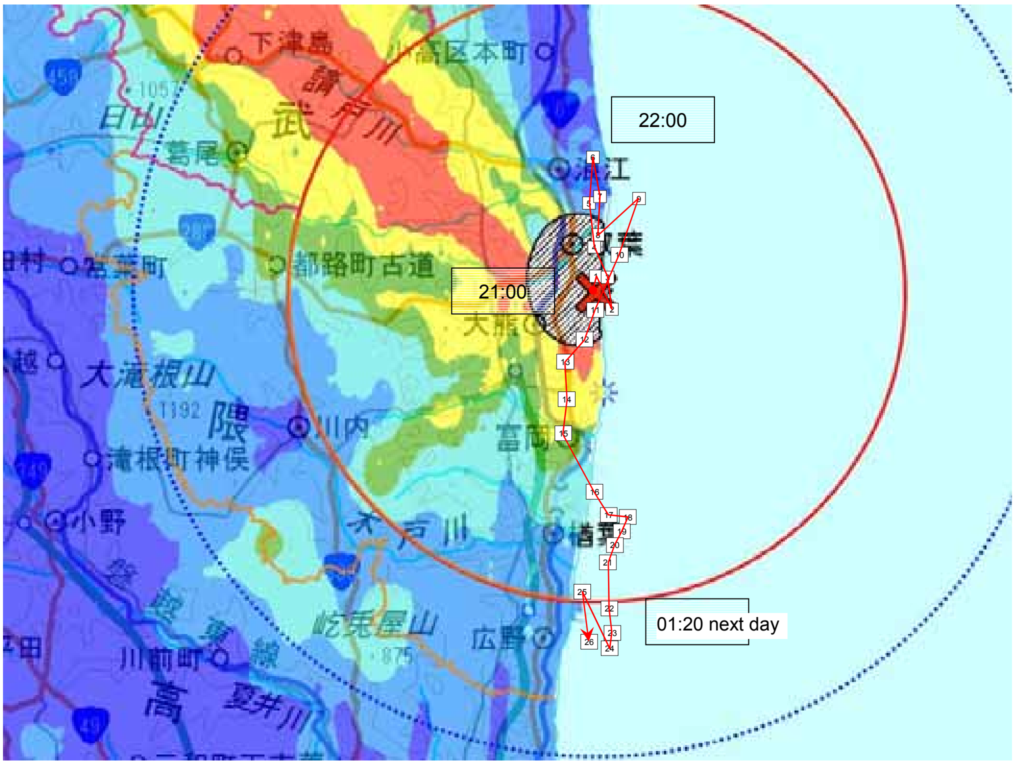
Trace of the "Steam Cloud" released when Unit 1 was vented at 10:00 on March 12



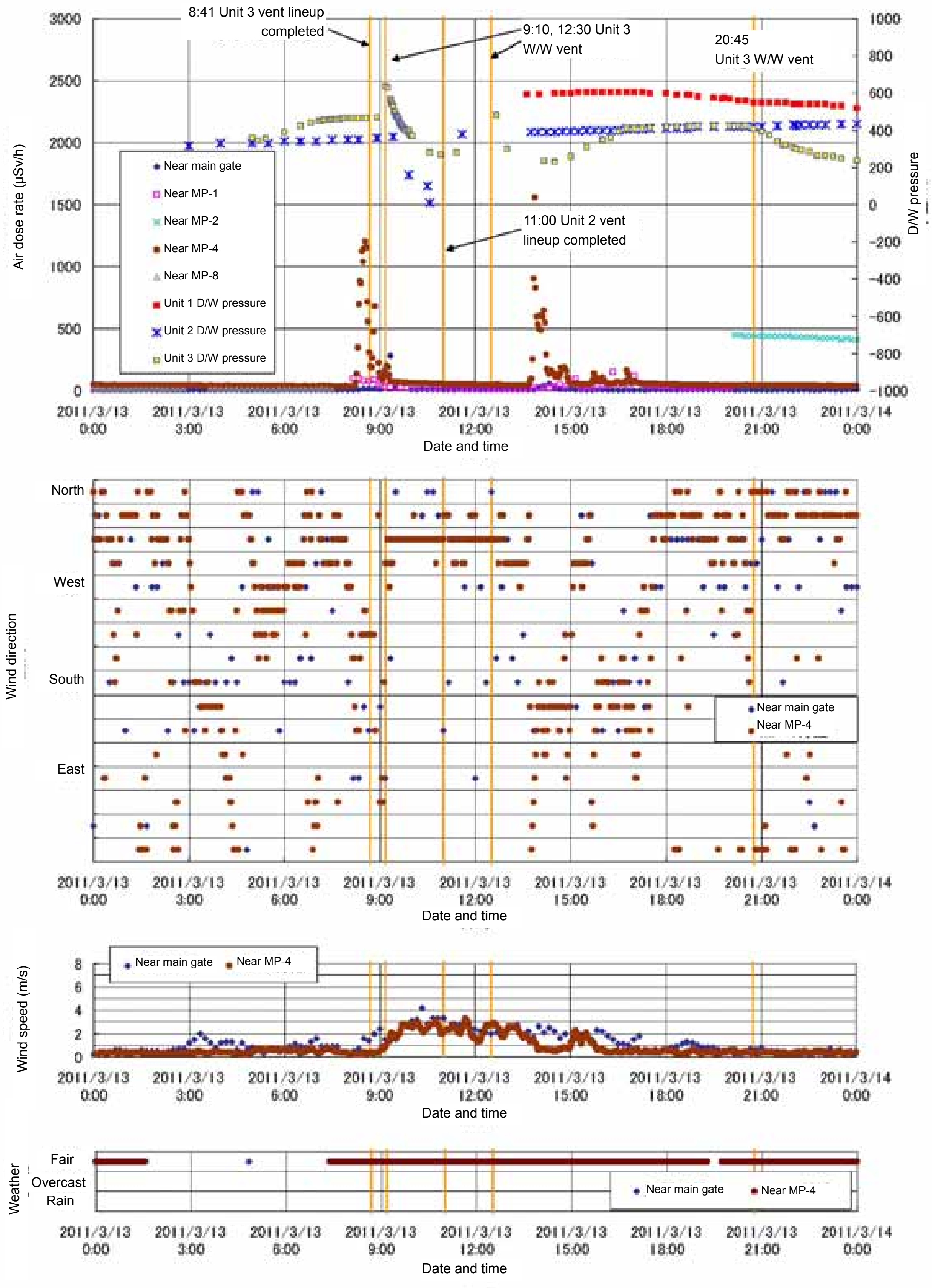
Trace of the "Steam Cloud" released when Unit 1 was vented at 14:00 on March 12



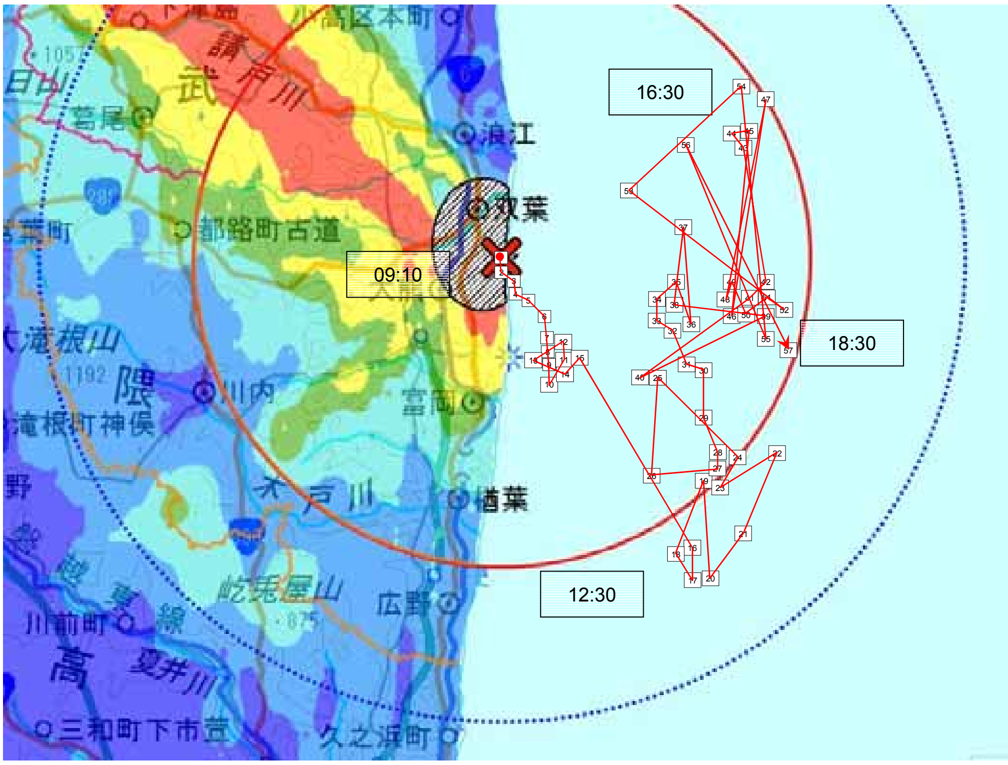
Monitoring data and trend data of wind direction (March 14)



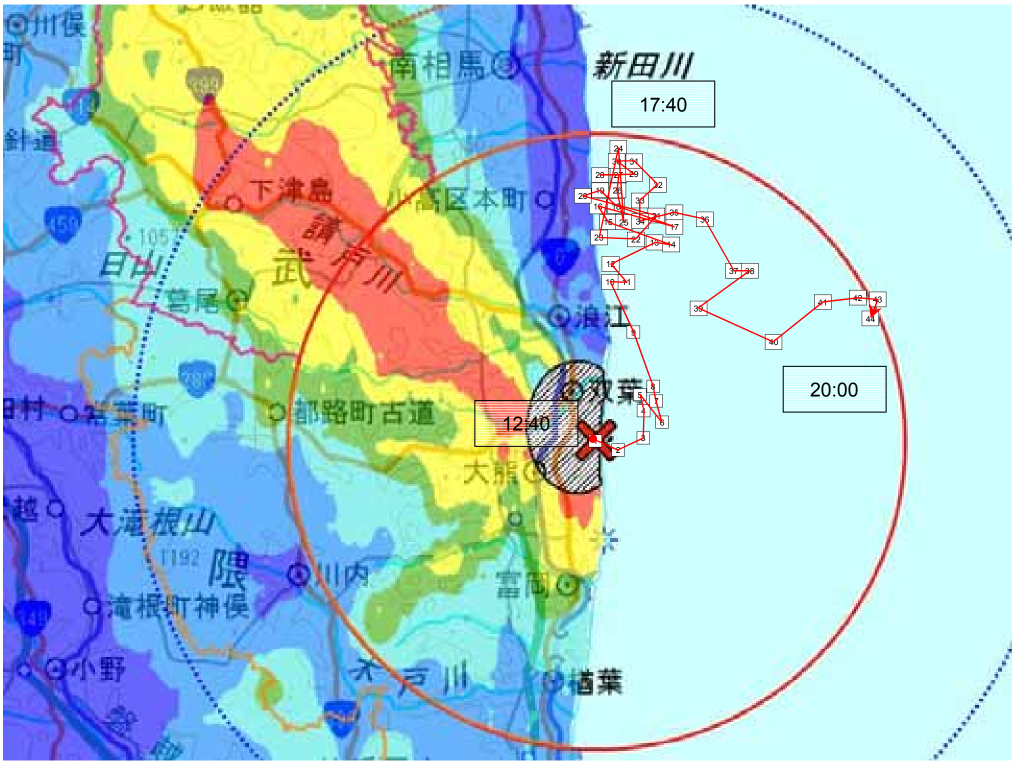
Trace of the "Steam Cloud" released when Unit 2 was vented at 21:00 on March 14



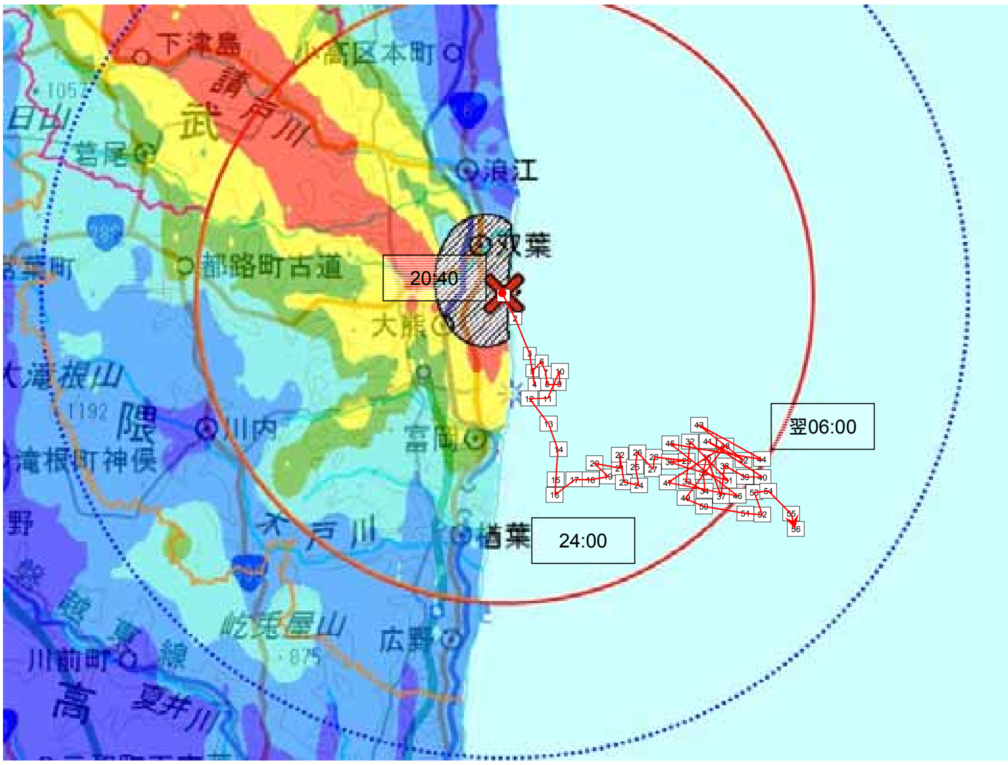
Monitoring data and trend data of wind direction (March 13)



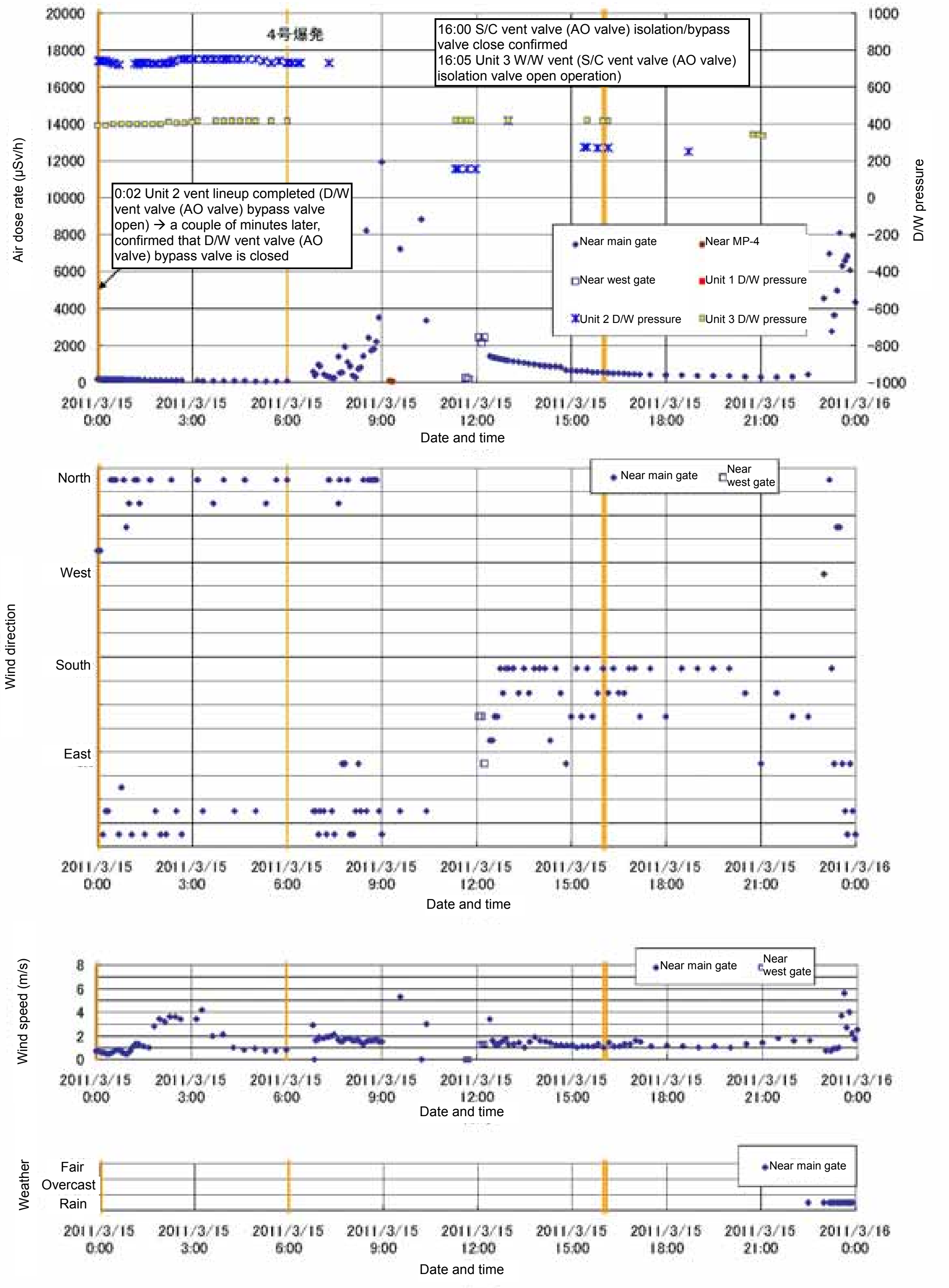
Trace of the "Steam Cloud" released when Unit 3 was vented at around 9:00 on March 13



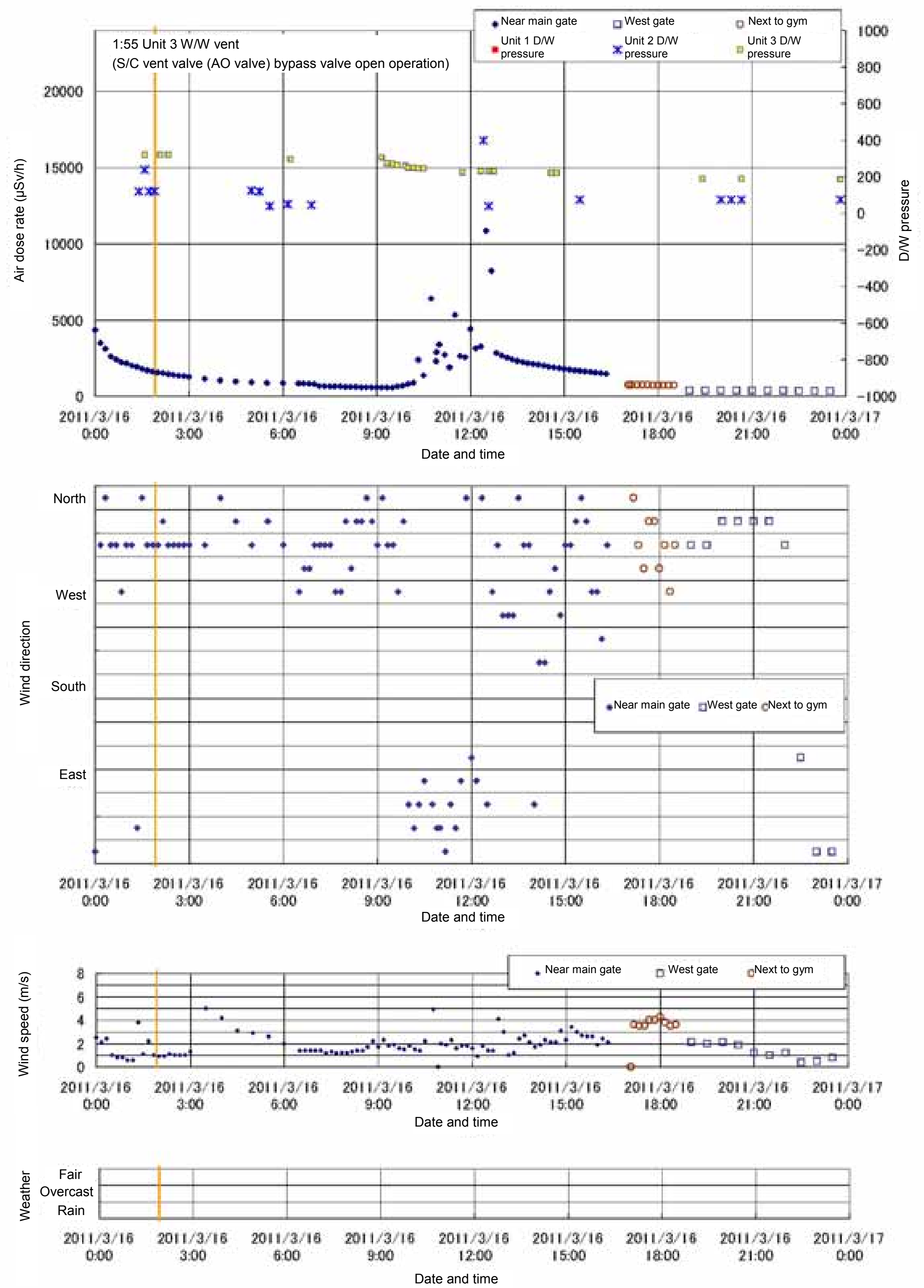
Trace of the "Steam Cloud" released when Unit 3 was vented at around 12:00 on March 13



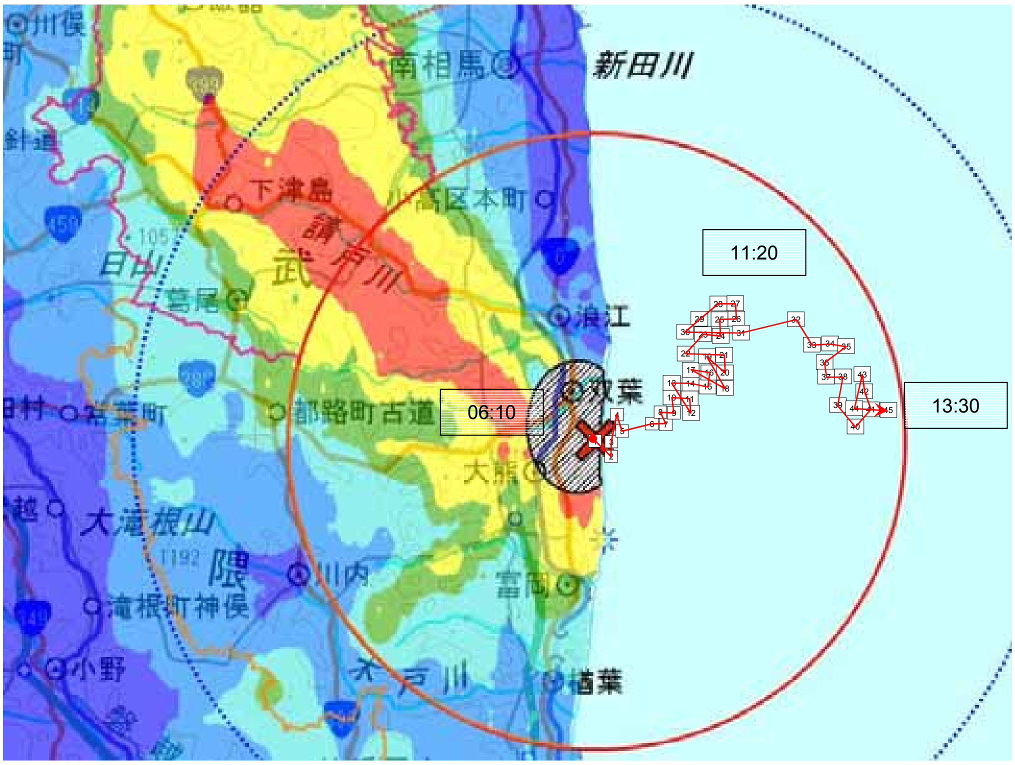
Trace of the "Steam Cloud" released when Unit 3 was vented at around 20:00 on March 13



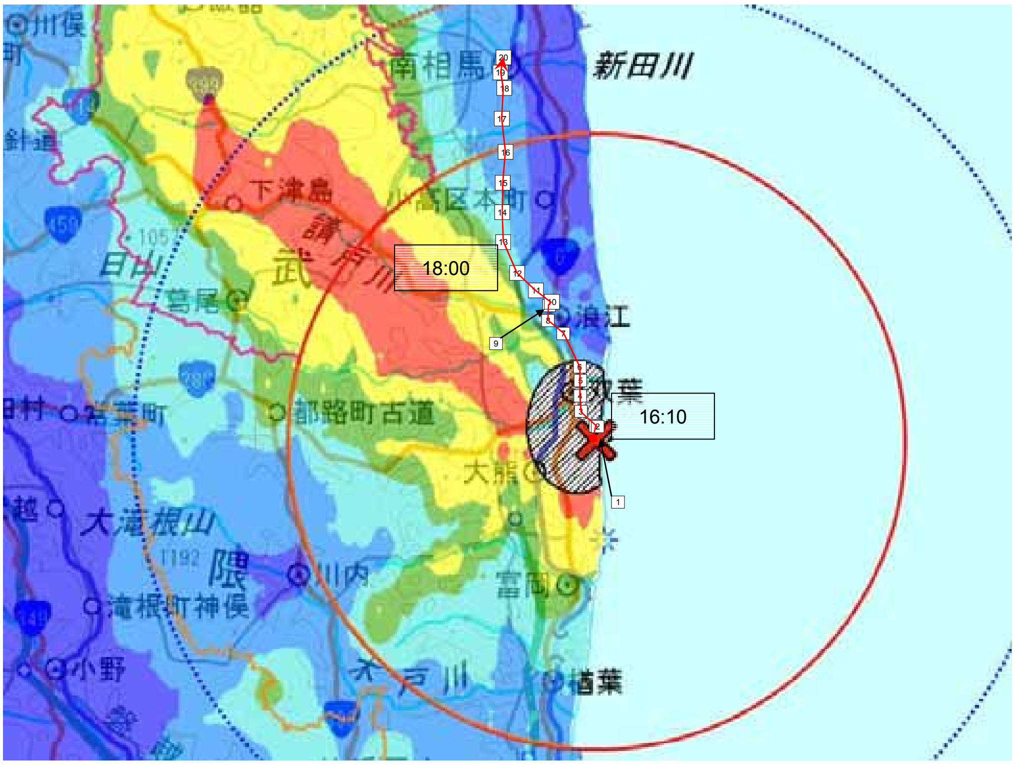
Monitoring data and trend data of wind direction (March 15)



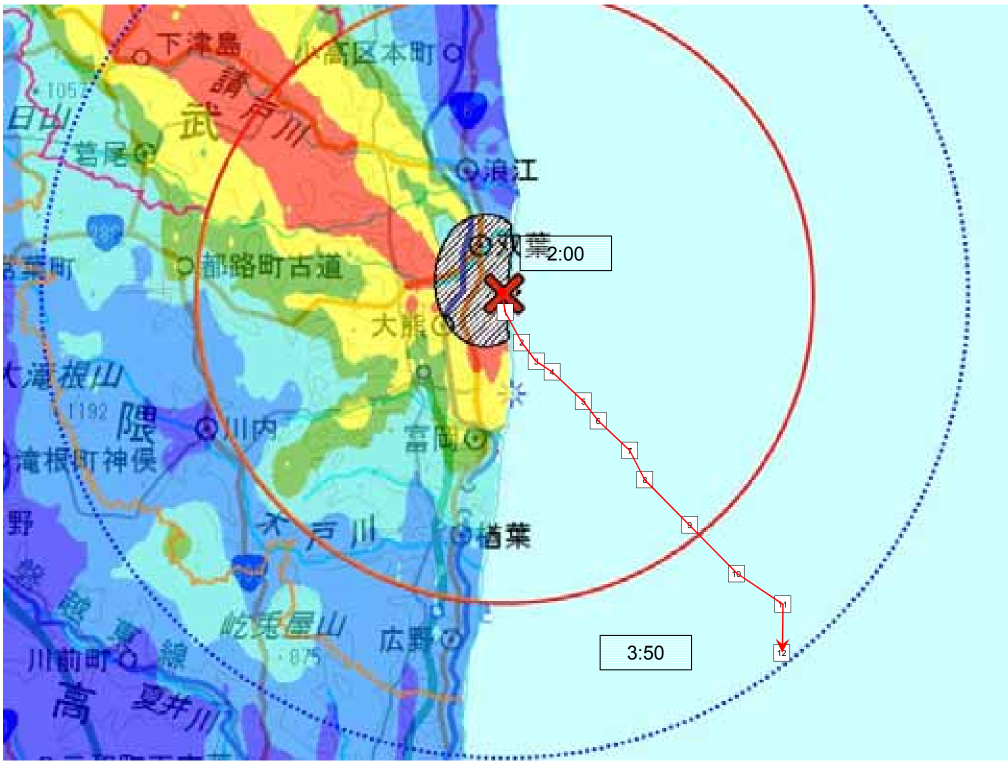
Monitoring data and trend data of wind direction (March 16)



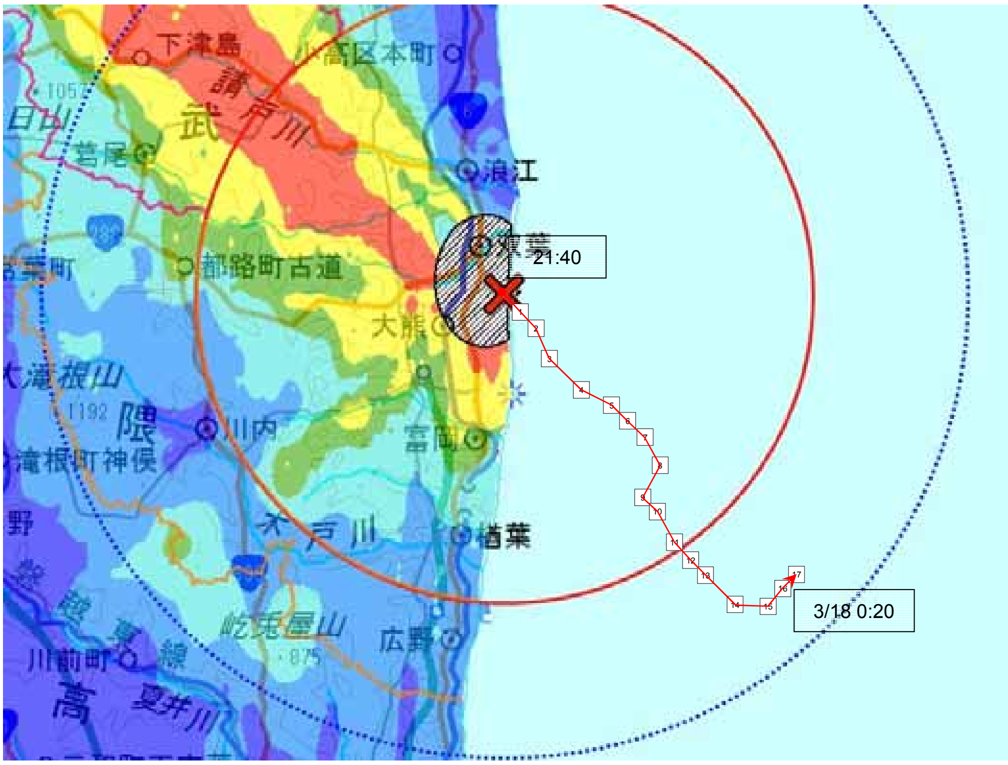
Trace of the "Steam Cloud" released when Unit 3 was vented at around 6:00 on March 14



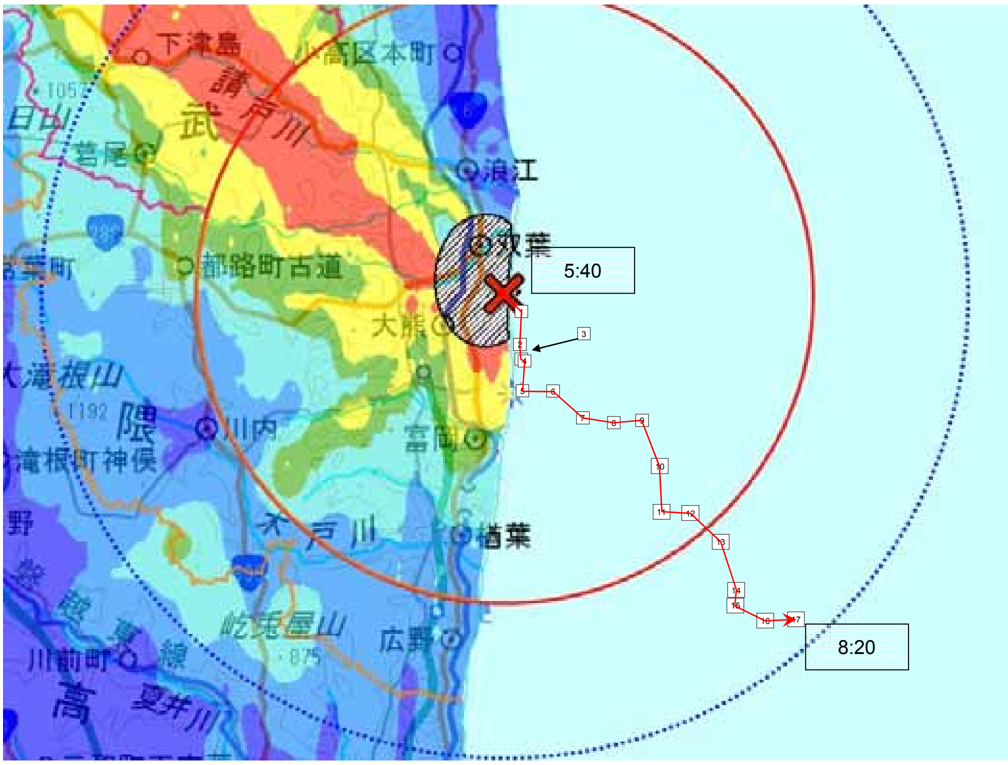
Trace of the "Steam Cloud" released when Unit 3 was vented at around 16:00 on March 15



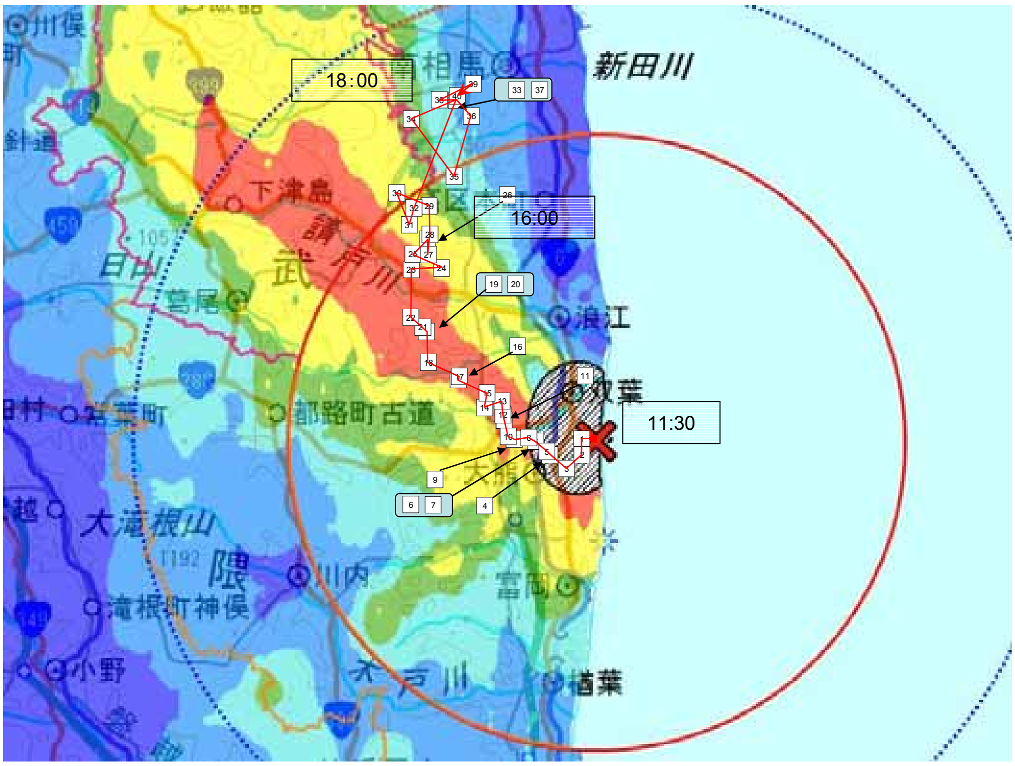
Trace of the "Steam Cloud" released when Unit 3 was vented at around 2:00 on March 16



Trace of the "Steam Cloud" released when Unit 3 was vented at around 21:00 on March 17

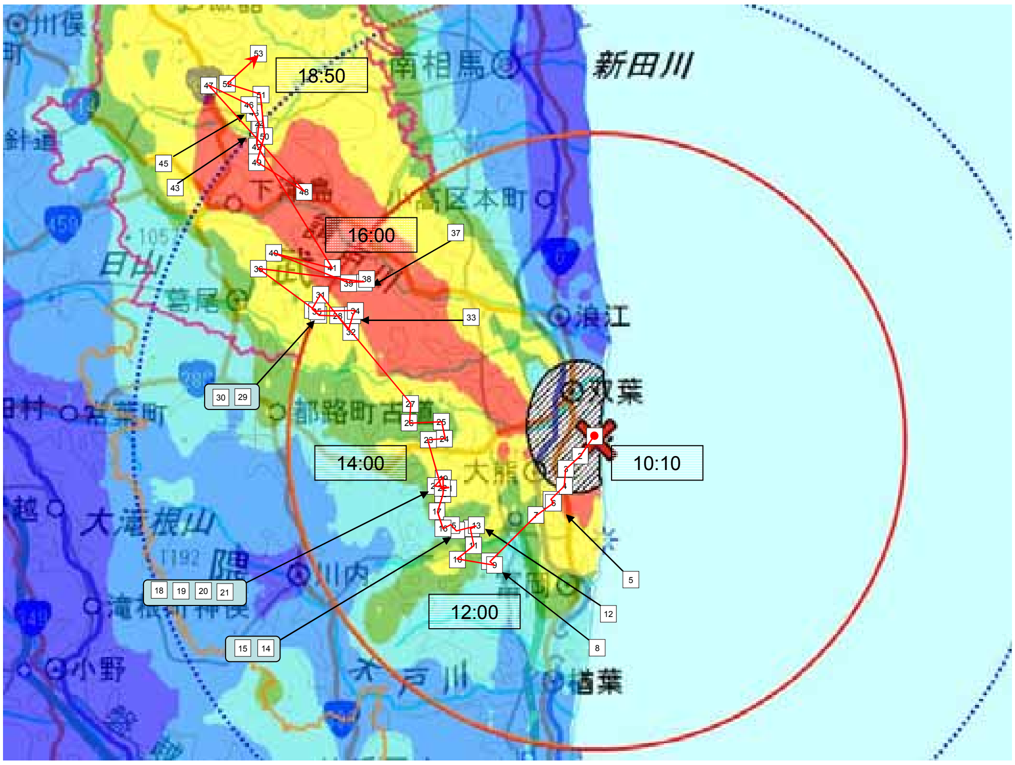


Trace of the "Steam Cloud" released when Unit 3 was vented at around 5:00 on March 18

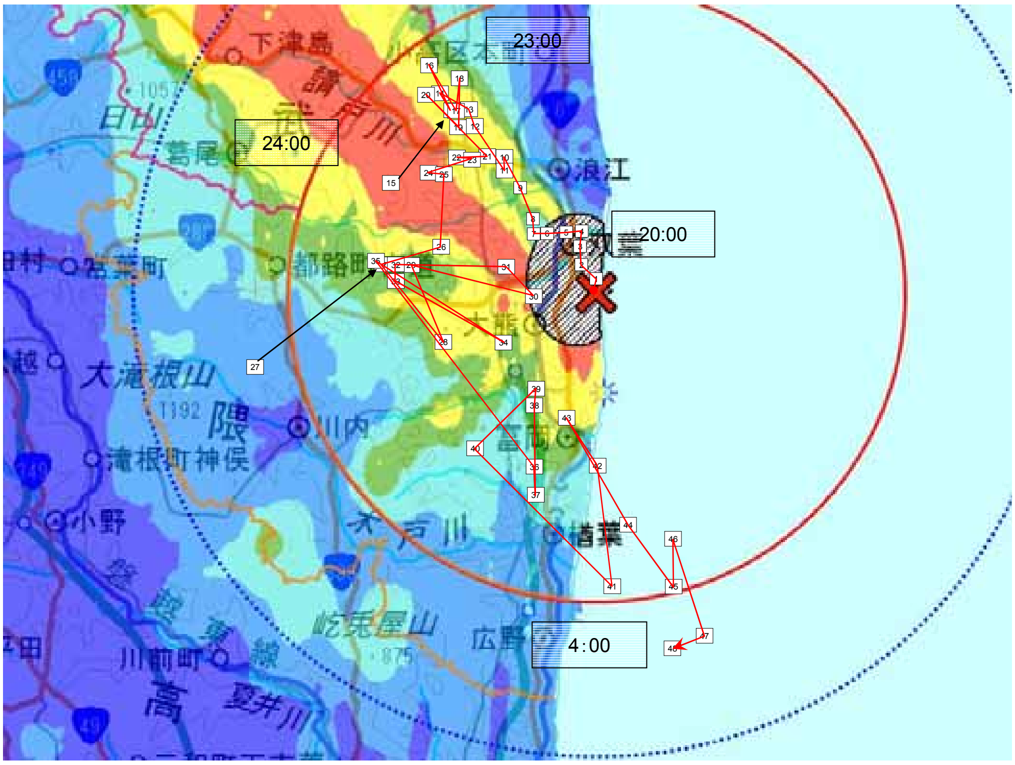


Trace of the "Steam Cloud" released when Unit 3 was vented at around 11:00 on March 20

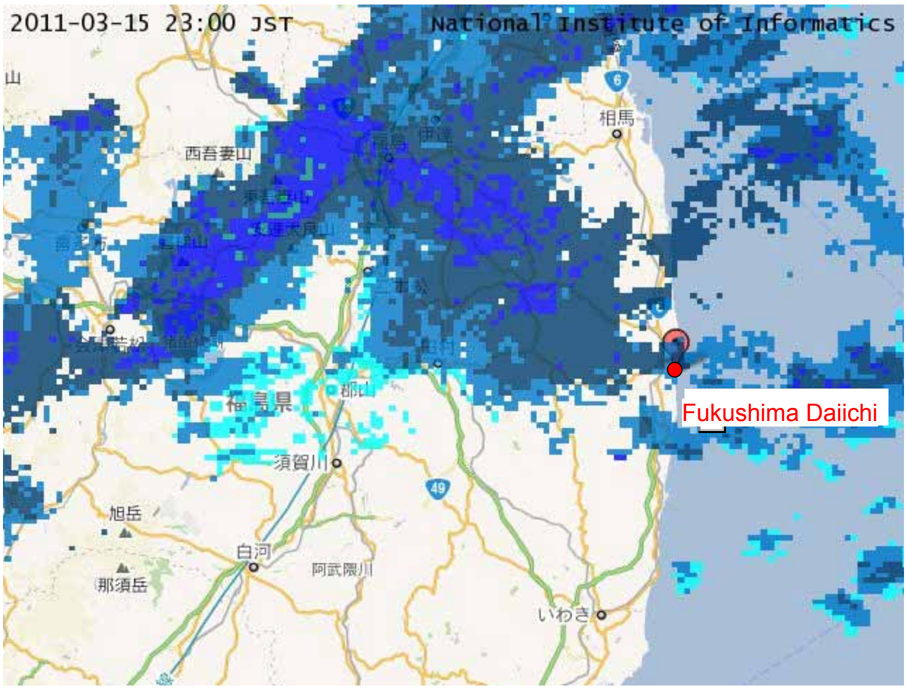
Fukuichi Live Camera footage (Around 10:00, March 15)



Trace of the "Steam Cloud" released when Unit 2 was vented at around 10:00 on March 15



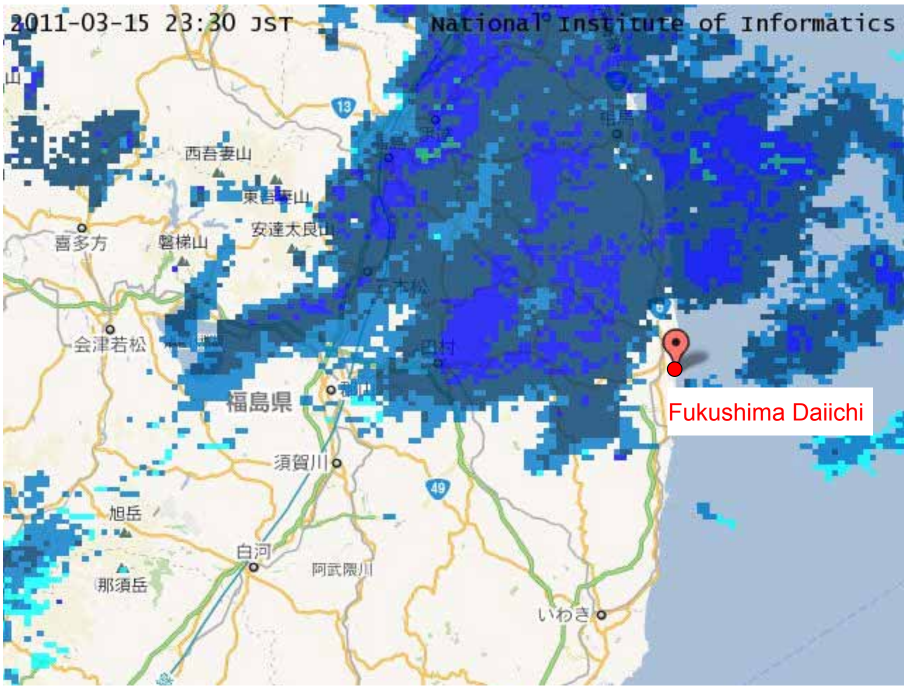
Trace of the "Steam Cloud" released when Unit 2 was vented at around 20:00 on March 15



Status of rain clouds in Fukushima Prefecture at around 23:00, March 15

(Source: National Institute of Informatics HP

http://agora.ex.nii.ac.jp/earthquake/201103-eastjapan/weather/data/radar-20110311/)



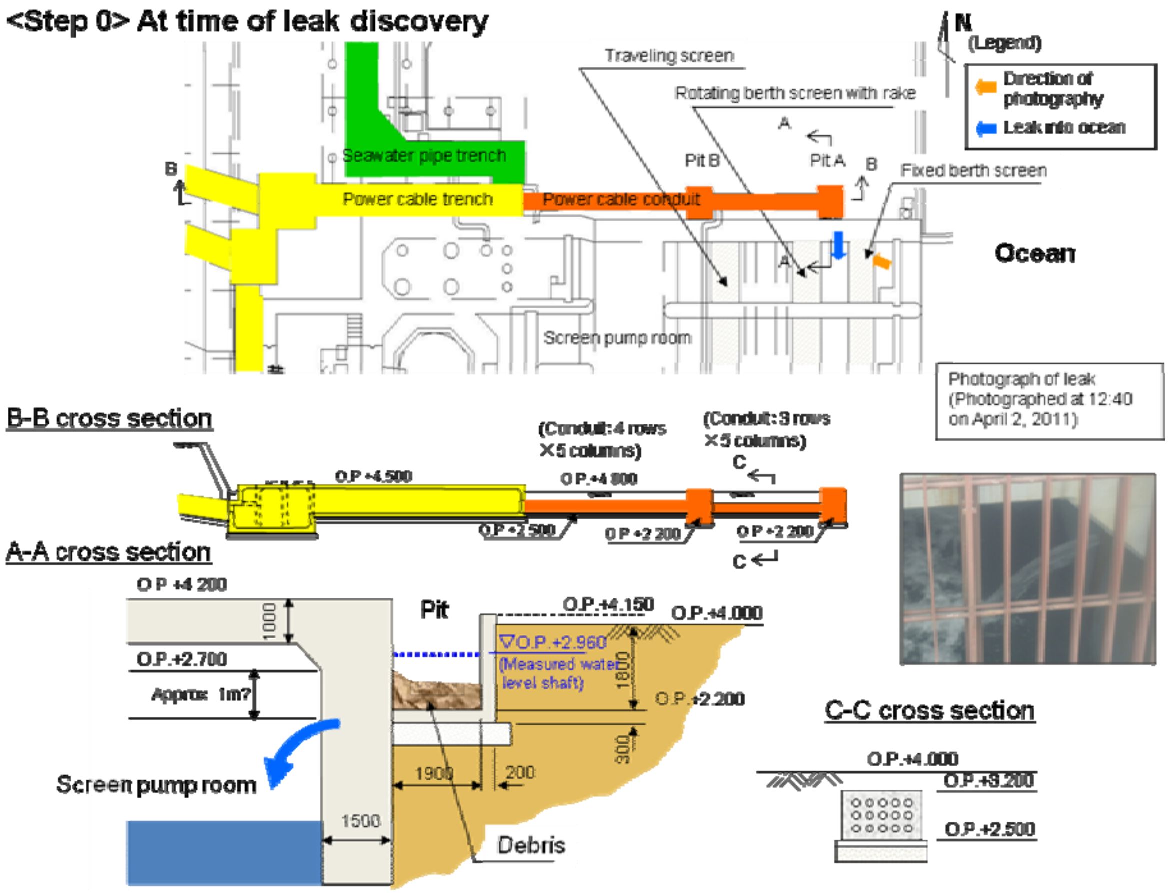
Status of rain clouds in Fukushima Prefecture at around 23:30, March 15

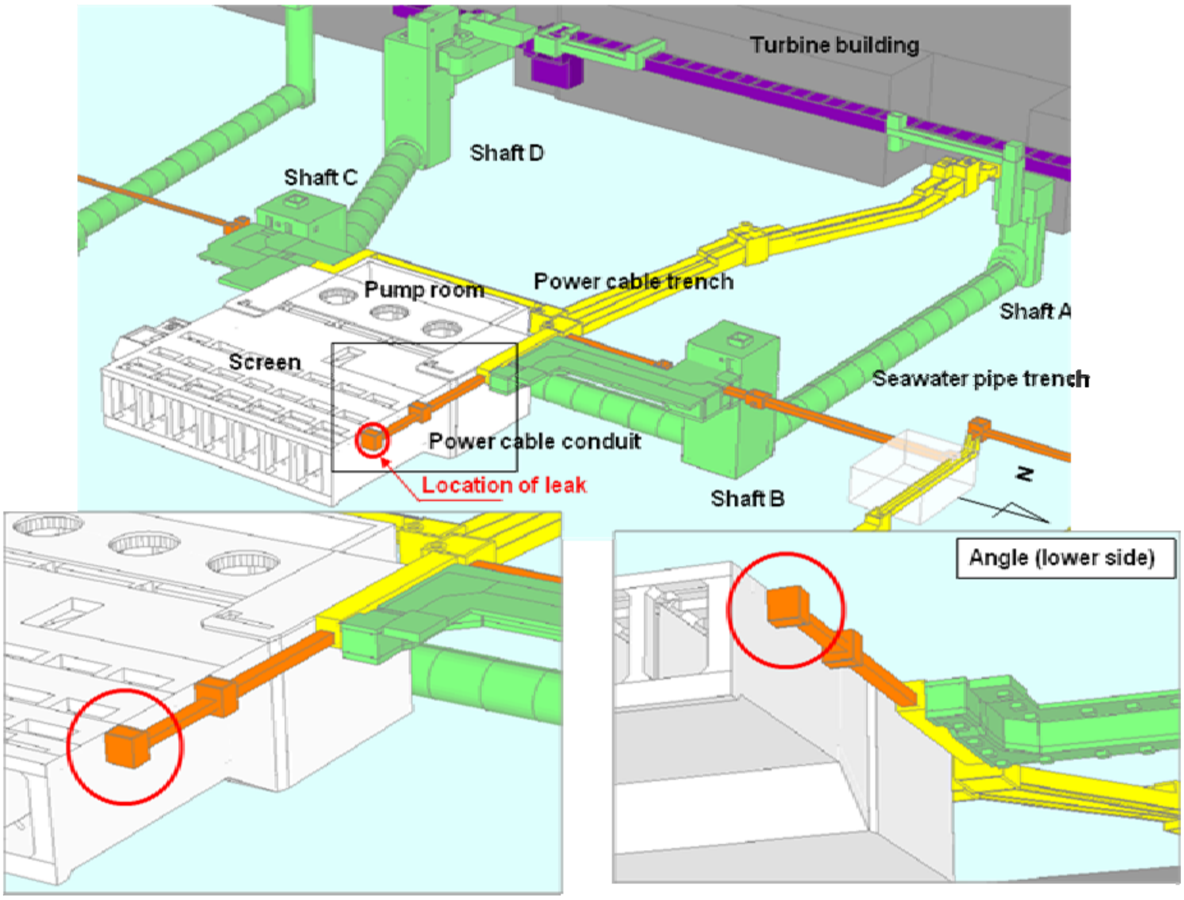
(Source: National Institute of Informatics HP

http://agora.ex.nii.ac.jp/earthquake/201103-eastjapan/weather/data/radar-20110311/)

Leak from area near Fukushima Daiichi Unit 2 Intake Screen

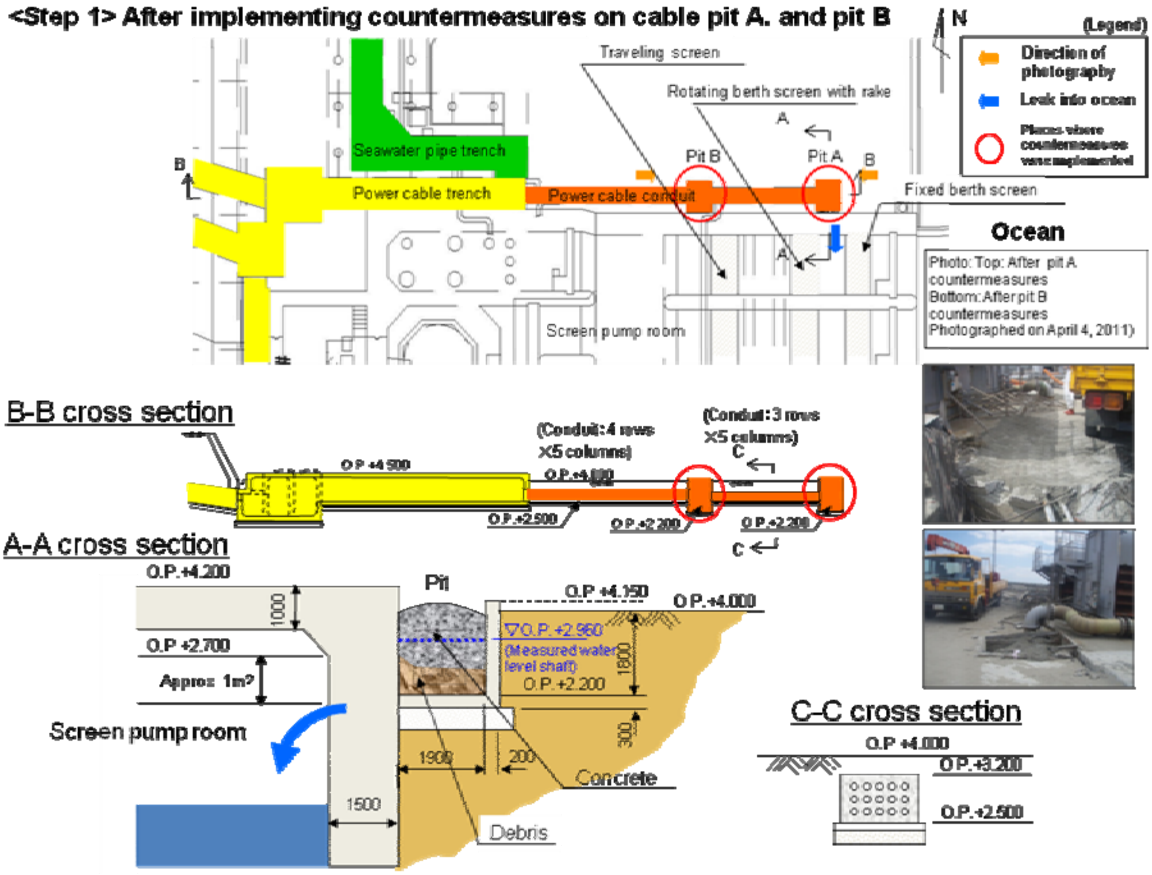
At around 9:30 on April 2, a TEPCO employee discovered that water with radiation levels that exceed 1000mSv/h had accumulated inside the trench pit where power cables are housed near the Unit 2 intake, that there were cracks in the concrete portions of the pit walls, and that the aforementioned water inside the pit was leaking into the ocean. (Step 0)



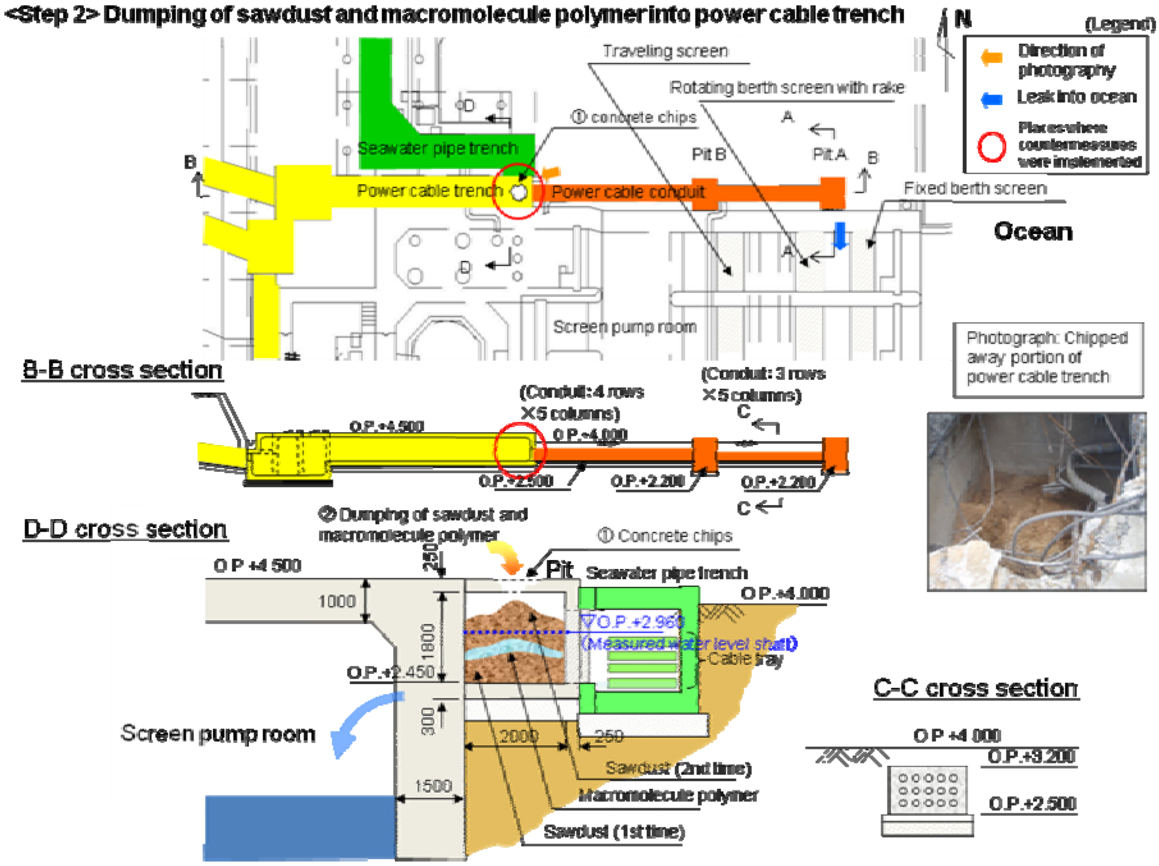


After the leak was discovered, methods for stopping the leak were immediately deliberated and the following action was taken.

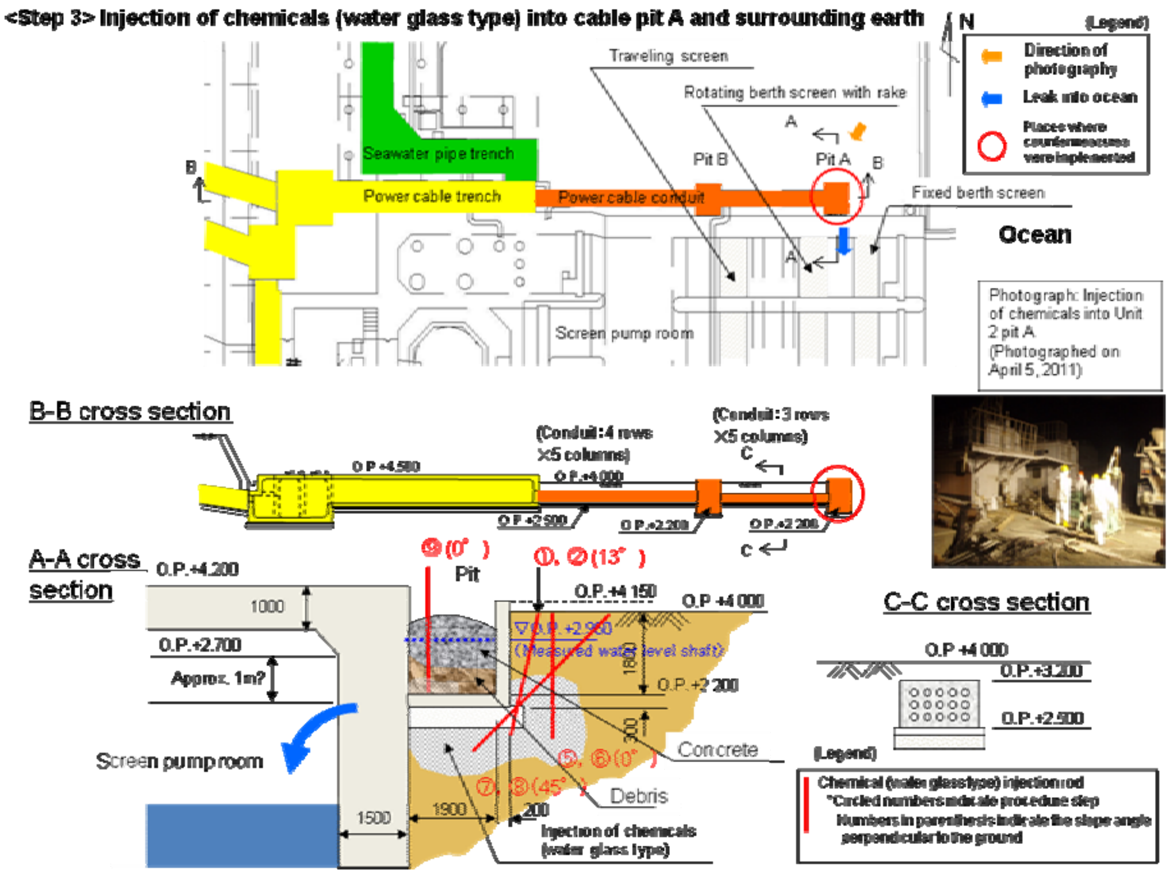
- At 14:52 on April 2, a concrete mixer truck arrived at the nuclear power station, and at 16:25, concrete started to be poured into the pit on the upstream (mountain) side (until around 16:50). At 19:02 concrete started to be poured into the pits on the downstream (ocean) side (~19:13), and the pouring of concrete was terminated when the pit was filled with concrete almost to the top, however the pouring of concrete did not stop the leak. (Step 1)



- At 12:07 on April 3, the trench duct top plate started to be destroyed in order to stop the leak by filling the pit with sawdust and a macromolecule polymer. The top plate was completely dismantled at 12:22, and at 13:47 five barrels of sawdust were poured into the pit. Thereafter, 80 bags of polymer and five barrels of sawdust were thrown into the pit. At 14:05 10 bundles (3 kg per bundle) of newspaper were added, and at 14:30 more sawdust was thrown in. Workers then retreated after alarmed pocket dosimeters (APD) started to sound. The sawdust was dry so at 17;42, in order to mix it with water, a mixer truck was brought to the pit opening in order to inject water which concluded at 17:52 with no effect. (Step 2)



- At 7:08 on April 4, 13 kg of tracer started to be dumped into shaft (B). This concluded at 7:11 but no change was seen.
- On April 5, machinery to inject a coagulant (water glass) was set up in the morning and injection began at 14:00. (Step 3)



✧ At 14:18 two holes were drilled (bored) in the pit (No. 1, 2) and tracer was injected at 14:23 (through hole No. 1) and the leak was checked (the same was done through hole No. 2 at 14:34).

✧ At 15:07 coagulant was injected (No. 1, 2) and at 16:00, 1500 liters of coagulant was injected.

✧ At 20:02 another hole was bored (No. 5) (No. 6 was bored at 20:16), and tracer was injected at 20:42 (No. 5) (tracer was injected into No. 6 at 21:50).

✧ At around 22:00 coagulant was injected (No. 5, No. 6) and at 22:45 coagulant injection into No. 5, 6 was terminated.

➢ At 0:38 on April 6, holes No. 7, 8 were deepened and at 1:53 coagulant was injected into No. 7 and No. 8. At 5:17 No. 9 was bored (directly above the pit) and coagulant was ejected (-5:30).

✧ At around 5:38 it was confirmed that the leak into the ocean had been stopped.

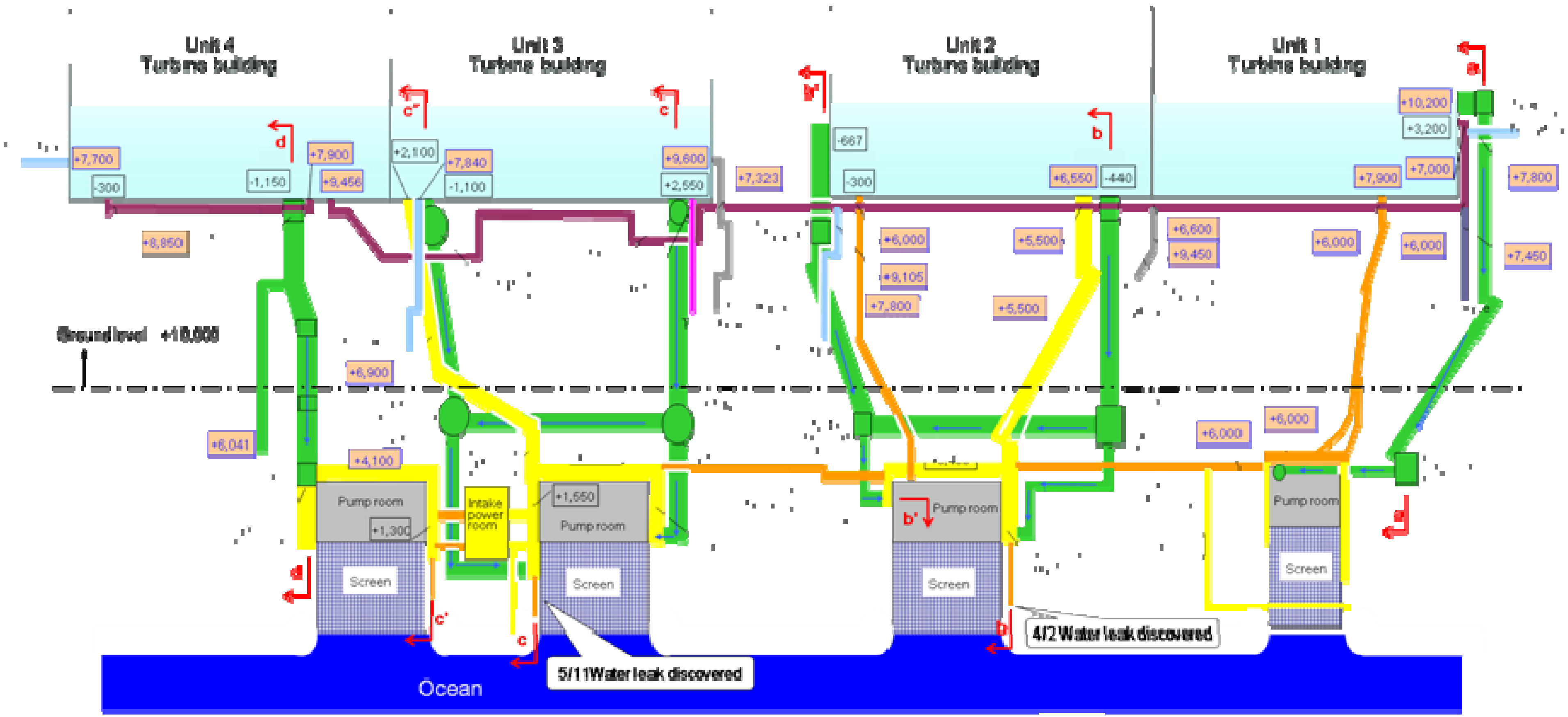
A radionuclide analysis of the leaking water and the contaminated water within the pit revealed that the concentration of radioactive materials was approximately the same, so it is estimated that the water that leaked was the contaminated water from within the pit. Furthermore, since the pit and the Unit 2 trench are structurally connected the water that leaked most likely leak into the ocean from the Unit 2 turbine building (T/B) via the Unit 2 trench.

An investigation into why the leak of highly contaminated water from the Unit 2 T/B into the ocean could not be contained revealed the following.

- -The exposure of contract workers on March 24 prompted an investigation into the risks associated with contaminated water leaking from the turbine building. The turbine building and seawater piping trench are connected at a relatively low elevation via piping penetrations and it was confirmed that contaminated water from within the turbine building was flowing into the trench.
- -It became clear that even though the aforementioned trench is not directly connected to the ocean, since the opening to the shaft is at O.P. +4,000mm if the water level in the trench exceeds the elevation of the inlet contaminated water may leak to the outside.
- -In order to stop the leakage of contaminated water to the outside the water levels in the turbine building and the trench shaft were monitored starting on March 28, and water in the condensate storage tank (CST) was transferred to the suppression pool water storage tank in order to secure a place to transfer contaminated water that had accumulated in the turbine building. (March 29 to April 1).
- -Sub-drain water also started to be monitored from March 30 since it was possible that contaminated water would leak directly into the ground from the turbine building.
- -The aforementioned power cable pipe pit next to the Unit 2 screen is located on the land side of the screen room concrete wall and since there are no penetration seals connected to the ocean side, the possibility of a leak was not considered.
- -On April 1 the installation location of a camera to monitor the water level of the sea water pipe trench shaft opening was confirmed. By coincidence this location registered high radiation levels so the Health physics team was notified. On the same day an investigation by the safety unit revealed that radiation levels were low so it was assumed that there were no problems,

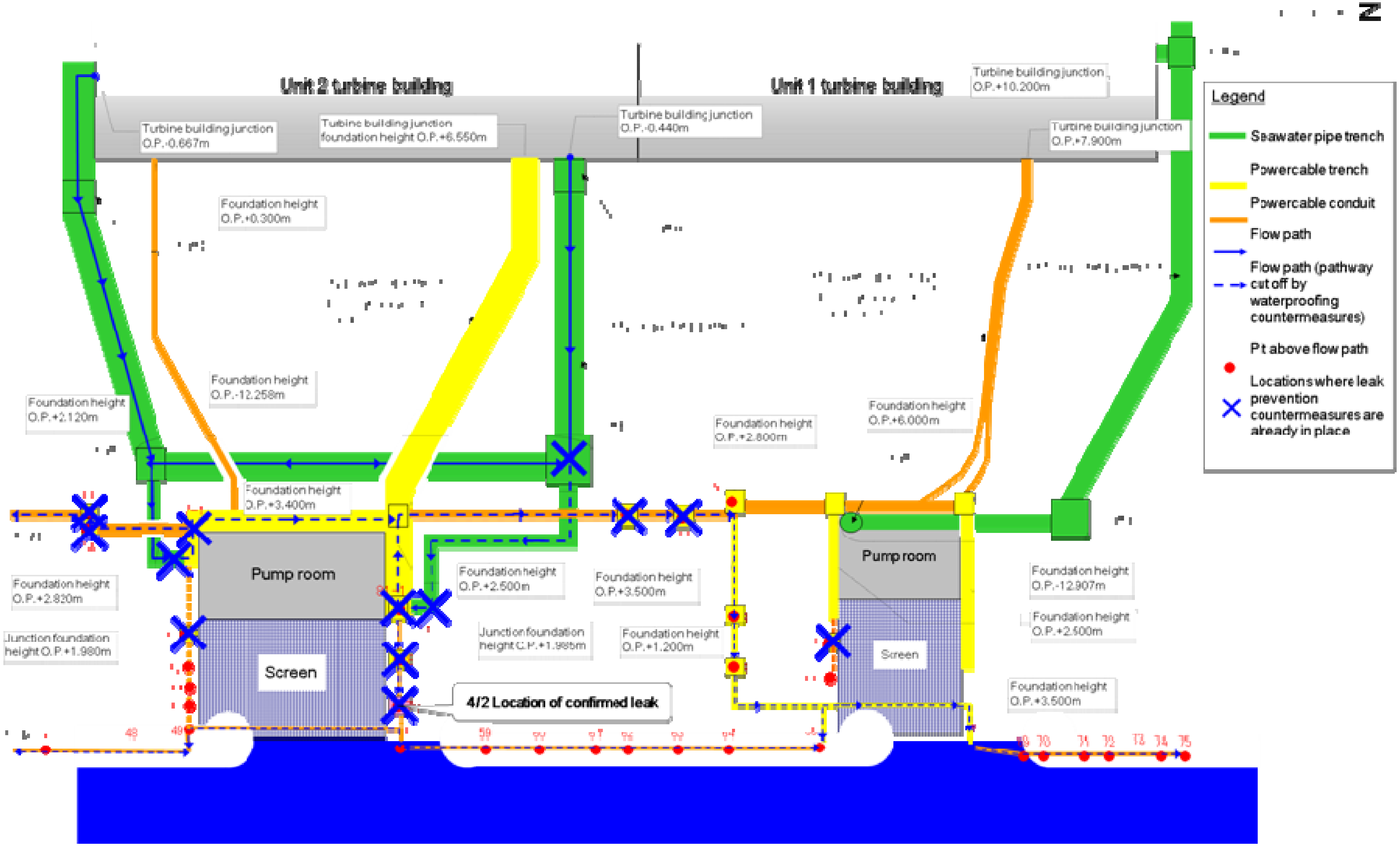
however on the next day (April 2) when the Health physics team surveyed near the Unit 2 screen it confirmed that water with the radiation level that exceeds 1000mSv/h had accumulated in the pit in which power cables are housed, and that water was leaking into the ocean through the concrete around the screen.

- -Periodic air dose monitoring was not being implemented since work was not being done in the vicinity of the screen prior to this.



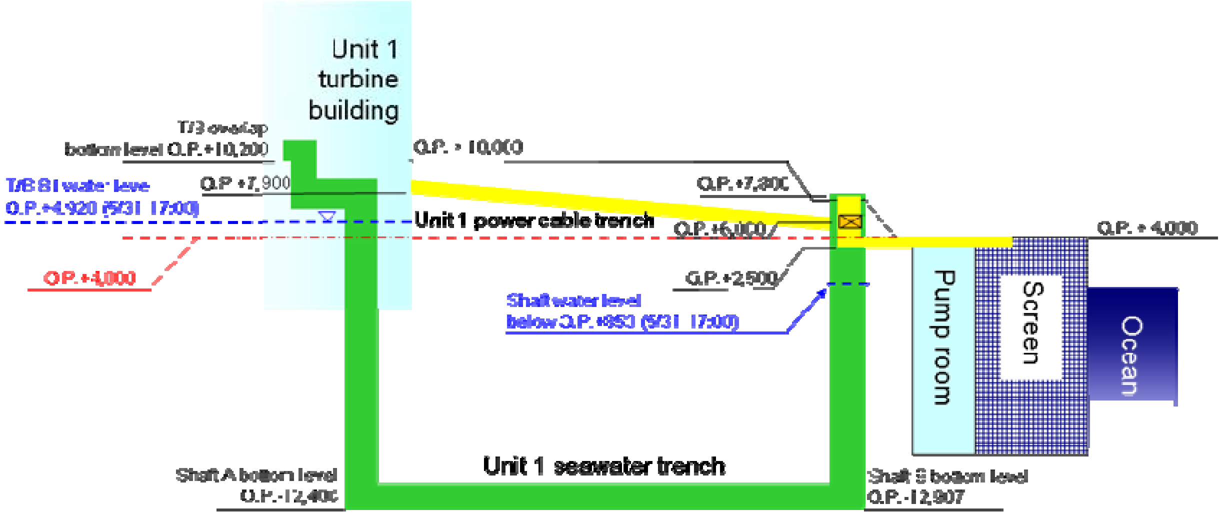
Legend

Seawater pipe trench	Chemical tank connection trench
Power cable trench	Heavy oil tank pipe trench
Power cable conduit	Light oil tank pipe trench
Common pipe trench	Structure foundation elevation (O.P. mm)
Steam drain pipe	Structure foundation elevation (O.P. mm) (More than O.P. 4000mm)

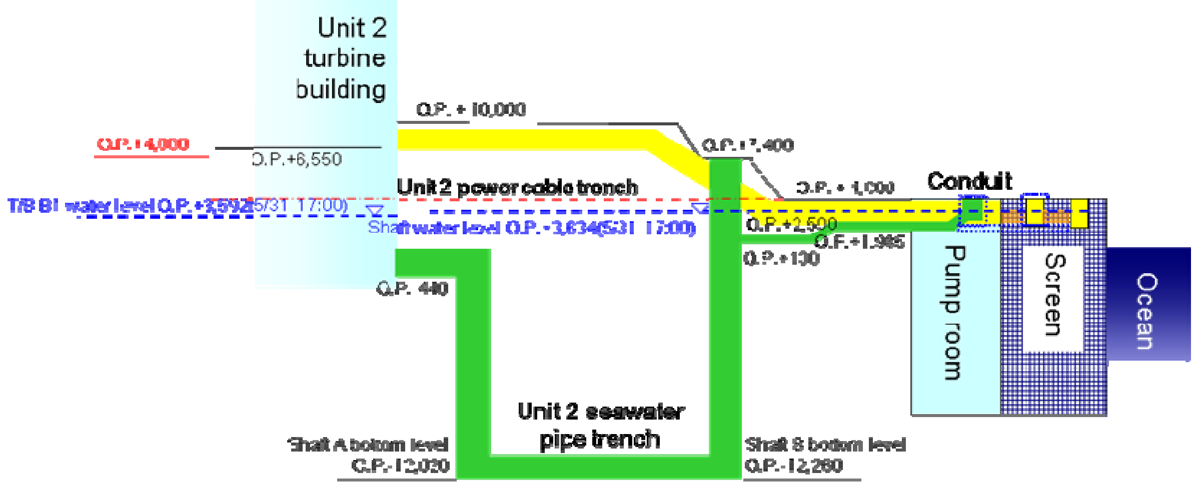


Unit 2 seawater pipe trench diagram

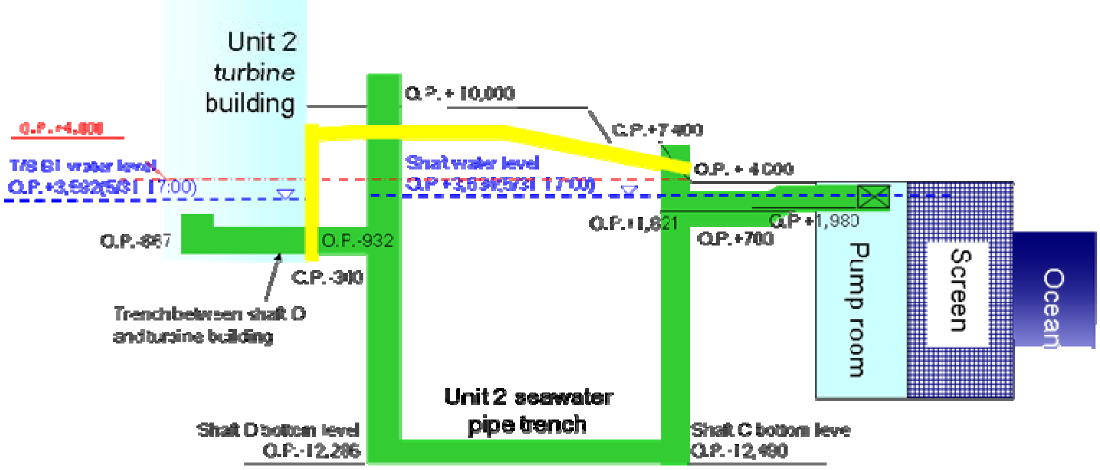
Unit 1 seawater pipe trench (a-a cross section)



Unit 2 seawater pipe trench (b-b cross section)



Unit 2 seawater pipe trench (b'-b' cross section)



Unit 2 seawater pipe trench cross-section

Ocean discharge of low contaminated water from the Fukushima Daiichi Nuclear Power Station (NPS)

The ocean discharge of low contaminated water implemented on April 4, 2011 was done so for the following reasons amidst the following circumstances based on Clause 64.1 of the Reactor Regulation Act as an emergency response to danger after it was deemed by operators that there was “a danger of disaster”.

1. Conditions leading up to April 4

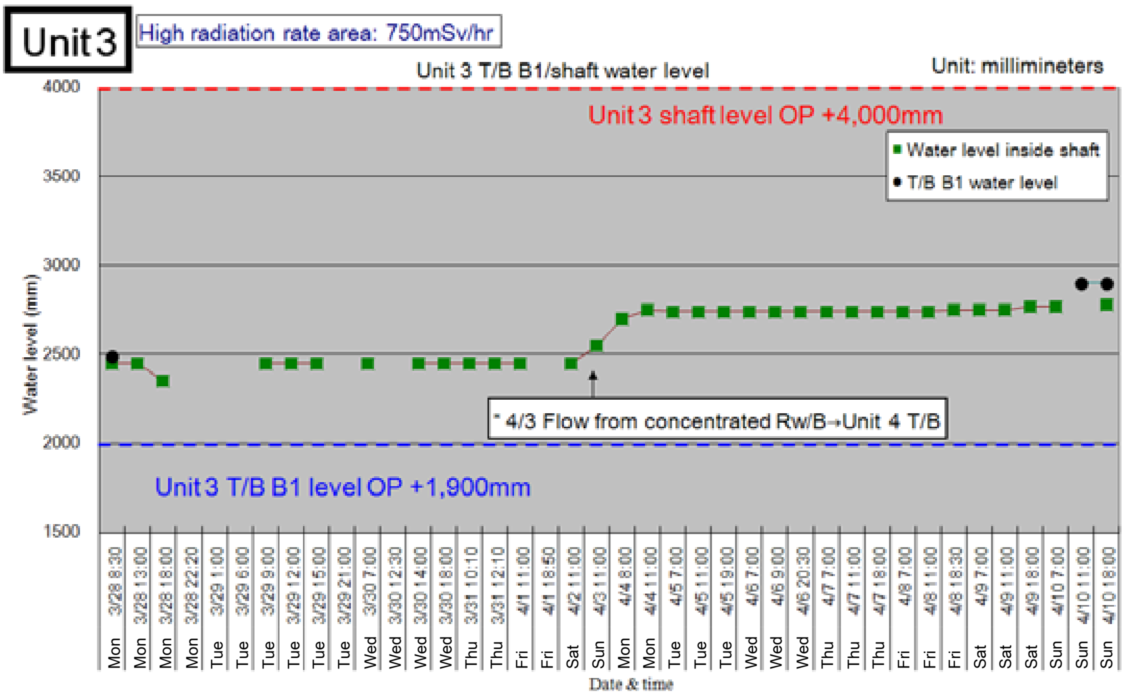
(1) Concentrated Radwaste Building

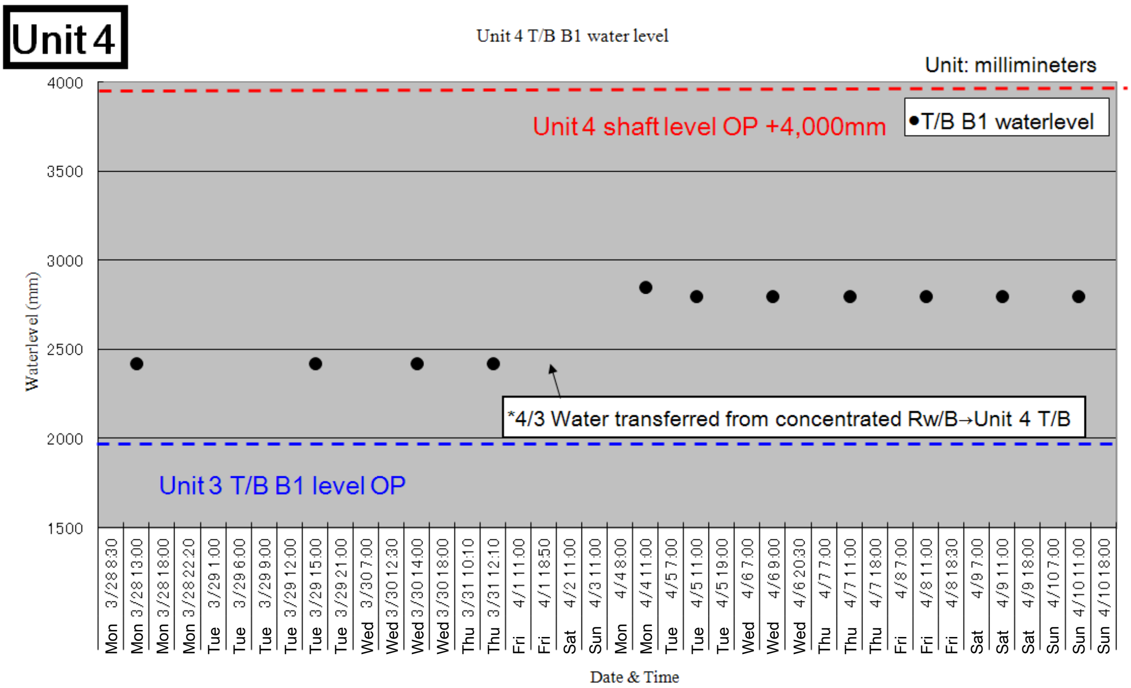
- The exposure of contract workers on March 24, 2011 led to the realization that highly contaminated water accumulated in the Unit 1-3 turbine buildings (T/B) could greatly hinder recovery efforts.
- On March 25, senior management of Fukushima Daiichi NPS and headquarters, who felt a sense of impending crisis, quickly formed a team to deliberate this issue in a unified manner (Turbine Building Wastewater Collection and Decontamination Team) since the processing of highly contaminated water would greatly hinder ongoing recovery efforts.
- From March 27, a special project plenary meeting comprised of other countermeasure teams (RHR substitute/recovery team, team in charge of reducing the release of rejected materials into the atmosphere, safety evaluation team) government officials (Prime Minister's office and NISA) and manufacturers was held every day.
- Since the level of highly contaminated water in the Unit 1-3 T/B was less than 1 m from the opening of the trench shaft, there was no telling when or from where water would leak into the ocean so it was imperative that a deliberation of where to transfer the water to be conducted immediately. The best candidate was the concentrated rad waste building which is a facility with a storage capacity of several tens of thousands of cubic meters.
- Approximately 16,000m^3 of low contaminated water (sea water pushed in by the tsunami that had mixed with radioactive materials inside the building) had accumulated in the concentrated rad waste building that has a storage capacity of approximately 32,000m^3. The transfer or discharge into the ocean of this low contaminated water

was inevitable in order to make enough space to transfer the more than 60,000m^3 of highly contaminated water that already existed in the Unit 1-3 T/B. At the time there were no other tanks or buildings on site that had a large enough storage capacity.

- As of the end of March, the fastest method by which a temporary storage tank could be installed at the site was the over-sea transportation proposal (proposal to assemble a storage tank at Onahama Port and transport the assembled storage tank by sea to the Fukushima Daiichi NPS after which it would be installed on the seawall side of Unit 1-4) which would require from late April to early May to complete. Furthermore, according to plans at that time the mega-float purchased from Shizuoka City (10,000 ton storage capacity) would only arrive at the Fukushima Daiichi NPS port in early May.
- On March 29, the Turbine Building Wastewater Collection and Decontamination Team proposed to the special project plenary meeting that the low contaminated water accumulated in the concentrated radioactive waste building should be discharged into the ocean and that the space should be used for storing highly contaminated water from the Unit 1-3 T/B. the government instructed that the origin of the contaminated water should be assessed and that a schedule for removing water from the building and transporting the wastewater should be presented.
- On March 31, the Turbine Building Wastewater Collection and Decontamination Team reported to the special project plenary meeting that the amount of radiation that the general public would be exposed to annually if low contamination water that exceeds discharge guidelines was to be discharged into the ocean was evaluated and that the estimated annual exposure would fall below annual exposure radiation limits (1mSv/year). Since there would be no impact on the environment or the human body it was once again proposed that the discharge to the ocean should be implemented as soon as preparations were made. Officials from the government remarked that in addition to technical and legal judgments, the political judgments of this action need also be considered so the issue needed to be carefully handled.

- At the special project plenary meeting on April 1, Assistant Secretary Hosono stated that the emergency water discharge to the sea containing low-level radioactive materials was not an option and that processing this water should be considered of the utmost importance along with deliberation of how this wastewater was to be processed over the long term, adding that this issue should be handled in a manner that does not make the people think that radioactive material has been carelessly scattered into the environment. Authorization to implement an ocean discharge was not obtained and meeting time elapsed.
- On April 2, it was discovered that some extremely highly contaminated water from Unit 2 had leaked directly into the water outlet from cracks in the pit. In order to stop the leak and minimize ocean contamination, many attempts were made to stop the leak, such as by injecting concrete and water glass. At the same time it was predicted that the pit might overflow or start leaking from a different place if the pit was adequately waterproofed, so it was determined that a alternative building or tank to which the water could be transferred was needed as soon as possible and that the concentrated radwaste building was the best option.
- From the same day (April 2), low contaminated water from the concentrated radwaste building was being transferred to the basement of the Unit 4 T/B, but this transfer was terminated on April 4 after water levels in the shaft began to rise as low contaminated water flowed into the Unit 3 T/B. Since there were no other places to which all the high contaminated water could be transferred to and all the risk of water leakage could not be predicted, the safest option was deemed to be the immediate low contaminated water discharge to the ocean.



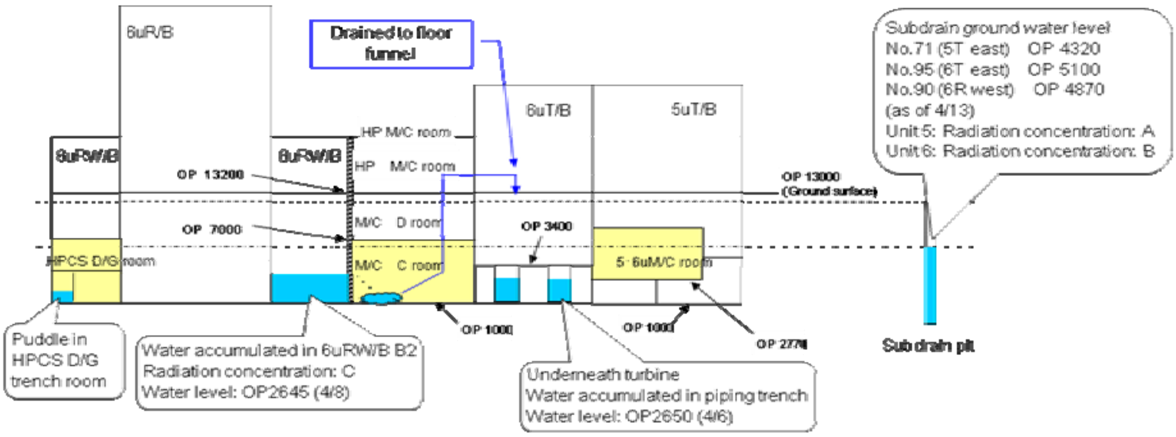


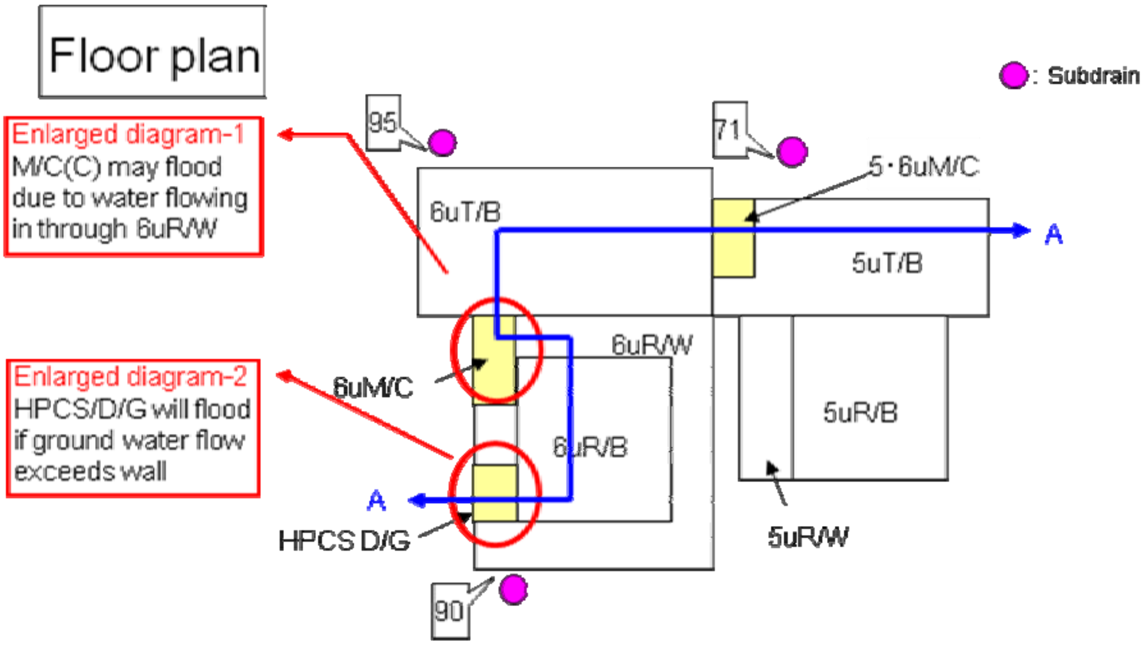
Water level of accumulated water in Unit 3/4 Turbine Building

(2) Unit 5, 6 subdrain

- From the time the earthquake occurred it was considered that ground water leaked into the building through pipe penetration seals, etc., and accumulated thereby affecting electrical equipment and the building soon if water in the subdrain could not be drained.
- Contaminated water from the Unit 6 radwaste building was seeping through the wall of the neighboring M/C (6C) room of Unit 6 (with power source cross-ties to the Unit 5 residual heat removal system (RHR)) and was bailed out by hand after March 19th. Even though some of the aforementioned contaminated water was transferred to the Unit 5 condenser between April 1 and April 2, the transfer was terminated when it became apparent that only a small amount could be transferred to the condenser. The leak to the M/C (6C) room continued along with the danger of loss of power.

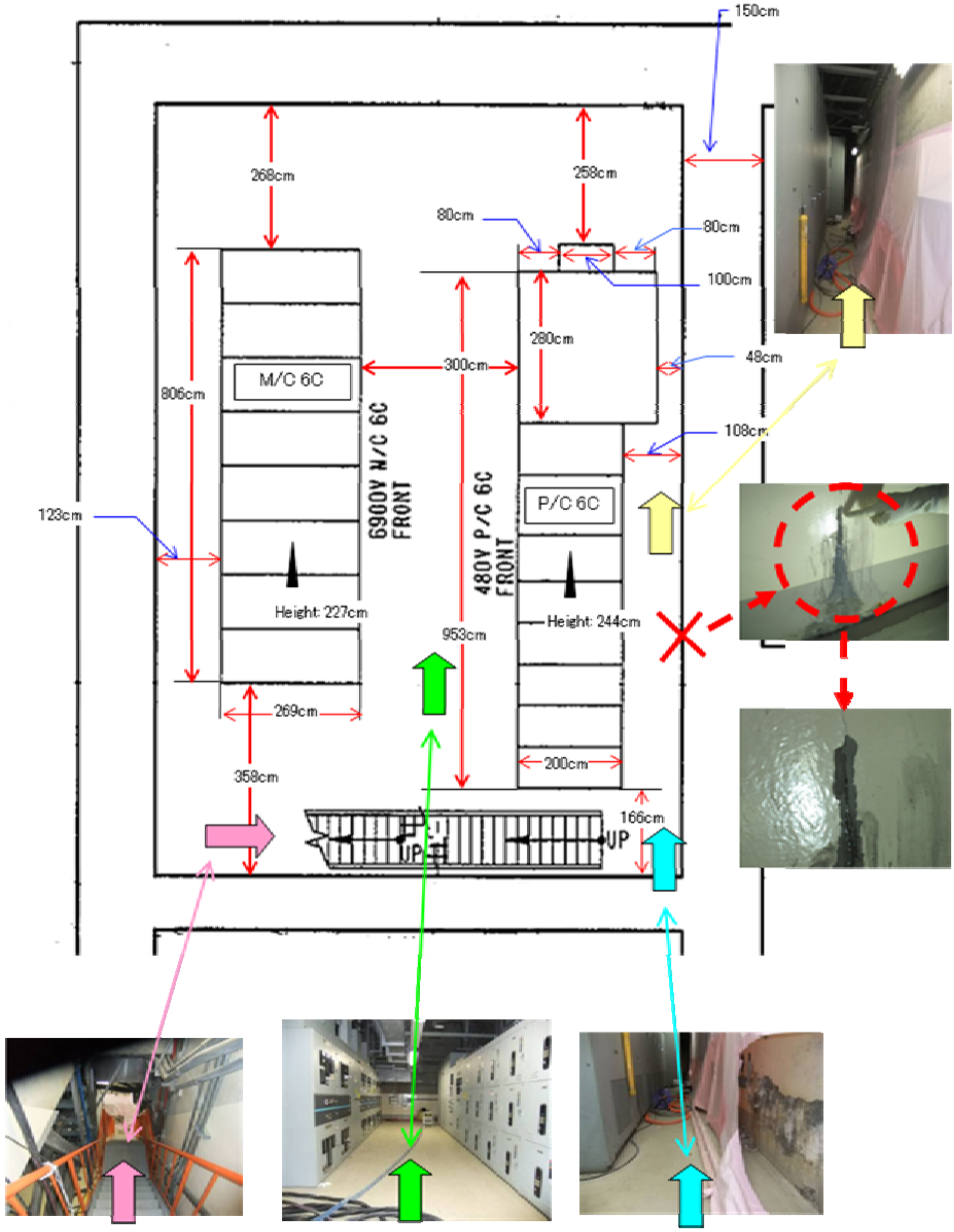
A-A cross section



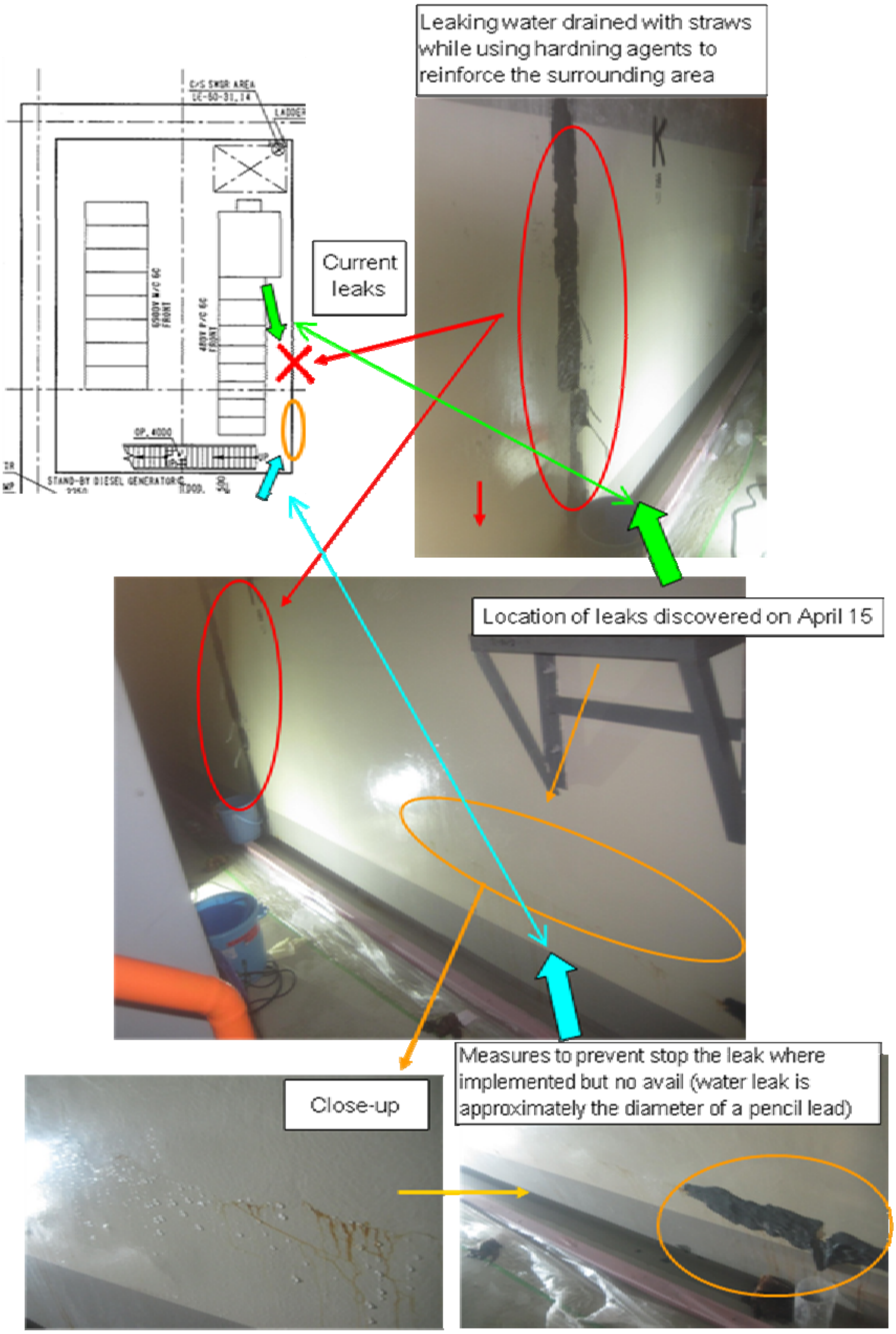


Unit: Bq/cm^3

Detected nuclear species (half-life)	Unit 5 subdrain (Radiation concentration A)	Unit 6 subdrain (Radiation concentration B)	Unit 6 R/W (Radiation concentration C)	Regulatory Limit
I-131 (Approx.8 days)	1.6	20	4.9	0.04
Cs-134 (Approx.2 years)	0.25	4.7	0.06	0.06
Cs-137 (Approx.30 years)	0.27	4.9	0.06	0.09
Sampling data	March-12	March-11	March-11	

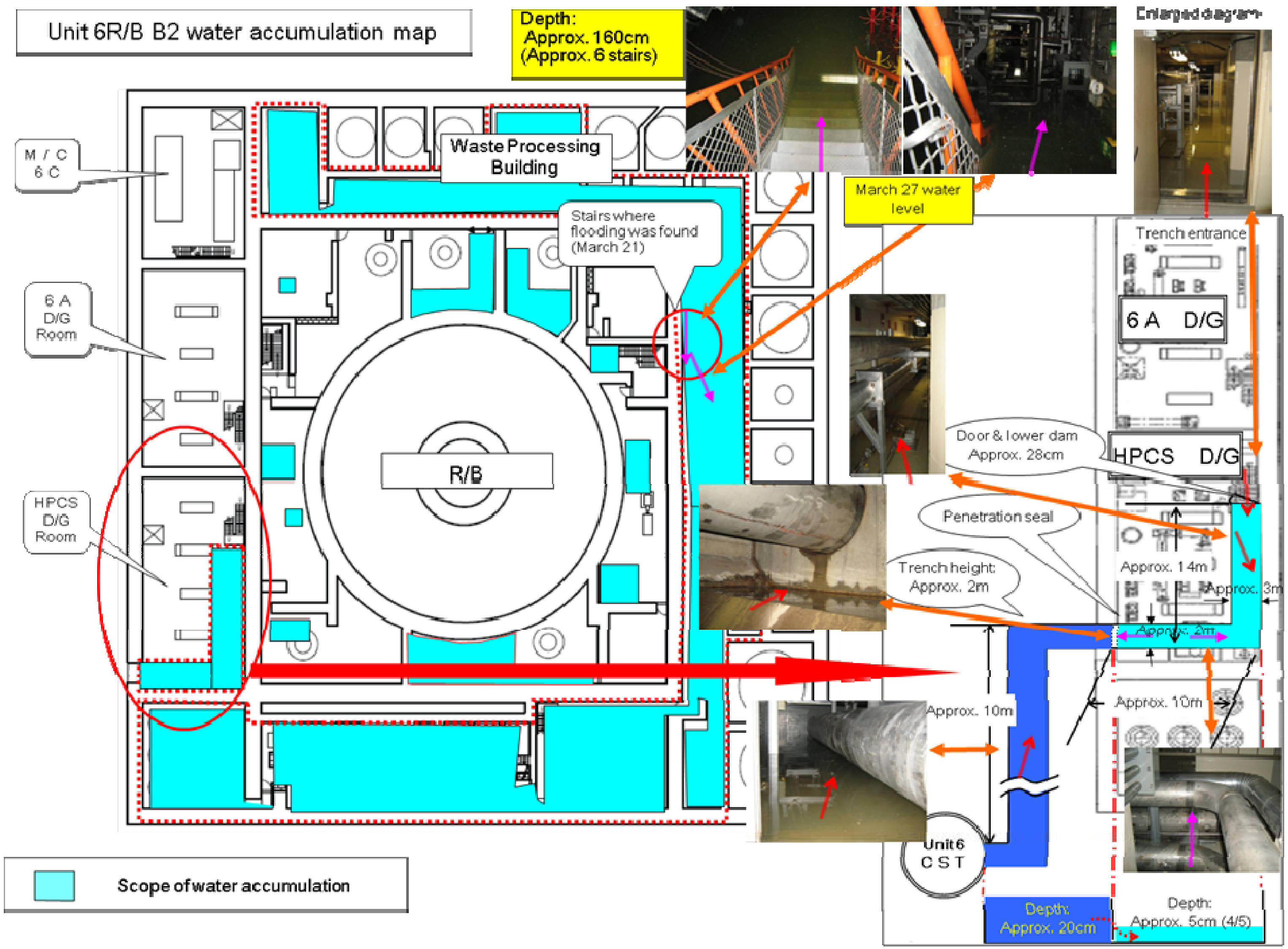


Unit 6 M/C room flooding (enlarged diagram-1 (1))
(March 26)



Unit 6 M/C room flooding (enlarged diagram-1 (2))
(April 15)

- On April 3, a leak with approximately 1 centimeter in the diameter was discovered coming through the penetration seals of the trench which neighbors the Unit 6 high-pressure core spray (HPCS) diesel generator room. An initial assessment predicted that water would exceed the barrier at the entrance to the trench room (approximately 28cm) in approximately 5 days and it was feared that this would impact the diesel generator.



Unit 6 R/B B2 accumulated water map

- Much water leaks into rooms for safety related system in Unit 6 became noticed. There was more aftershocks since even though it was the beginning of April, and it was feared that more damage to walls (cracks) from aftershocks as well as heavy rains may quickly increase the volume of leakage thereby causing heat removal/cooling function loss and plunging Unit 5, which shares power source cross-ties for heat removal equipment with M/C (6C), into the same situation as Units 1-3.
- Therefore, in order to quickly reduce the risk associated with groundwater leaking into the Unit 6 building and remain on the safe side amidst an unpredictable future, it was necessary to reduce the water level of the sub-drain surrounding buildings which is the fundamental cause of the groundwater inflow to the buildings. Therefore existing pumps were used to discharge some drain water into the ocean.

2. After April 4

At 9:00 on April 4, 2011 the Fukushima Daiichi NPS superintendent reported the following to the Integrated Nuclear Accident Response Headquarters plenary meeting (attended by Minister Kaieda and Assistant Secretary Hosono).

- "Contaminated water has flowed from Unit 4 T/B into Unit 3 T/B and Unit 3 T/B shaft water levels are rising (15cm rise in 21 hours as of this morning). At this rate, highly contaminated water in Unit 3 may leak into the ocean so the transfer from the concentrated radwaste building to Unit 4 will be stopped."
- "The Unit 2 leaks and water processing are of the utmost importance as far as I, the site superintendent, is concerned."
- "Currently the subdrain has been stopped, but ground water may flow into the building through penetration seals. Water levels are rising regardless of the fact that cooling water is not being injected into the reactor which indicates that there is a high possibility that ground water is flowing into the building."
- "Ground water is flowing into the HPCSD/G and other important electrical equipment rooms and is a great impact on the soundness of Units 5 and 6 themselves (there's no time to build a tank outside)."
- "It's hard to 'do our best' as ordered with our hands tied. If a decision is

not made the integrity of the facility itself, including Unit 5 and Unit 6, will be at risk, so I would like the issue of starting the subdrain system to be deliberated immediately."

In response to this, the integrated nuclear accident response headquarters, realizing that an important decision in regard to subdrain was needed to be made, immediately began debating the issue, including the transfer of seawater in the concentrated radwaste building, after the plenary meeting concluded.

Since low contaminated water that was being transferred to Unit 4 was leaking into the Unit 3 T/B and causing Unit 3 shaft water levels to rise the transfer of water was stopped at 9:22 on April 4 (approx. 6,000m^3 were transferred). This resulted in not having a place to which the low contaminated water in the concentrated radwaste building could be transferred.

At 9:40 following the end of the teleconference with the general headquarters, officials gathered at (former) Minister of Economy, Trade and Industry Kaieda's office to discuss the issue at which time the Minister requested that everything that could be done to help the power station be deliberated and implemented. Since TEPCO had already prepared a draft of an evaluation concerning the water discharge to the ocean (special project (March 31) explanation materials), documents were created based on this evaluation. At 9:55, work to revise the evaluation report draft began in the teleconference room on the sixth floor of headquarters. The details that were deliberated are as follows:

- To add the description of Unit 5/6 subdrain (subdrain drainage volume 1,500m^3)
- Date for discharge from the concentrated rad waste building changed from the 10^{th} to the 5^{th} .

These details were explained to NISA as necessary.

AT 10:45 Assistant Secretary Hosono conveyed that the water discharge to the ocean including the subdrain water was to be implemented and explained the details of the evaluation report (by NISA and TEPCO), and that around 11:00 NISA gave an explanation to the Nuclear Safety Commission (NSC).

At around 11:30 TEPCO headquarters conveyed to the Fukushima Daiichi

NPS that the report submission to the regulatory body for the action needed and that headquarters would handle it.

At 13:10 NISA received the report from TEPCO and the fundamental authorization was obtained from (former) Minister of Economy, Trade and Industry Kaieda in regard to the decision that an ocean discharge could not be avoided in response to the submission of the report. At this time Assistant Secretary Hosono who was in attendance said that he would obtain authorization from the Prime Minister's office.

Right before 15:00 the report was compiled and ultimately the following explanation was given to Minister Kaieda.

- In regard to the impact of discharging low concentrated contaminated water into the ocean, it was evaluated that if an adult were to eat fish and seaweed from the neighboring area everyday said individual would suffer an annual effective dose of approximately 0.6mSv (radiation levels limit for the general public: 1mSv/year)
- Assessment results show no significant impact on human health and since compared with a discharge of high concentrated radioactive waste, the radioactivity levels of low concentrated contaminated water to be discharged are considerably small; therefore from the standpoint of risk management discharge is a rational measure.

The Minister instructed TEPCO to minimize the impact on the ocean so it was decided that the water would be discharged directly from the south side of the water outlet (TEPCO headquarters contacted the Fukushima Daiichi NPS and told it to change the route).

At 15:00, TEPCO reported to the Nuclear and Industrial Safety Agency on how the ocean discharge was decided, the impact assessment, and how the discharge was to be carried out in accordance with Clause 67.1 of the Law for the Regulations of Nuclear Source Material, Nuclear Fuel Material, and Reactors. The Nuclear and Industrial Safety Agency asked the Nuclear Safety Commission for advice, shown below, which it received and conveyed the decision to TEPCO at 15:20.

- The concentration of radioactive materials in the discharged water and the volume of the discharge needs to be confirmed
- Ocean conditions at the time of discharge need to be confirmed
- Ocean monitoring before and after the discharge needs to be implemented

- A suitable impact assessment based on the above information needs to be performed

After receiving authorization from the Nuclear and Industrial Safety Agency in regard to the TEPCO report, TEPCO (Executive Vice President Muto acting as division director of the emergency response center in the headquarters) ultimately decided to proceed with the water discharge to the ocean.

At 16:00 on April 4 at the chief cabinet secretary's press conference, Chief Cabinet Secretary Edano announced that the water discharge to the ocean was to be implemented. Low concentrated contaminated water that had accumulated inside the radwaste building started to be discharged from the south side of the water outlet at 19:03 on April 4 and the discharge was completed at 17:40 on April 10. Thereafter, at 9:55 on the morning of April 11 it was determined that enough water had been drained from within the building so as not to hinder countermeasures (countermeasures to stop the leak) to be implemented inside the building when transferring high concentrated wastewater.

The discharge into the ocean of low concentrated groundwater that had accumulated in the Unit 5 and Unit 6 sub-drain pit commenced from the Unit 5, 6 outlet at 21:00 on April 4 and concluded at 18:52 on April 9.

As instructed by the Nuclear and Industrial Safety Agency, when discharging low concentrated contaminated water, etc., into the ocean, the ocean was monitored, measurement points and measurement implementation frequency were increased, and the impact from the dispersion of radioactive materials is investigated and confirmed upon which the results were publicly disclosed.

A comparison of the radioactive concentration at measurement points, including around the power station, taken one week prior to the discharge indicate no large fluctuation.

In conjunction with the conclusion of the discharge, extremely highly concentrated radioactive waste liquid inside the Unit 2 turbine building was transferred to the concentrated waste treatment facility after the stoppage countermeasures within the building had concluded on April 19 and is being stored in a stable manner.

Furthermore, groundwater that had accumulated in the Unit 5 and Unit 6 sub-drain pit was transferred to a temporary tank constructed outside beginning on May 1.

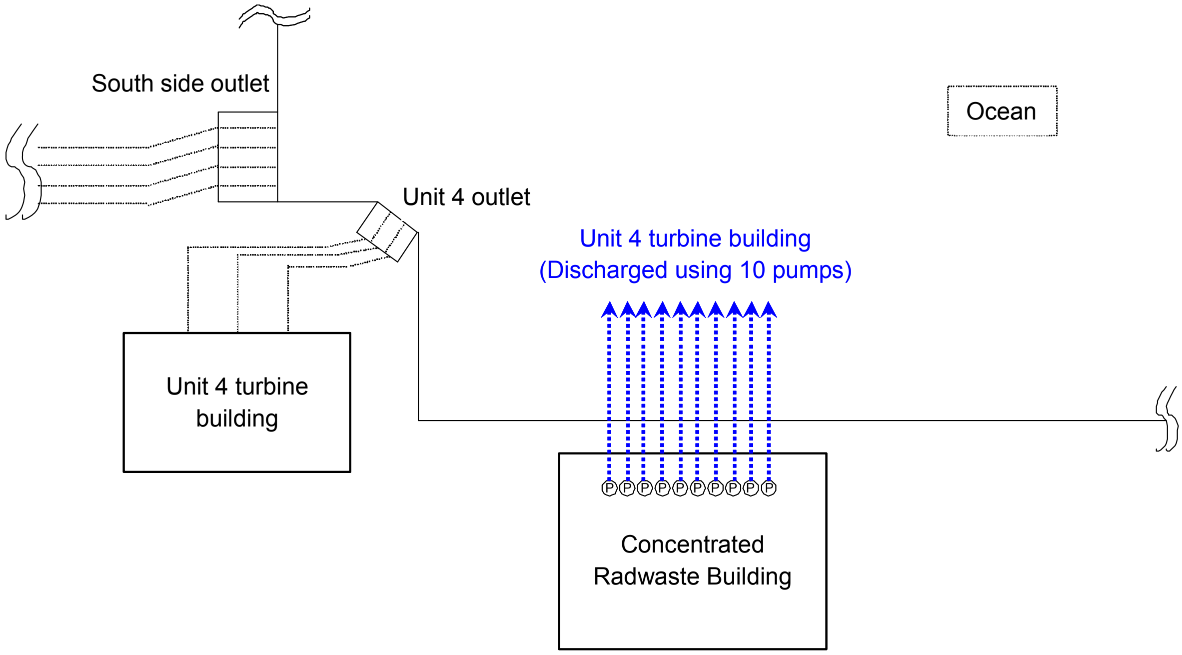


Diagram of the Low Contaminated Water Discharge to the Ocean

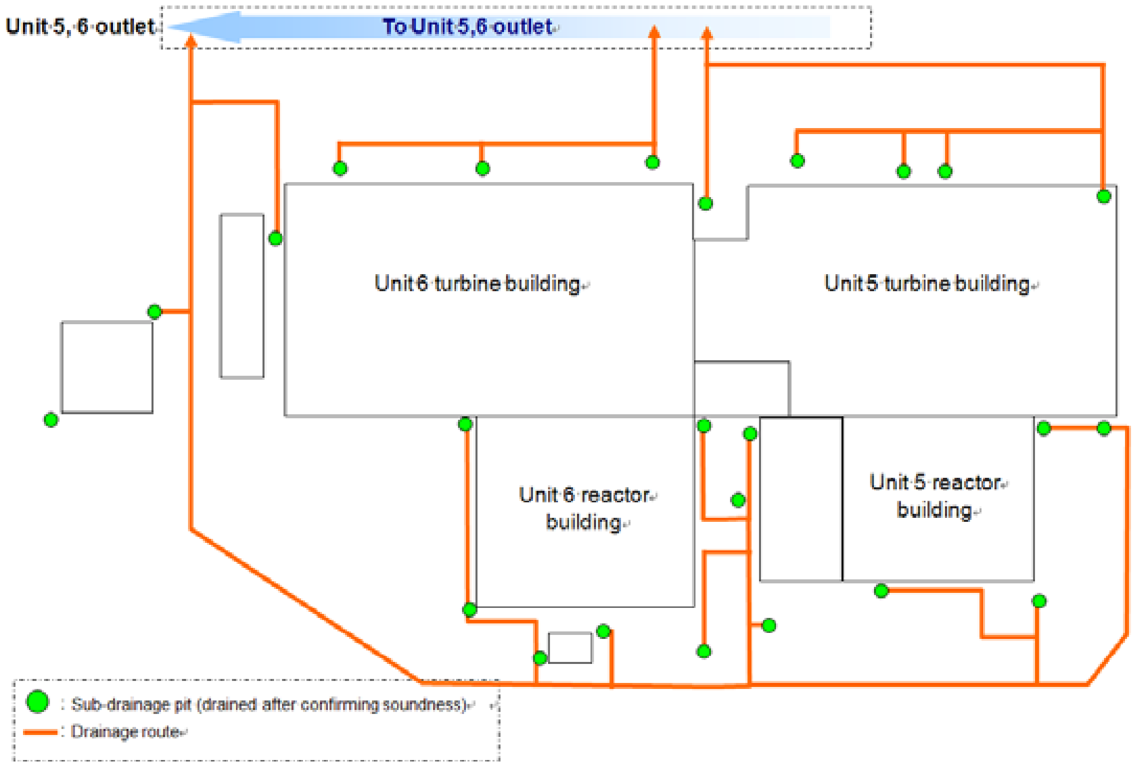


Diagram of Unit 5, 6 subdrain route

Date samples were taken	15:30 March 28, 2011	16:00 March 28, 2011	10:30 March 30, 2011	10:40 March 30, 2011
Sampling Location	Concentrated radwaste building accumulated water (non-controlled area side)	Concentrated radwaste building accumulated water (controlled area side)	Unit 5 sub-drain pit	Unit 6 sub-drain pit
Detected nuclear species (half-life)				
I-131 (approx. 8 days)	6.3E+00	8.7E-01	1.6E+00	2.0E+01
Cs-134 (approx.. 2 years)	2.7E+00	4.4E+00	2.5E-01	4.7E+00
Cs-137 (approx. 30 years)	2.8E+00	4.4E+00	2.7E-01	4.9E+00

*X.XE-X means X.X x 10^{-x}.

*Values for I-131, Cs-134 and Cs-137 are definitive values. Other nuclear species are being evaluated.

Results of radionuclide analysis of accumulated water and subdrain water

3. Advance notification

The facts regarding the advanced provision of information related to the water discharge to local municipalities and fishery related officials have been compiled as follows.

- ○ In regards to whether or not to implement the discharge NISA was consulted during the morning of April 4, a report based on the Reactor Regulation Act was submitted and authorization from NISA was obtained, so TEPCO made the final decision to implement the discharge and did so after notifying related agencies.
- ○ Prior to the discharge information was provided to the central government (NISA), Fukushima Prefectural government and the five towns surrounding the power station, the National Federation of Fishery Cooperatives and the Fukushima Fishery Cooperative.
- ○ The notification about the water discharge to the ocean that was given is as follows:
- ➢ Prior to discharge:
  - ✧ At 18:43 on April 4, it was conveyed that a discharge will be implemented in accordance with Clause 64 of the Reactor Regulation Act as soon as preparations are made. A discharge from the concentrated rad waste building will be implemented around 19:00, and a discharge from the Unit 5, 6 subdrain will be implemented around 21:00.
- ➢ Following discharge:
  - ✧ At 19:31 on April 4, it was conveyed that the discharge from the concentrated rad waste building had begun.
  - ✧ At 21:15 on April 4, it was conveyed that the discharge of the Unit 5/6 subdrain had begun.
  - ✧ At 21:15 on April 5, it was conveyed that the discharge of the Unit 5/6 subdrain had begun.
  - ✧ At 20:20 on April 9, it was conveyed that the discharge of the Unit 5/6 subdrain had concluded.
  - ✧ At 18:17 on April 10, it was conveyed that the discharge from the concentrated rad waste building had concluded.
- ○ Parties Notified:
- ➢ Central government

  - ✧ NISA, the Ministry of Education, Culture, Sports, Science and Technology, the Cabinet Secretary and the Cabinet were notified in accordance with the Nuclear Disaster Preparation Plan.
- ➢ Local municipalities
  - ✧ Fukushima Prefecture was notified as usual, but the four local towns (Oguma, Futaba, Tomioka, Naraha) had been evacuated so the power station notified the people of these towns after contact information was obtained.
- ➢ Fishery Cooperatives (National Federation of Fishery Cooperatives and the Fukushima Fishery Cooperative)
  - ✧ The fishery cooperatives need not be officially notified in accordance with the Nuclear Disaster Preparation Plan so they were notified by TEPCO headquarters.

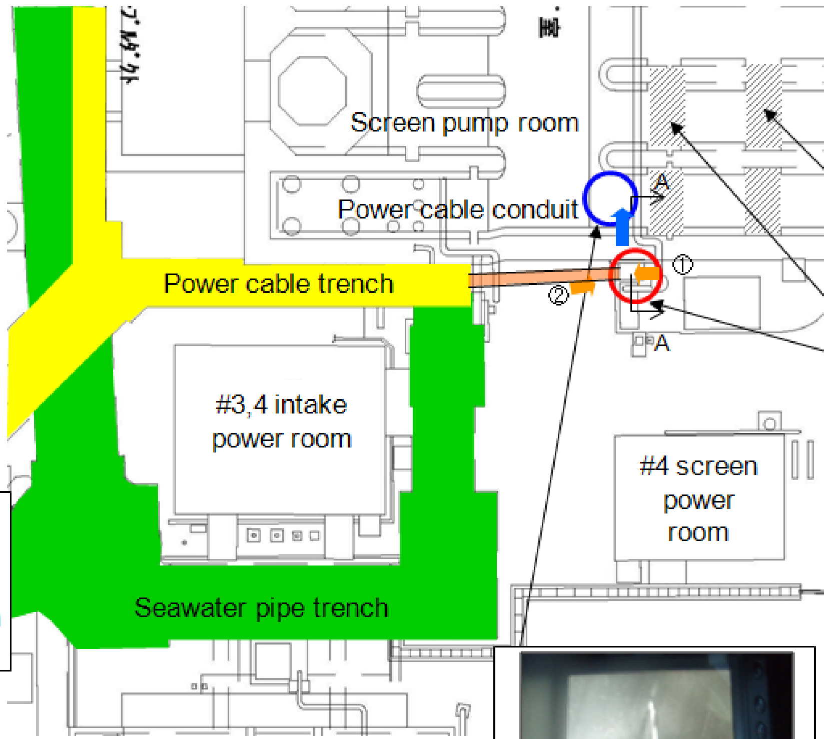
Leak from around the Fukushima Daiichi Unit 3 Intake Screen

At around 10:30 on May 11, 2011 workers were engaged in work to close the shaft near the Unit 3 intake. They heard the sound of water flowing into the pit and opened the lid of the pit to ascertain the situation. However, they did not realize at the time that there was a leak into the screen area.

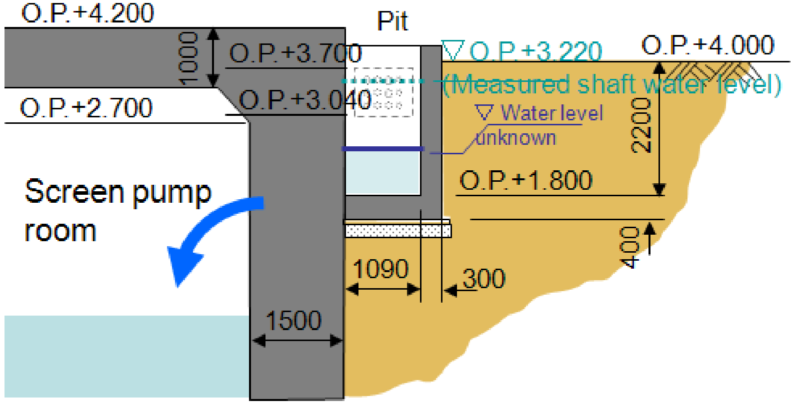
Thereafter when the area was checked again by opening the cover hatch and inserting a CCD camera inside the screen room, it was confirmed at around 16:05 on the same day that water was leaking from the pit into the screen area.

The leaking water contained high concentrations of radioactive materials. Therefore, it was assumed that drainage water from the Unit 3 turbine building side that had leaked into the power cable pit on the T/B ocean side through power cable pipes from the power cable trench interface via the seawater pipe trench had leaked from the penetration seals in the concrete wall between the power cable pit on the north side of the aforementioned pit and the screen pump room into the Unit 3 intake screen area.

After confirming that there was a leak from the aforementioned pit into the screen area power line pipe cables inside the pit were immediately shut off, waste cloth were stuffed into the leak and the pit was sealed with concrete. As a result it was confirmed using a CCD camera at 18:45 on May 11 that the leak had been stopped.



A-A cross section

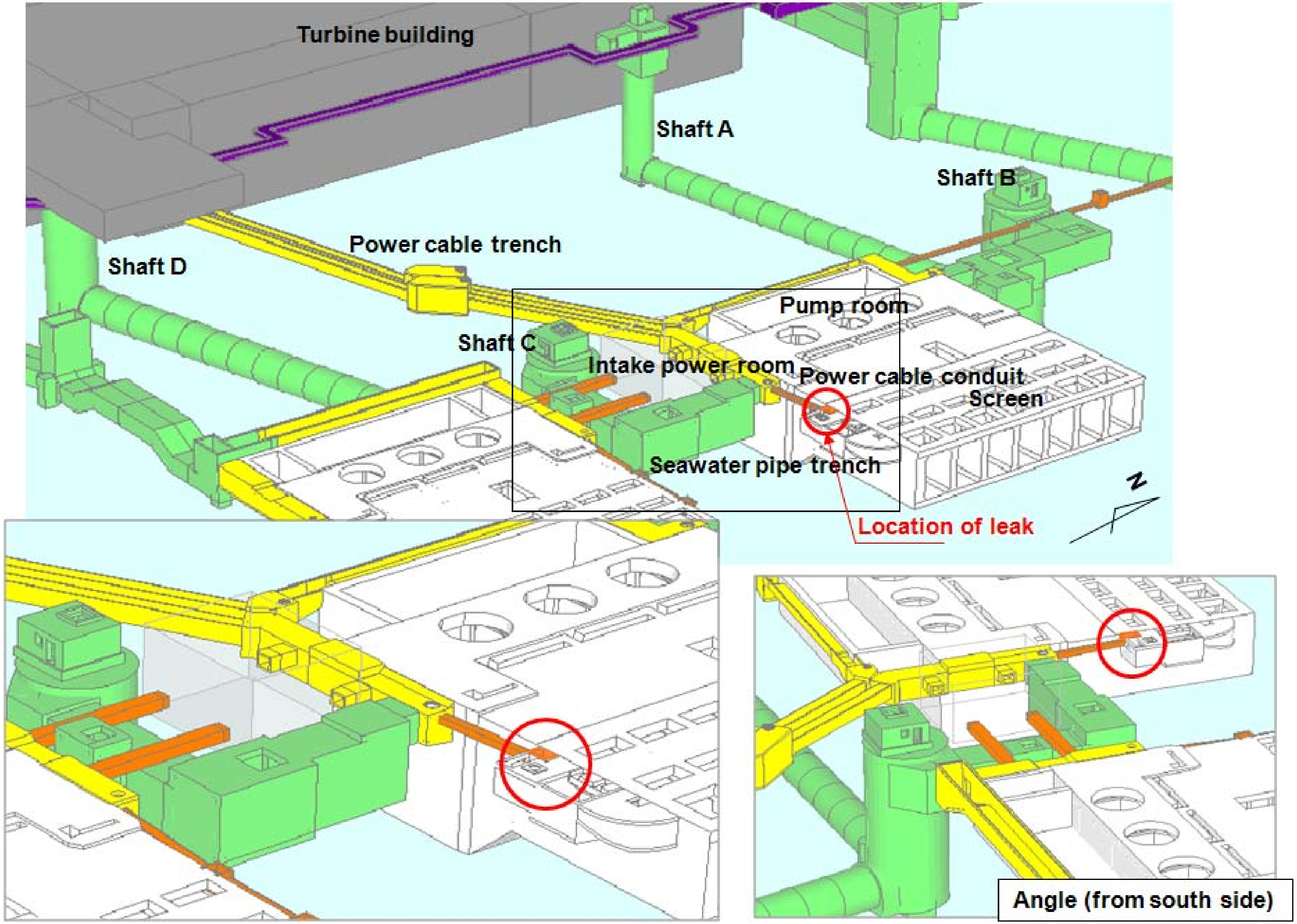


Date of photograph: Around 10:30 on May 11, 2011

Photo① Leak into power cable pit

Date of photo: Around 18:30 on May 11, 2011
Photo: Conditions around the screen from the power cable pit

Photo② After filling leaking pit with concrete


Turbine building
Shaft A
Shaft B
Power cable trench
Shaft D
Pump room
Shaft C
Intake power room
Power cable conduit
Screen
Seawater pipe trench
N
Location of leak
Angle (from south side)

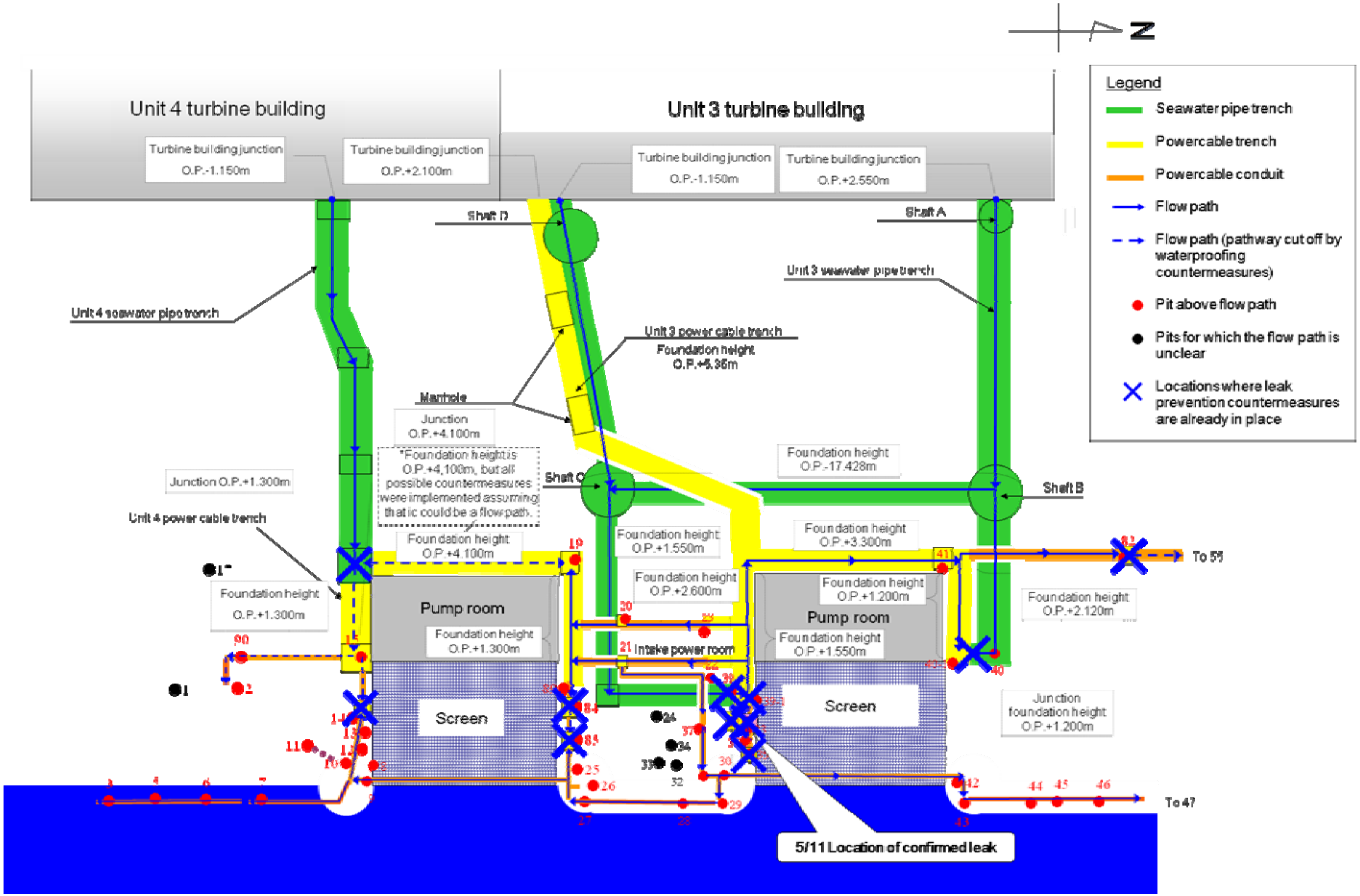
It was clear from the radionuclide analysis results of the leaking water and the contaminated water inside the pit that the radioactive material concentration was approximately the same, and therefore estimated that the leaking water was from the contaminated water in the pit. Furthermore, since it was known that the pit and the Unit 3 trench are connected structurally it was assumed that the leaking water had leaked into the ocean from the Unit 3 turbine building via the Unit 3 trench.

The results of an investigation have found that the leak into the ocean of highly contaminated water from the Unit 3 T/B was unable to be prevented for the following reasons.

- In consideration of the leak that occurred at Unit 2 on April 2 and with the knowledge that Unit 3 has the same structure as Unit 2 as confirmed through design and working drawings, with the exception of areas that could not be inspected due to rubble or floating wreckage from the tsunami, the front of the screen pump room, which was the location of the leak at Unit 2, was confirmed, but the leak from the pit was not discovered (April 20).
- The seawater pipe trench, which served as the path of leakage, has a shaft opening at OP+4,000mm so the water level inside the shaft was continually monitored.
- Since the possibility of a leak from the pit could not be denied, work to seal off the seawater pipe trench shaft was planned in order to cut off the path of leakage into the ocean, but high radiation levels around the shaft necessitated the use of shielding during the work process. Furthermore, it became clear that cutting off the leakage path at the shaft would be difficult due to wreckage on the stairs, etc.
- In order to prevent water from overflowing topside from the shaft, it was decided that the above-ground opening would be sealed shut and that the joint between the seawater pipe trench on the downstream side and the intake power cable trench would also be sealed off. To do this, rubble around the screen was being removed at which time the leak was discovered.
- The pit leak was discovered while removing rubble from around the screen in order to seal off the joint between the seawater pipe trench and the intake power cable trench. After rubble was removed the sound of leaking water could be heard, but whether or not there was

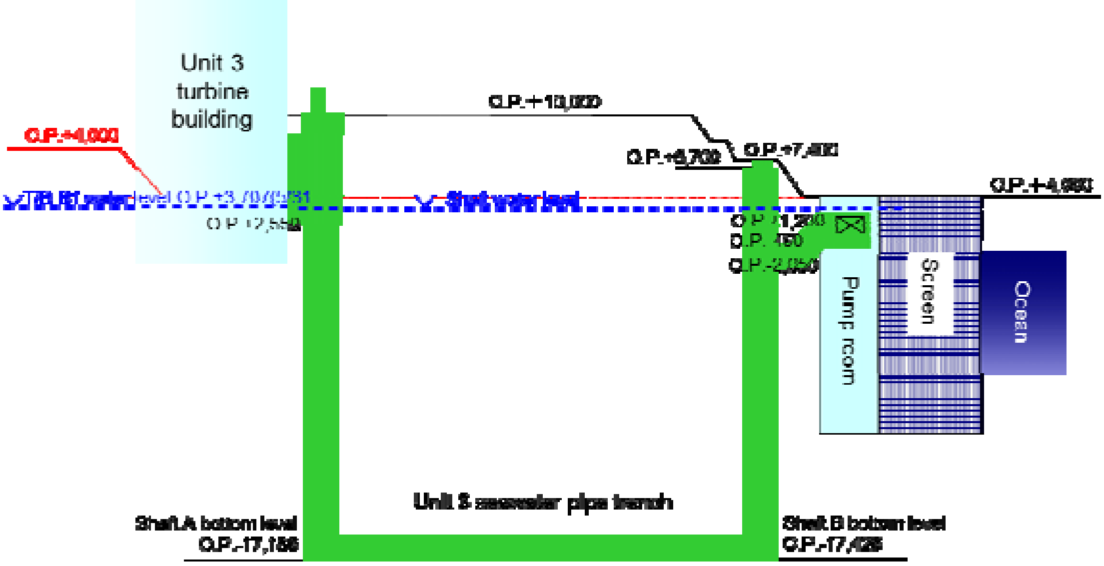
a leak into the screen could not be determined.

- Unlike the leak at Unit 2 which was in a location that could be confirmed visually, the leak in the screen pump room was under the screen equipment and difficult to see. Therefore, at around 12:30 on May 11, when another field inspection was ordered it took time to discover the leak (by confirming the sound of leaking water) and it also took time to identify the leak into the screen pump room by inserting a CCD camera around 16:05 on the same day.

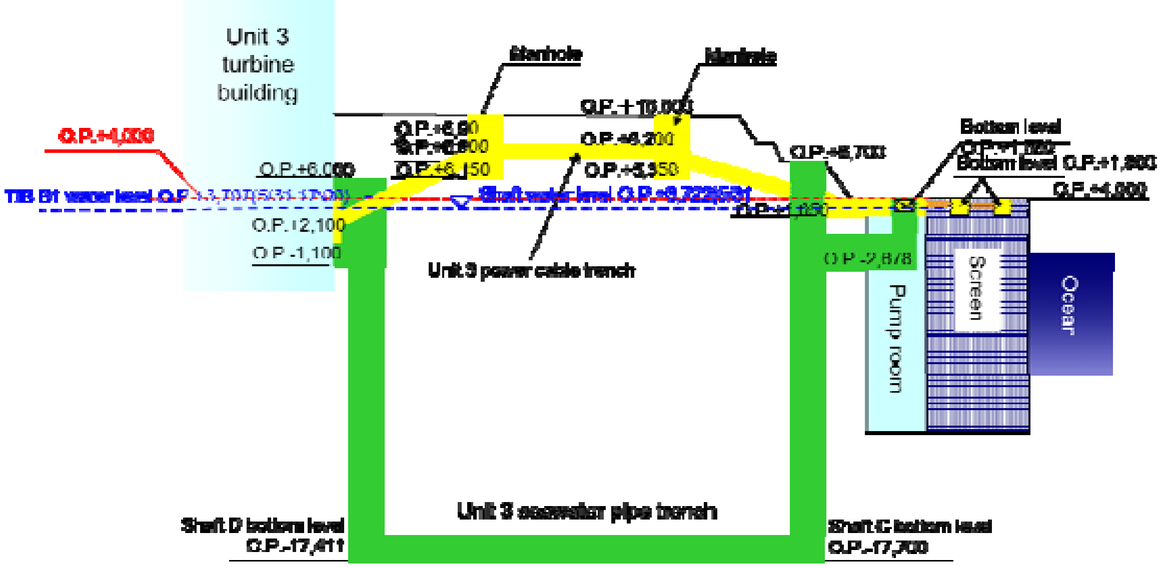


N
Legend
Seawater pipe trench
Powercable trench
Powercable conduit
Flow path
Flow path (pathway cut off by waterproofing countermeasures)
Pit above flow path
Pits for which the flow path is unclear
Locations where leak prevention countermeasures are already in place
Unit 4 turbine building
Unit 3 turbine building
Turbine building junction O.P.-1.150m
Turbine building junction O.P.+2.100m
Turbine building junction O.P.-1.150m
Turbine building junction O.P.+2.550m
Shaft D
Shaft A
Shaft C
Shaft B
Unit 4 seawater pipe trench
Unit 3 seawater pipe trench
Unit 3 power cable trench
Foundation height O.P.+5.35m
Manhole
Junction O.P.+4.100m
*Foundation height is O.P.+4,100m, but all possible countermeasures were implemented assuming that it could be a flow path.
Junction O.P.+1.300m
Unit 4 power cable trench
Foundation height O.P.+1.300m
Foundation height O.P.+4.100m
Pump room
Foundation height O.P.+1.300m
Screen
Foundation height O.P.-17.428m
Foundation height O.P.+1.550m
Foundation height O.P.+2.600m
Foundation height O.P.+3.300m
Foundation height O.P.+1.200m
Pump room
Foundation height O.P.+1.550m
Intake power room
Screen
Foundation height O.P.+2.120m
Junction foundation height O.P.+1.200m
To 55
To 47
5/11 Location of confirmed leak

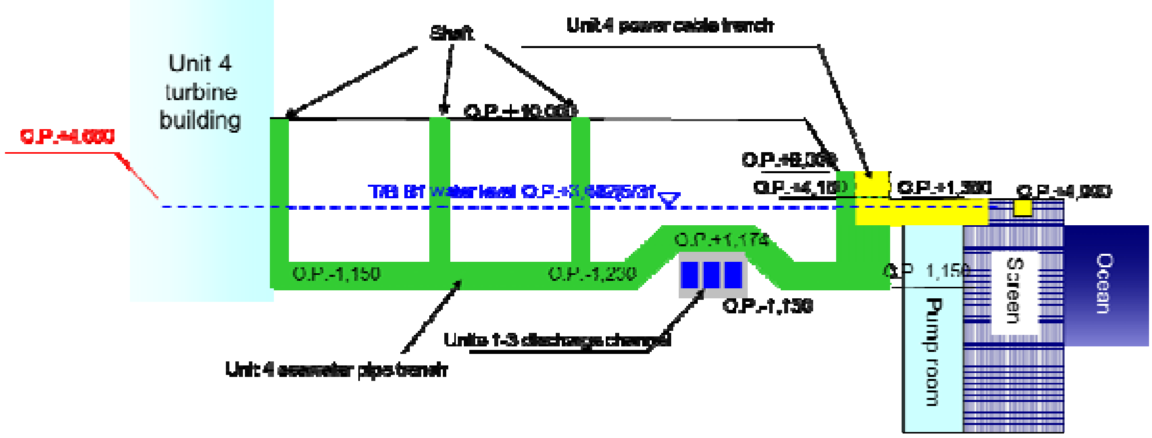
Unit 3 seawater pipe trench (c-c cross section)



Unit 3 seawater pipe trench (c'-c' cross section)



Unit 4 seawater pipe trench (d-d cross section)



Unit 3 seawater pipe cross section

Ocean Impact

1. Discharge volume overview

   During April 1 to 6, 2011, approx. 520m^3 of contaminated water containing approx. 4.7 x 10^{15}Bq of radioactive material from Unit 2 leaked into the bay. The amount of low contaminated water that was discharged as an emergency measure during April 4 to 10 was approx. 10,393m^3 and this contained approx. 1.5 x 10^{11}Bq of radioactive material. And, between May 10 and May 11 approx. 250m^3 of contaminated water from Unit 3 containing approx. 2.0 x 10^{13} Bq of radioactive material leaked into the bay.

2. Ocean monitoring results overview

   The ocean around the Fukushima Daiichi NPS has been monitored by TEPCO since March 21 and seawater within an area with a radius of 30km has been monitored by the Ministry of Education, Culture, Sports, Science and Technology since March 23. Thereafter, in accordance with instructions from the Nuclear Safety Commission and NISA, TEPCO increased the number of monitoring locations 15km of the coast and off the coast to the south to a current total of 29 monitoring locations. According to monitoring results from around April 5 through around April 20 peak levels thought to be caused by the leakage of contaminated water from Unit 2 were recorded at points not just around the power station but also at 15 km offshore and within an area with a radius of 30 km. Thereafter the levels decreased in by the beginning of May many of the values recorded were below detection limits (approx. 10Bq/L).

   Furthermore, results of monitoring and 15 km off the coast on May 15 are for the most part below detection limits and at current time no impact from the leak from Unit 3 has been observed.

   The details of these results are as follows.

   (1) Monitoring results from the Fukushima Daini NPS (10km to 15km off the southern coast)

   Peak radioactive concentration levels (April 5: Max. 3700Bq/L of I-131, Max. 1400Bq/l of Cs-137) were observed around April 5 and levels decreased overall thereafter thereby indicating the advection of radioactive materials from the Fukushima Daiichi NPS to the south.

(2) Results from monitoring at points 15 km off the coast

Peak increases (April 11: Max. 920Bq/L of I-131, Max. 760Bq/L of Cs-137) were observed at all points, however these levels decreased after April 22 and are currently below detection limits for the most part.

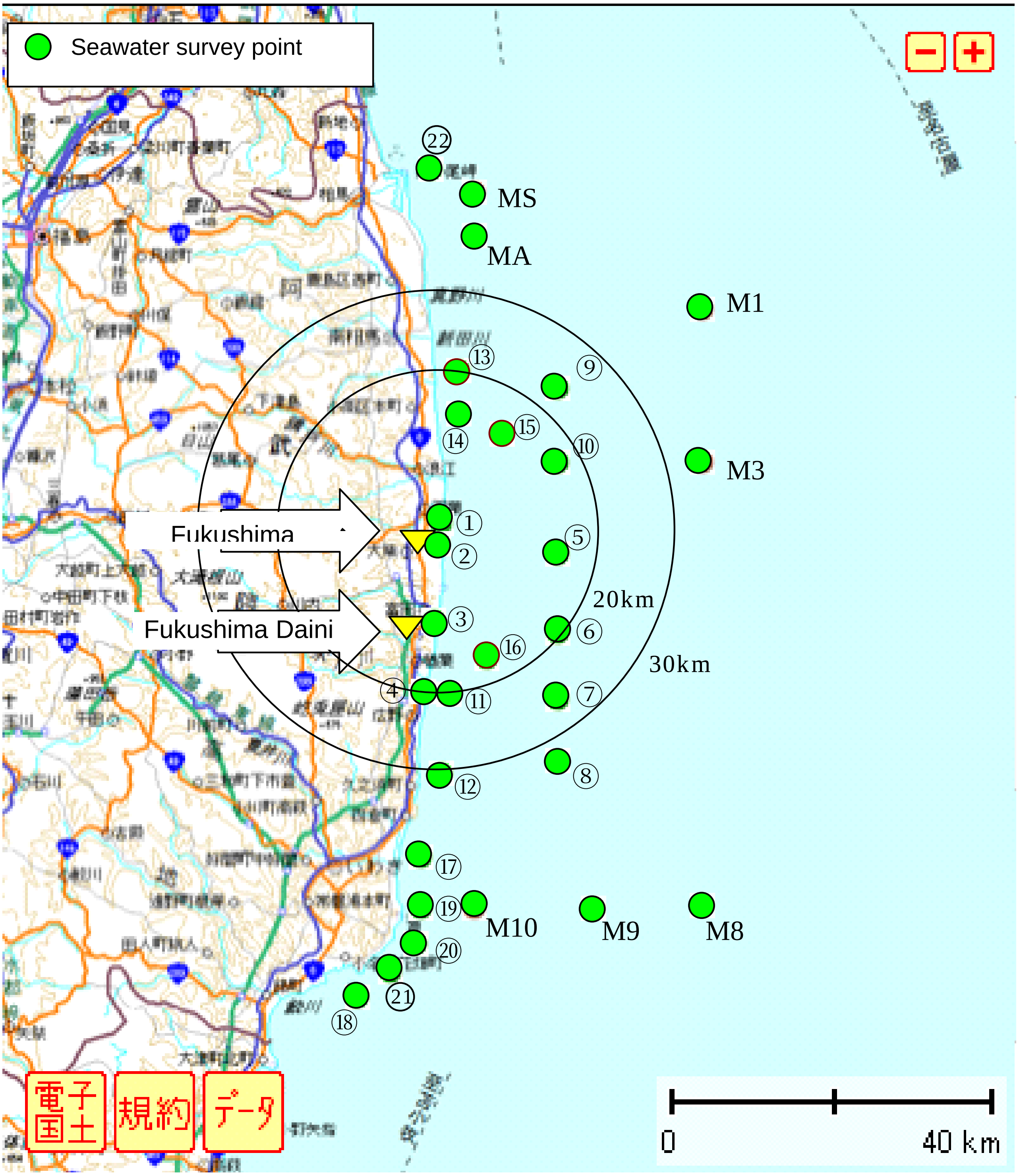
Furthermore, Peak increases were not observed off the coast of the North (from 15 km to 30 km).

(3) Results of monitoring at points within a 30 km radius

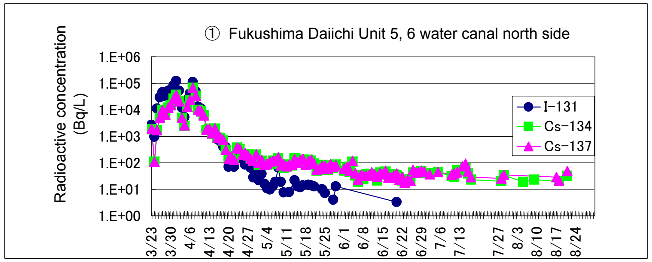
Peak concentration increases (April 15: Max. 161Bq/L of I-131, Max. 186Bq/L of Cs-137) were indicated at points east between around April 5 and around April 20. No large peak increases were recorded at points to the north so it is safe to assume that there was little advection of radioactive material to the north and northeast.

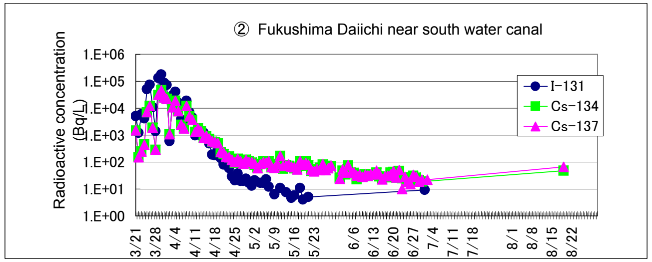
(4) Results of monitoring around Ibaraki Prefecture

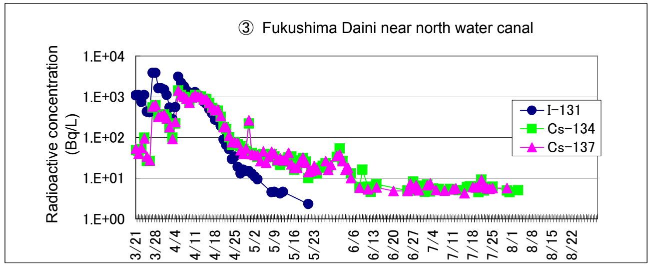
After April 25, monitoring was performed four times at 10 locations and on April 25 a small amount of I-131 was detected, however all other values were below detection limits.

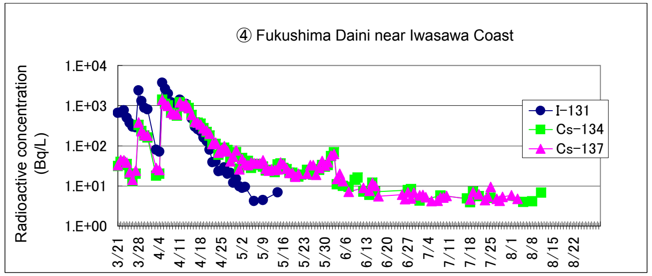


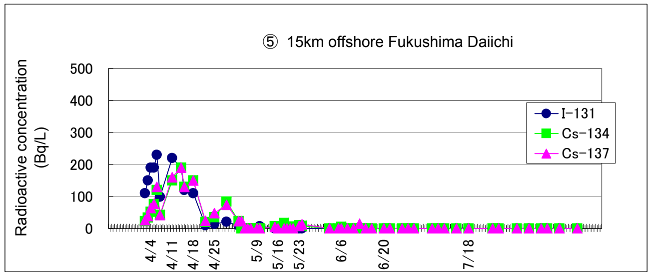
Sea area monitoring survey points around Fukushima Daiichi Nuclear Power Station

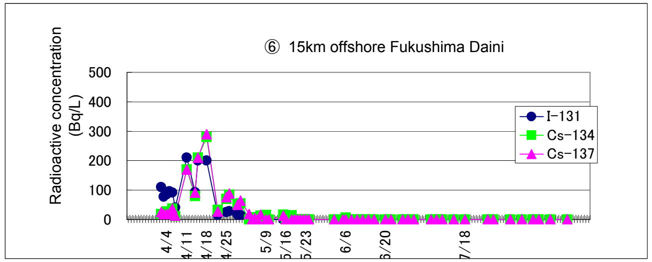


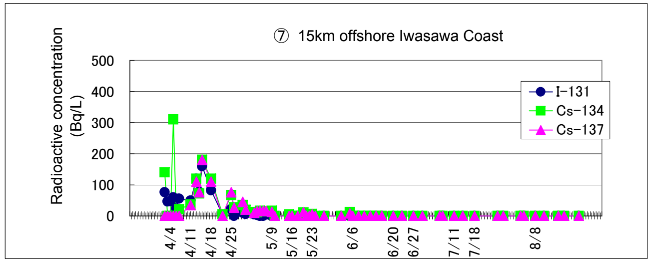


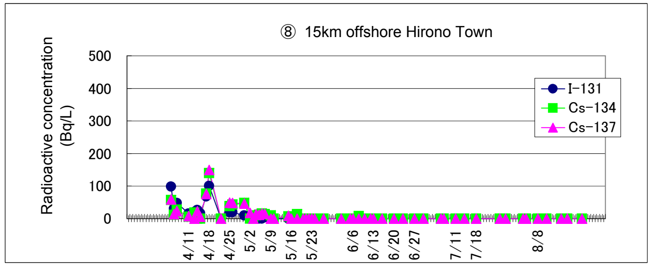


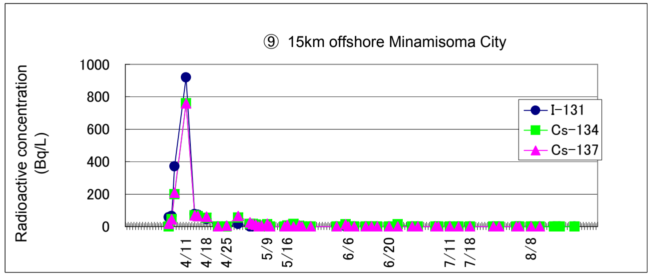


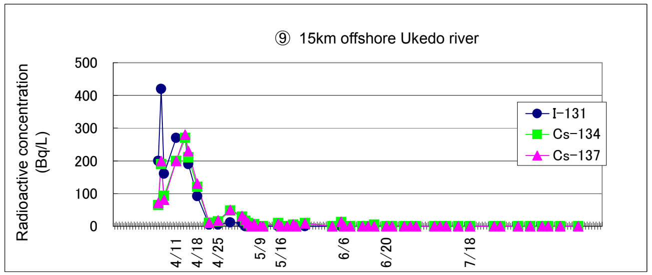


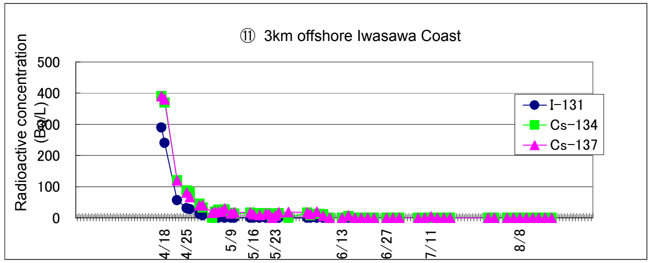


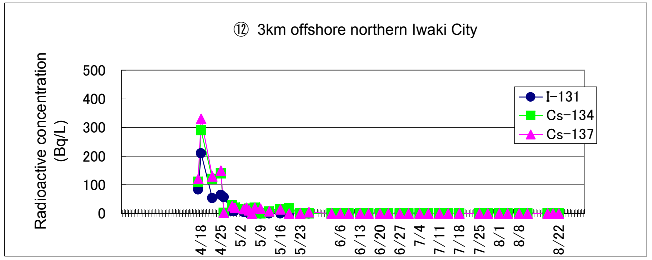


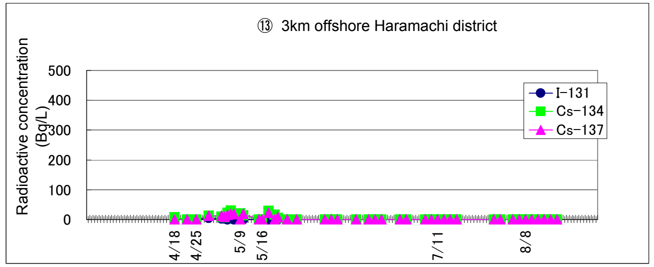


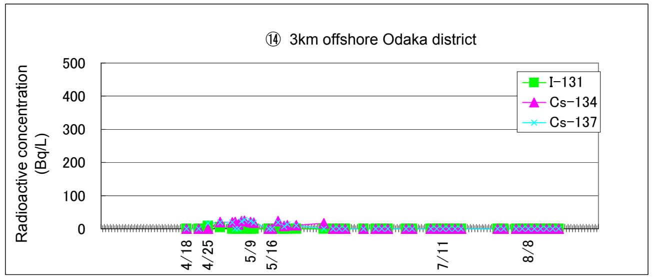


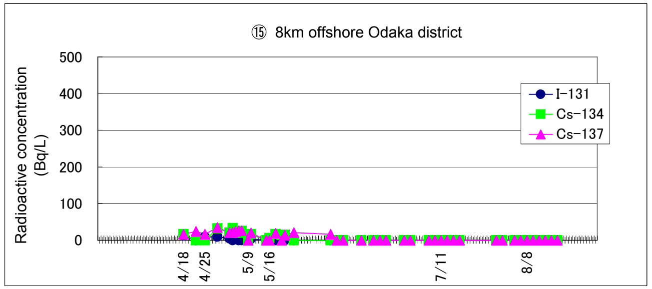






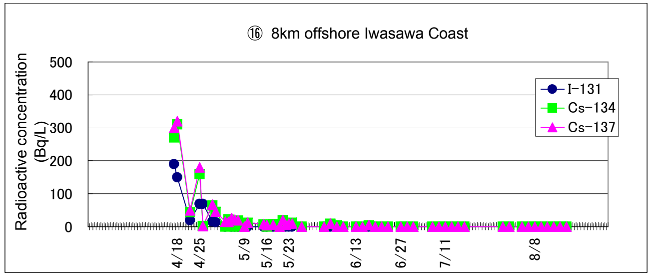


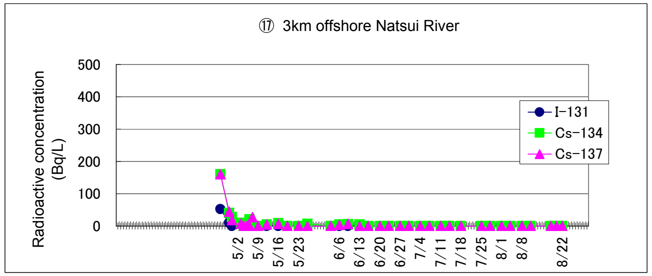


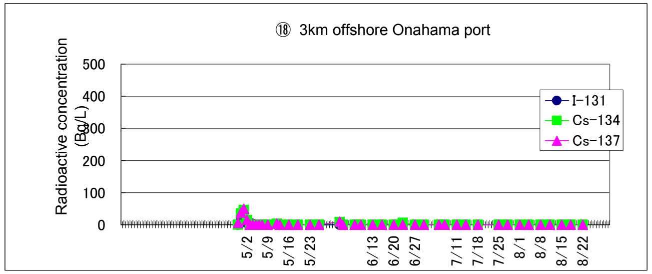


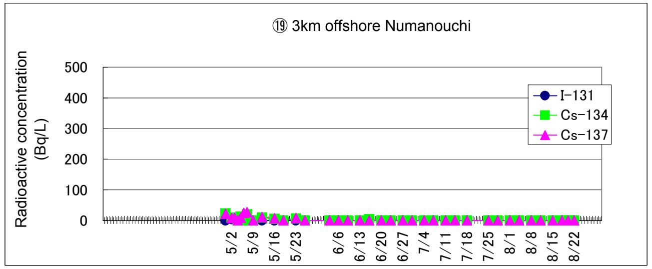
Radioactive concentration sea area monitoring survey results underwater (upper layer) around Fukushima Daiichi Nuclear Power Station (1)

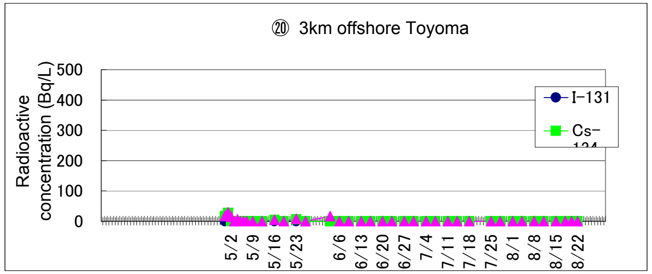
Attachment 12-16 (4/5)

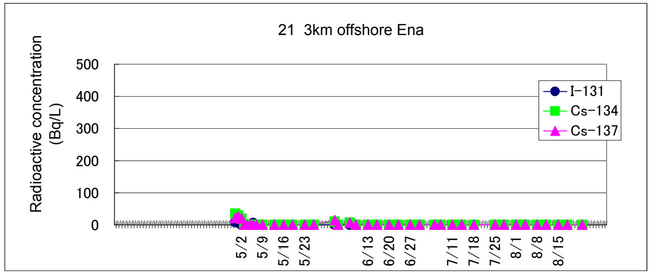


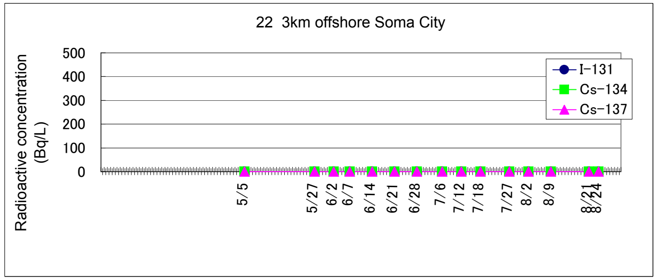


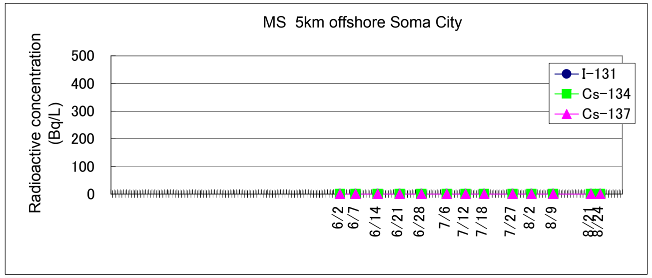


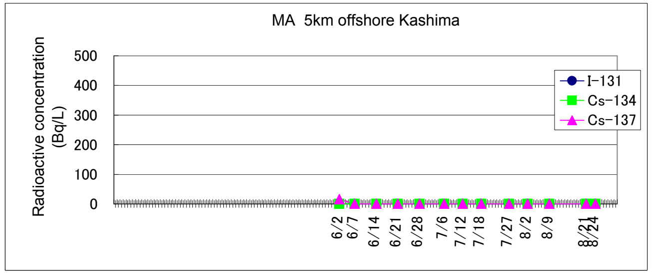


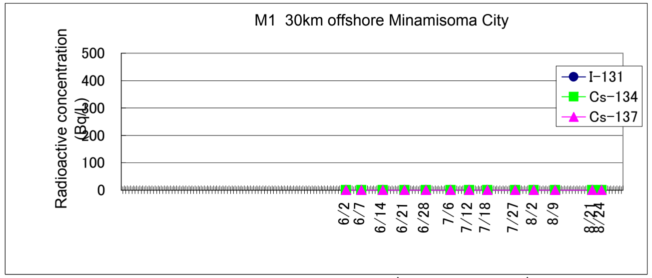


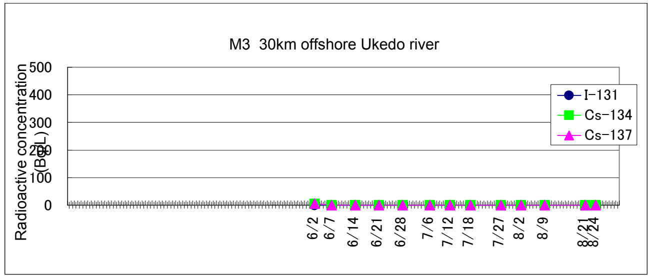


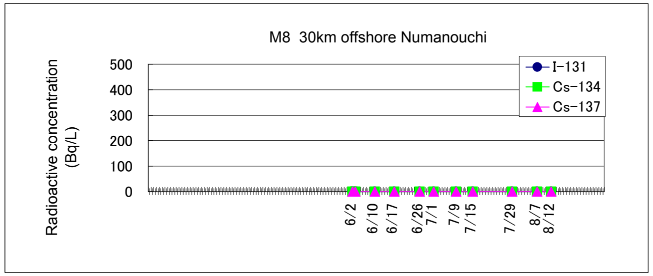


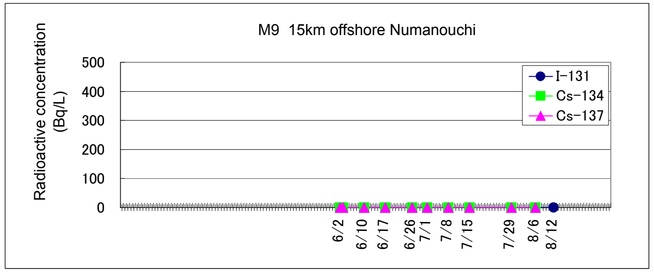


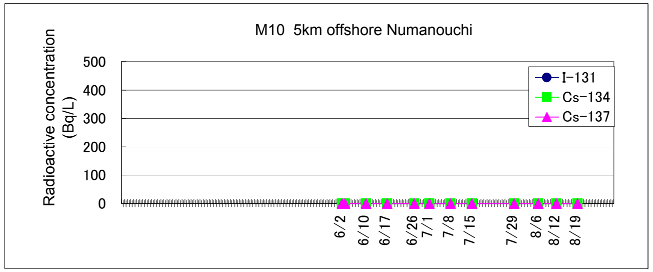












* Last sampling date: August 24, 2011
* When the result of the survey was "not detected", it is shown as 0Bq/L.

Radioactive concentration sea area monitoring survey results underwater (upper layer) around Fukushima Daiichi Nuclear Power Station (2)

Attachment 12-16 (5/5)

Counter Measures for Preventing Contaminated Water Leaks and Strengthening Diffusion Control

In consideration of the confirmed leakage path the following leak prevention countermeasures were implemented along with diffusion control countermeasures in case of a leak (some countermeasures are being implemented and others are planned). Furthermore, countermeasures for stopping highly contaminated water from accumulating in buildings in trenches, recovering and processing this water, and controlling the flow of groundwater are proceeding as part of the plan to remove any obstacles hindering decommissioning.

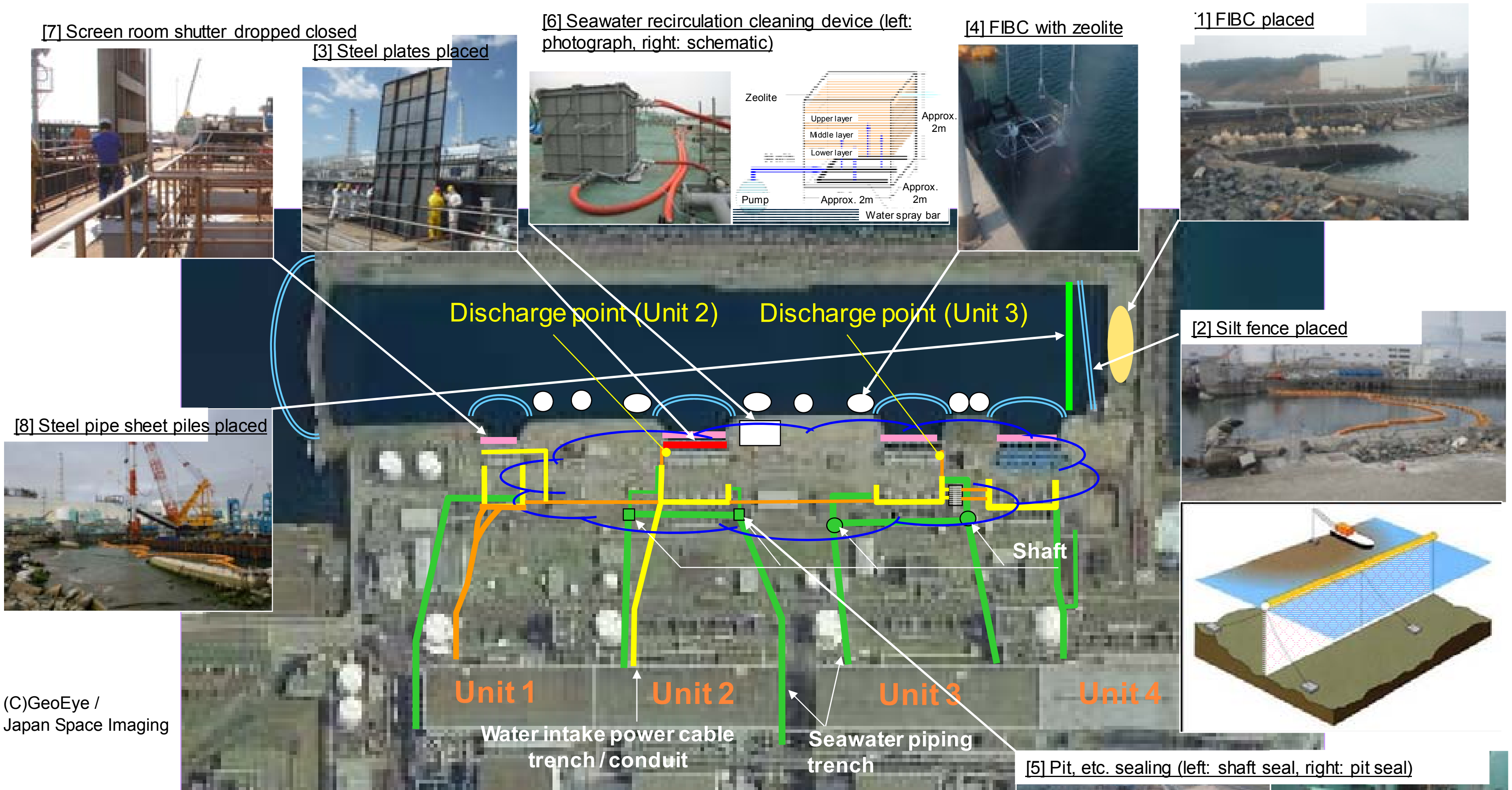
The numbers to the right in brackets are used in the following pages to indicate the type of preventive countermeasure.

① Leak prevention countermeasures
-Sealing off of sea water pipe trenches located upstream of leakage paths [5]
-Sealing off of pits that are at risk of leaking [5]
-Sealing damaged areas of seawall [5]
-Isolating the Unit 1~4 screen pump room [3, 7]
-Building silt fences and large sandbags [1, 2]
-Repairing damaged permeation prevention structure [8]
-Sealing off the Unit 2, 3 pump room circulating water pump delivery valve pit [5]

② Diffusion control countermeasures
-Removing radioactive materials from sea water off the coast [4, 6]
-Countermeasures for preventing ocean contamination via groundwater [9]
-Covering of the sea bed soil in the bay [10]

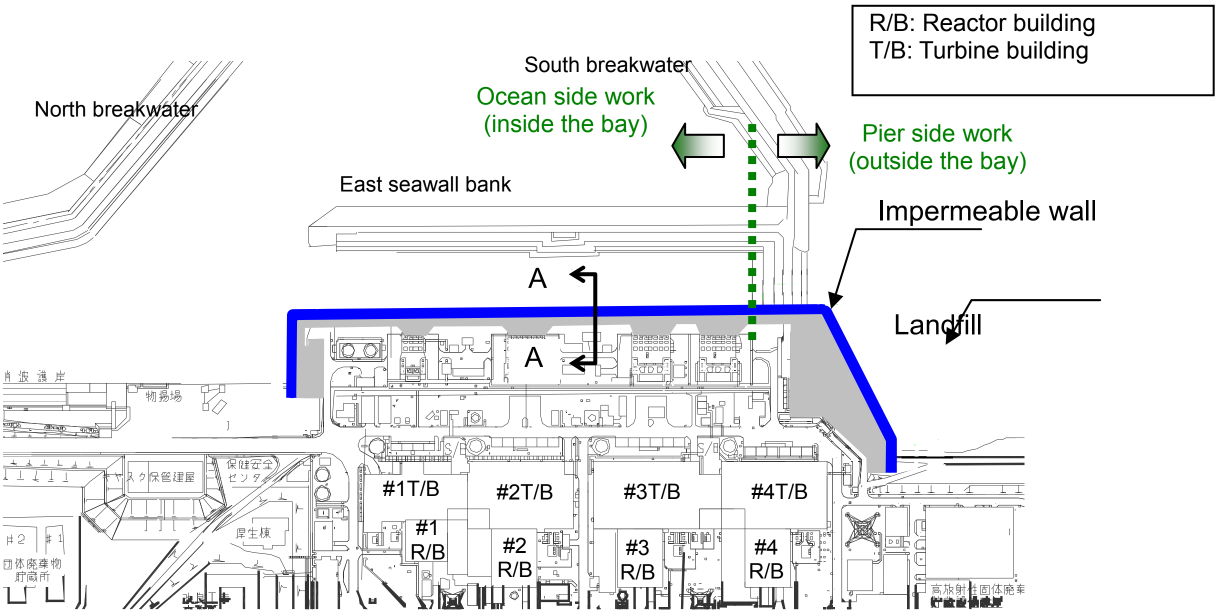
③ Stopping highly contaminated water accumulated in buildings and trenches, and collecting and processing this water [11]

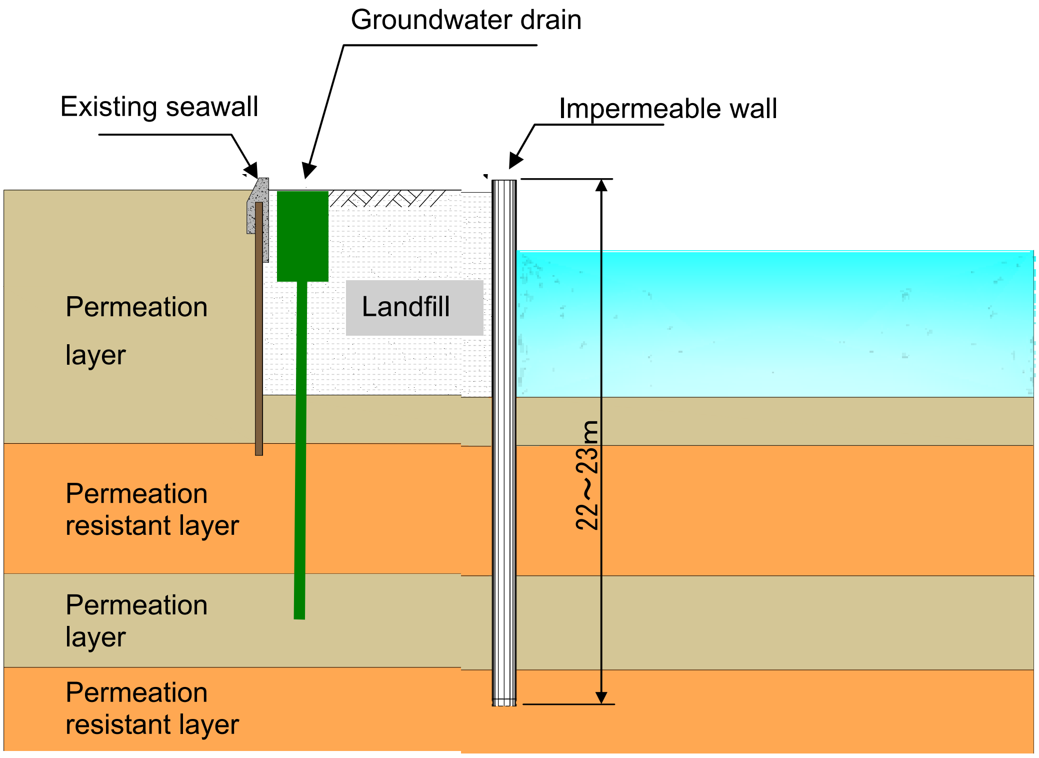
④ Countermeasures for controlling the flow of groundwater
-Reducing the volume of groundwater flow by decreasing water levels in subdrains [12]
-Reducing the volume of groundwater inflow by building an groundwater bypass system [13]



- [1] FIBC (Apr 5 to Apr 8)
- [2] Silt fence (Apr 11 to Apr 14)
- [3] Steel plates placed (Apr 12 to Apr 15)
- [4] FIBC with zeolite (Apr 15, 17, 19)
- [5] Pit, etc. sealing (seawater piping trench shaft: Apr 5 to May 30, power cable trench pit etc. sealing: Apr 2 to Jun 25)
- [6] Seawater cleaning device (installation: mid-May to late May, operation from Jun 16)
- [7] Screen room shutter dropped closed (Jun 12 to 29)
- [8] Steel pipe sheet piles etc. (Jul 12 to late Sep) [sweeping started Jul 12, steel pipe sheet piles construction: Aug 17 to Sep 6]

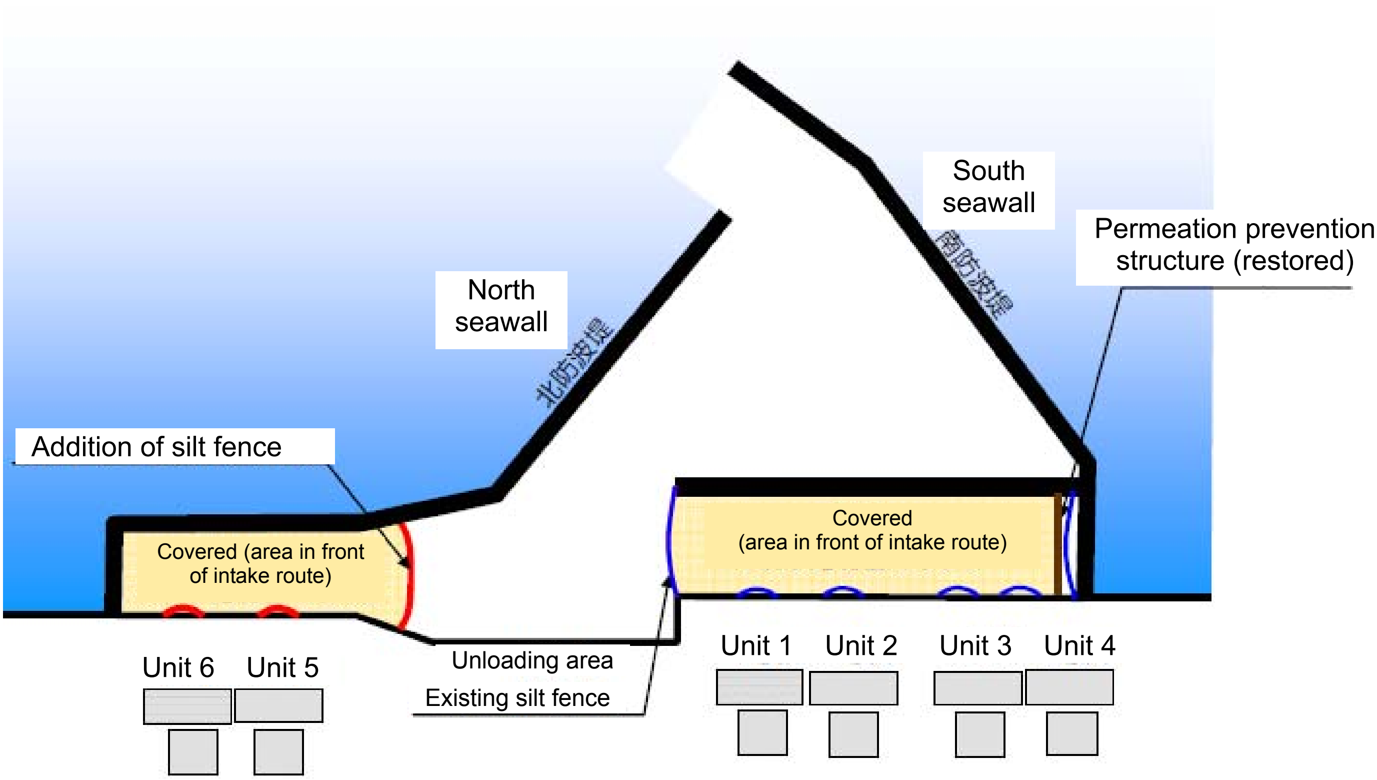
Countermeasures for Enhancing Diffusion Prevention of Liquids that Contain Radioactive Materials





(A-A cross-section)

Countermeasures for Preventing Ocean Contamination via Groundwater [9]



Location of covering engineering

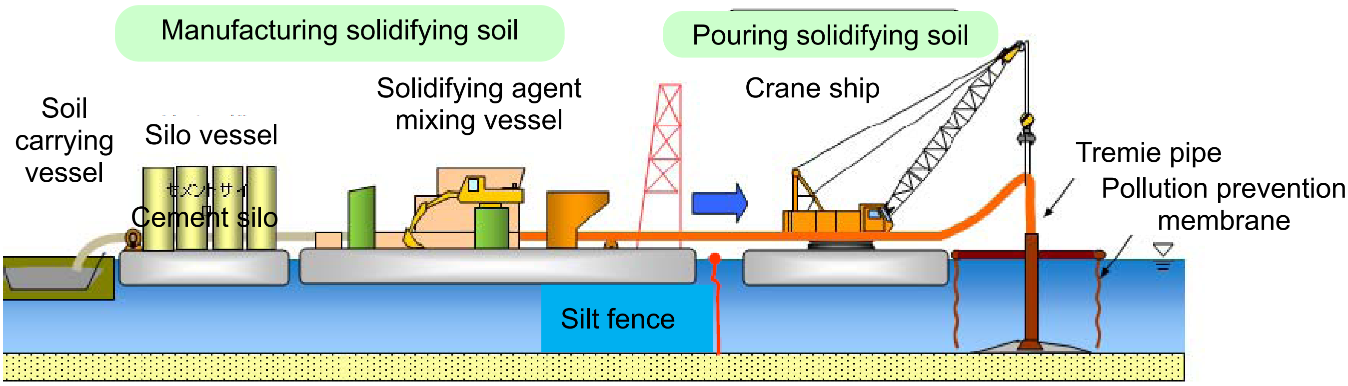
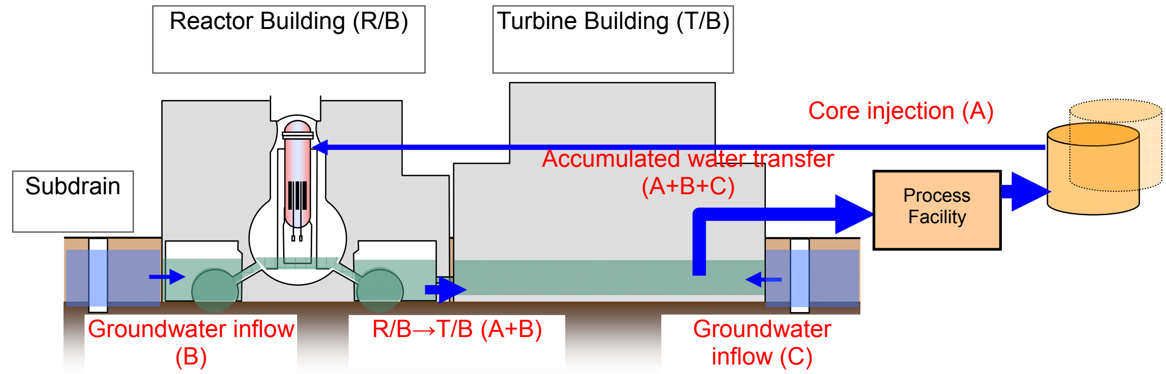


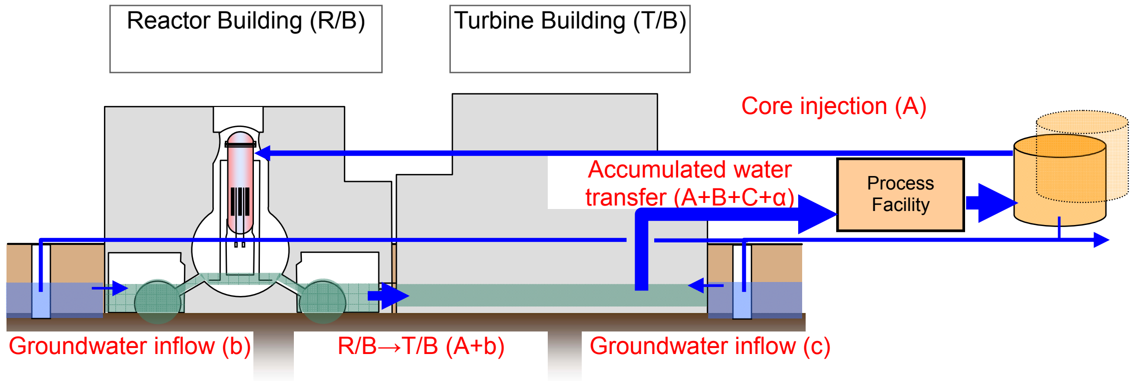
Diagram of Covering work (ship configuration)

Overview of Bay Seabed Covering Work [10]

[Current state]

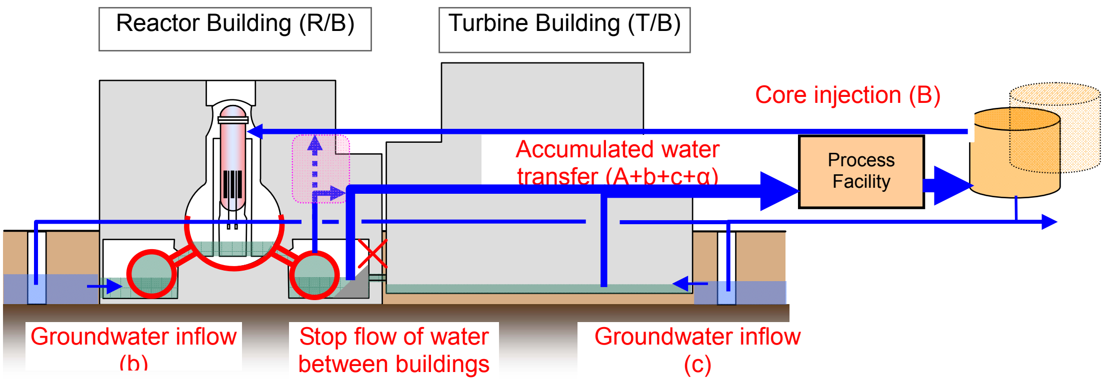


[Water level in buildings drop]

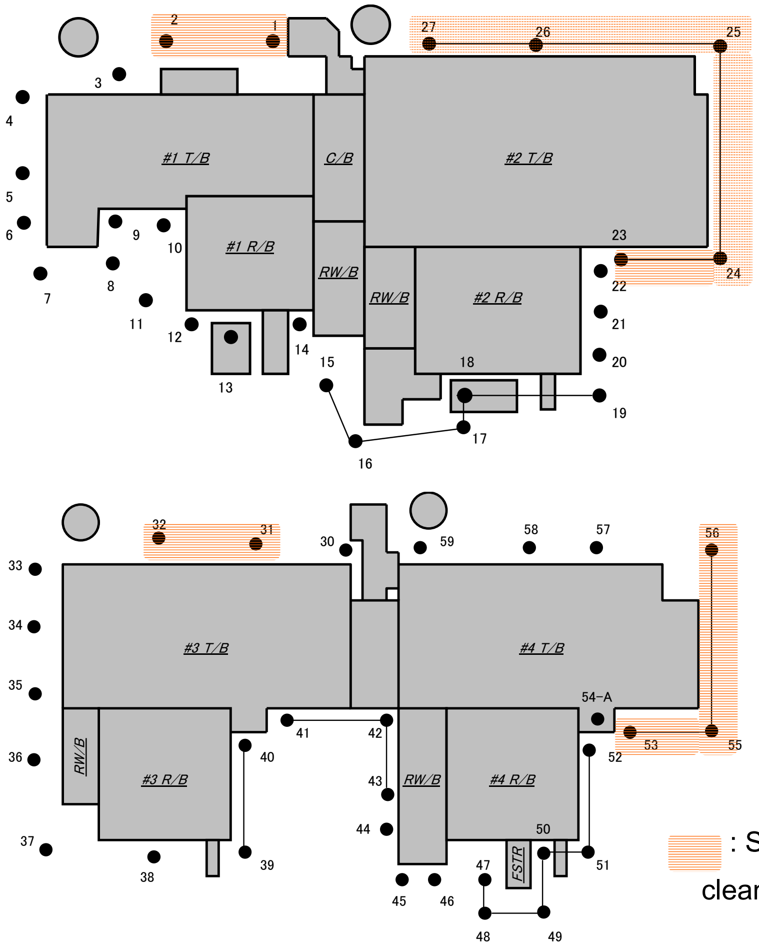


(Maintain the water level in the building below the surrounding subdrain water level)

[Reactor Building water sealing / accumulated water collection]

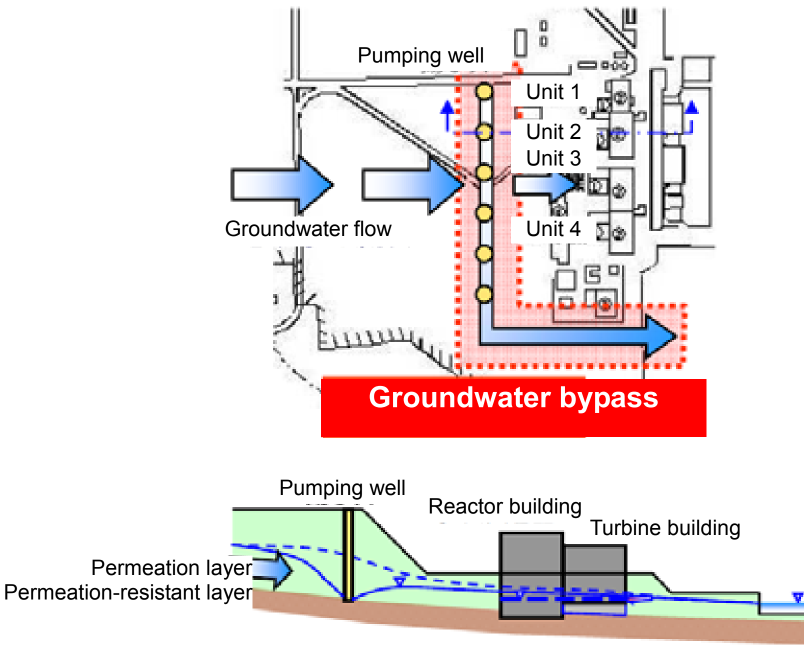


Stopping Contaminated Water from Accumulating in Buildings and Collecting the Water [11]



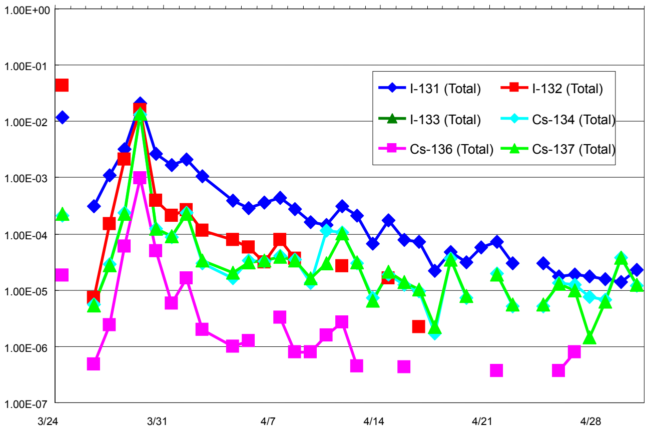
: Subdrains to be subject to cleansing tests beforehand (planned)

Subdrain pit location diagram (Upper level: Unit 1, 2, Lower level: Unit 3, 4)

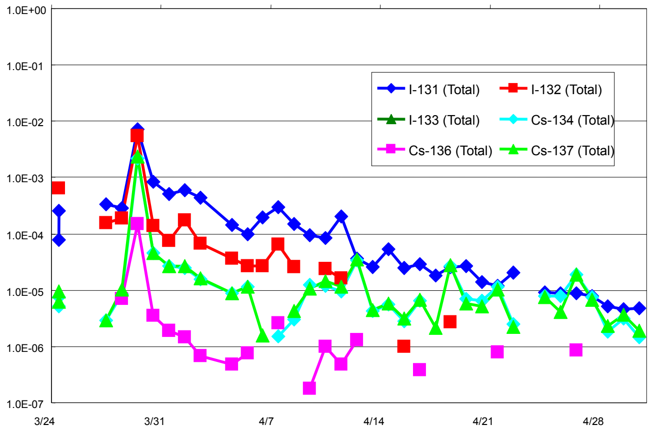


Groundwater bypass (concept image) [13]

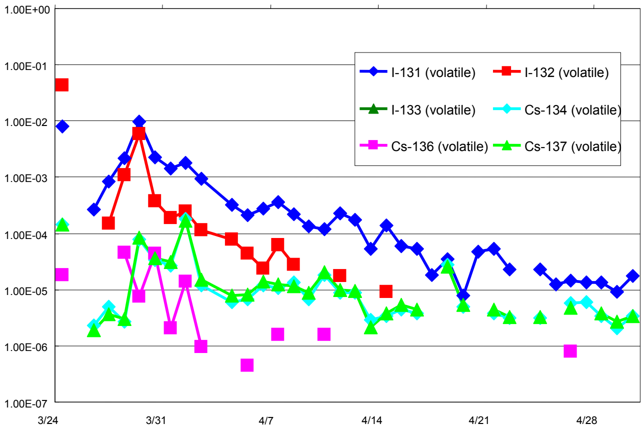
Fukushima Daiichi Nuclear Power Station
- Trending of airborne radioactive material concentration in the seismic isolated building



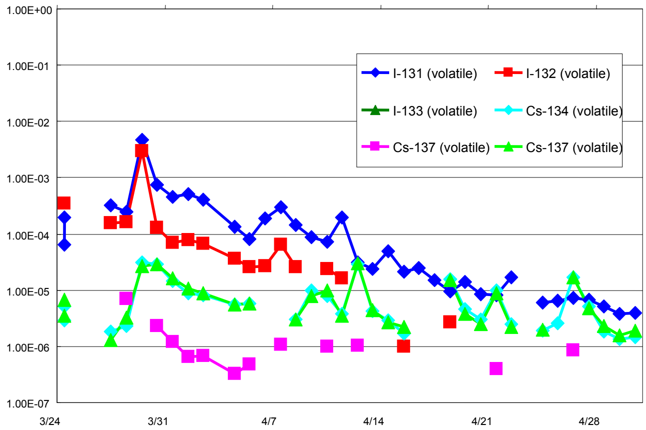
1st floor total value (charcoal + particulate)



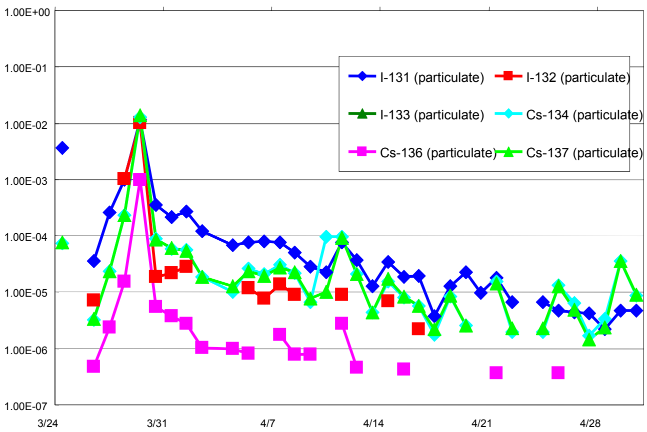
2nd floor total value (charcoal + particulate)



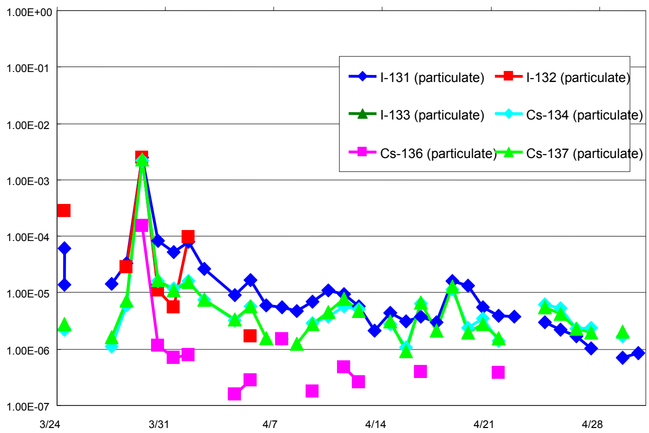
1st floor charcoal



2nd floor charcoal

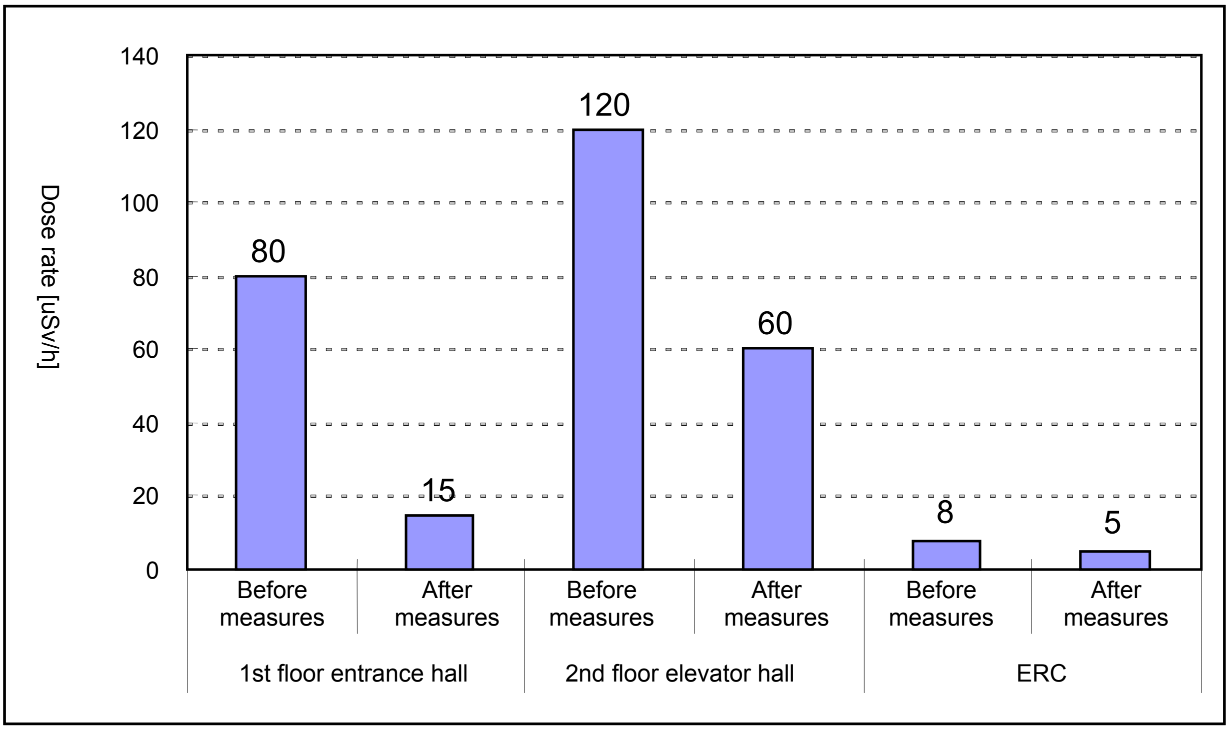


1st floor (particulate)



2nd floor (particulate)

Trending of seismic isolated building dose rate before and after the installation of shields



Status of ensuring radiation protection Equipment

1. Status of Securing radiation protection Equipment at Fukushima Daiichi
   (1) Area Passive Dosimeter (APD) with alarms, alarm setting equipment and rechargers
   - Prior to the disaster of March 11, approximately 5000 APD had been stored at the entrance to controlled areas, such as the service buildings for Units 1 to 6, the seismic isolated building, and the main gate. However, the tsunami rendered all but approximately 320 of these APDs unusable (this is the total of 50 APDs stored in the seismic isolated building (including rechargers (50 rechargers for APD)), APD worn by workers at the time, and APDs recovered from the Solid Radioactive Waste Storage Facility, etc.). On the same day, assistance in the form of personnel and equipment was asked in accordance with the agreement of cooperation between operators and an “Electric Company Support Team” was formed by other nuclear power operators.
   - By around March 15, the number of APDs that could be lent out had fallen to approximately 10, so the Fukushima Daiichi health physics team started giving APDs to only one member of the team and asked the headquarters health physics team to do something about the APD situation.
   - In response, the headquarters health physics team decided to advance delivery (scheduled to be delivered in April to the Fukushima Daiichi NPS by Panasonic) on 400 APDs that had been ordered from the manufacturer prior to the disaster (March 2010) and asked the headquarters procurement team to take care of the paperwork. As a result, 100 out of the 400 procured APDs arrived at the Fukushima Daiichi NPS on around March 18. However, since on-site radiation levels prevented the calibration of the units, which is normally done after arrival at the power station, the APDs were not initially used. Furthermore, since it was confirmed that the remaining 300 APDs could be delivered by the end of March, the manufacturer was asked to deliver them on April 1 and 300 APD arrived at Fukushima Daiichi NPS on April 3.
   - Then, on March 16, when the headquarters procurement team

contacted a contractor it was learned that one APD recharger that had been sent for inspection/calibration prior to the disaster was still at the contractor's research center (Oarai) and it was transported to Fukushima Daiichi on March 17.

- Furthermore, on March 17, the headquarters general affairs team asked Chubu Electric, which was the company overseeing the Electric Company Support Team, for APDs and as a result from March 19 through the 21 450 APDs from Shikoku Electric, which uses the same Panasonic APDs employed by Fukushima Daiichi (however those are second generation older than TEPCO's), arrived at J Village. On March 21, 100 of these units were transported to Fukushima Daiichi, but the alarm setting devices had been misplaced at J Village and were not sent along with the APDs. When it was discovered that the existing alarm setting device at Fukushima Daiichi was not compatible with the older type of APD the units were returned to J Village.
- Since the alarm setting devices could not be found at J Village, on March 22 the headquarters health physics team ordered alarm setting devices from the manufacturer and three of the new alarm setting devices arrived at J Village on March 31. Furthermore, on April 5 two alarm setting devices that are thought to have been sent along with the APDs from Shikoku Electric were found at J Village. (However, at this point in time there were enough APDs at Fukushima Daiichi so ultimately the APDs from Shikoku Electric were not used).
- It was learned that at the end of March, APDs had been sent along with other aid from Kashiwazaki-Kariwa to Fukushima Daiichi and after a search for them, 500 APDs (manufactured by Fuji Electric) and two APD setting devices were found. (However, at this time the rechargers were not found)
- Through procurement and aid by March 31, the number of APDs totaled approximately 920 (counting the 320 that were delivered early by the manufacturer and 100 that were used with being calibrated a total of 420 of these could be immediately used), and there was a sufficient quantity the Fukushima Daiichi health physics team stopped giving APDs to only one member of each team on March 31 and started lending an APD out to each member of every team starting

April 1, a fact that was conveyed to the headquarters health physics team. (As of the 31 the APD recharger from Kashiwazaki-Kariwa had not been found, but it was confirmed that the recharger had been transported to Fukushima Daiichi, so there was the expectation that it would be found without much trouble. Furthermore, there is information that 300 APDs procured from the manufacturer would be arriving in a couple days. It was therefore deemed possible to resume giving one APD to each worker.)

- During a teleconference with the integrated accident response headquarters at 21:00 on March 31, the headquarters health physics team shared the information that as of April 1 there were at least 420 APDs so as a rule one APD was being given out to each worker.
- On April 1, it was learned that five APD rechargers had been sent from Kashiwazaki-Kariwa to Fukushima Daiichi (this will be discussed later), and on the same day they were transported to the seismic isolated building and used.
- As mentioned above, as soon as the Fukushima Daiichi health physics team realized that the number of APDs was insufficient, it asked headquarters to procure APDs and in response headquarters did all it can to procure APDs. In addition, attempts were made by Kashiwazaki-Kariwa to send aid, such as APDs, but since there were problems with calibrating the units at the power station and transporting them to Fukushima Daiichi, personnel were forced to give only one APD to each team until a sufficient number of APDs could be secured.

(2) Protective clothing/protective equipment

- Prior to the disaster of March 11, approximately 1000 full face masks, approximately 700 charcoal filters, and approximately 6000 Tyvek suits had been stored at the entrance of controlled areas in, for example, the Units 1 to 6 service buildings, the waste treatment facility group laundry room, materials warehouse, and the seismic isolated building, however approximately 80% of these safety materials were in the Units 1 to 4 service building and waste treatment facility group laundry room, and were therefore rendered unusable by the tsunami. Only approximately 20% of these materials that had been stored in the Unit 5, 6 service building, materials warehouse, and seismic isolated building were affected less by the tsunami and could still be used.

- Around 17:00 on March 13, the Fukushima Daiichi health physics team left by bus for the Onahama coal center in order to pick up support workers from Kashiwazaki-Kariwa, transport materials for the procurement team and ensure radiation protection equipment.
- At around 21:00 on the same day, the Fukushima Daiichi health physics team loaded approximately 300 to 400 Tyvek suits, rubber gloves and boots into a bus at the Onahama coal center and left for Fukushima Daiichi along with support workers from Kashiwazaki-Kariwa.
- At around 24:00 on the same day, the bus carrying approximately 300 to 400 Tyvek suits, rubber gloves, and boots arrived at Fukushima Daiichi.
- Thereafter, the Fukushima Daiichi health physics team used the aid from Kashiwazaki-Kariwa, etc. and after around March 17 protective clothing and equipment started to continuously arrive.

2. Aid from Kashiwazaki-Kariwa and Fukushima Daini

(1) APD, APD setting devices and rechargers

- On March 11 immediately after the earthquake, the site superintendent at Kashiwazaki-Kariwa instructed each team established in conjunction with the Tohoku-Chihou-Taiheiyo-Oki Earthquake to provide aid to Fukushima Daiichi as much as possible. In response to this the Kashiwazaki-Kariwa health physics team on its own initiative decided to send radiation protection equipment, such as APD, under the assumption that the APD at Fukushima Daiichi had most likely been rendered unusable by the tsunami.
- On March 11, when support workers from the Kashiwazaki-Kariwa health physics team departed for Fukushima Daiichi to engage in support activities, 30 APDs, and three ADP rechargers (each capable of recharging 10 APD) were loaded into two buses which departed for Fukushima Daiichi at around 19:00 and 23:00.
- On March 12, the aforementioned two buses arrived at Fukushima Daiichi at around 2:30 and 12:30. This support team mainly engaged in safety work, such as managing entry and exit to the seismic

isolated building, helping workers take off clothing, and providing/keeping equipment.

- At 16:58 on the same day, a helicopter lifted off from Tokyo to go to Fukushima Daini via Kashiwazaki-Kariwa in order to transport personnel returning to Fukushima Daiichi as well as radiation protection equipment.
- At 18:03 on the same day, the aforementioned helicopter arrived at Kashiwazaki-Kariwa, was loaded with 300 APDs (stored in crates), two APD setting devices, 100 C equipment, 20 masks and charcoal filters, and departed for Fukushima Daini at 18:12 on the same day.
- At 19:03 on the same day the aforementioned helicopter arrived at Fukushima Daini and loaded a bus with the radiation protection materials in addition to 50 masks, and five boxes (for approximately 250 people) of charcoal filters stored at Fukushima Daini into a bus which left for Fukushima Daiichi at around 20:00 on the same day there after arriving at Fukushima Daiichi at around 21:20.
- At around 20:00 and 23:00 on the same day 200 APDs for Fukushima Daiichi (stored in opaque plastic case), and five APD rechargers (capable of charging 100 APDs, covered with a tarp to prevent them from getting wet) from Kashiwazaki-Kariwa were loaded along with electrical related aid materials for Fukushima Daini into two trucks which left for Fukushima Daini.
- At around 4:00 and 7:00 on March 13, the aforementioned two trucks arrived at Fukushima Daini. The 200 APDs were temporarily stored with other safety equipment at the entrance of the main building, and the five APD rechargers were stored along with electrical related aid material for Fukushima Daini in the Fukushima Daini warehouse. (When the APD rechargers were unloaded from the truck, Fukushima Daini restoration team members realized that they were indeed APD rechargers, but since the restoration team had not ordered APD rechargers, the team members conveyed to the restoration team leader that APD rechargers had arrived. Since a lot of aid from different locations was arriving at Fukushima Daini, the restoration team leader assumed that the owner would appear eventually and for the time being ordered that the materials be stored in the warehouse.) As a result, information about APD rechargers was not conveyed to

the Fukushima Daiichi health physics team.

- In the early hours of March 14, a helicopter with Kashiwazaki-Kariwa restoration team members landed at Iwaki City, Fukushima Prefecture in order to help out at Fukushima Daiichi and Fukushima Daini after which the members boarded a bus that had been sent from Fukushima Daiichi to pick them up. This bus stopped by at Fukushima Daini to let some of the Kashiwazaki-Kariwa restoration team members off and load aid materials for Fukushima Daiichi that had been stored at the entrance to the main building. At this time the 200 APDs that had been sent from Kashiwazaki-Kariwa on the morning of March 13 were loaded. Around noon on March 14, the bus arrived at Fukushima Daiichi and the aid material was carried into the seismic isolated building by Kashiwazaki-Kariwa restoration team members.
- As mentioned above, as of March 14 a total of 500 APDs and APD setting devices had arrived at Fukushima Daiichi as aid from Kashiwazaki-Kariwa, but even though support workers from Kashiwazaki-Kariwa who were managing entry and exit to the seismic isolated building had realized that radiation protection equipment, including APDs, had been sent, since there were only 30 dedicated chargers these workers assumed that the APD would not be immediately available at Fukushima Daiichi and put the crates and plastic containers in which they were stored in the work space for Kashiwazaki-Kariwa support workers. As a precaution, the Kashiwazaki-Kariwa support manager informed Fukushima Daiichi health physics team member that APD had arrived from Kashiwazaki-Kariwa, but that APD rechargers for 100 APDs had not arrived. At this time since they were not aware that there was an insufficient number of APD, and since the APD rechargers could only recharge 30 APDs, the Fukushima Daiichi health physics team member did not consider this to be useful information. After March 15 it became clear that the number of APDs was insufficient and efforts were hastily made to procure APDs in consultation with the headquarters health physics team, but the APDs sent from Kashiwazaki-Kariwa cannot be used immediately due to the absence of rechargers. Furthermore, the Fukushima Daiichi health physics

team member who had spoken with the Kashiwazaki-Kariwa support manager had returned to his own office between March 21 and April 1 so the fact that 500 APDs and two APD setting devices had arrived was not conveyed by the aforementioned health physics team member to the other health physics team members.

- At the end of March, 500 APDs and two APD setting devices were discovered at Fukushima Daiichi after a search.
- Meanwhile, after returning to Kashiwazaki-Kariwa from Fukushima Daiichi, the health physics team support brigade members from Kashiwazaki-Kariwa learned that five APD rechargers had already been transported from Kashiwazaki-Kariwa and started searching for them during the middle of March. At the end of March Fukushima Daini was asked to search for the item since it was confirmed that "on March 12 the eight materials were loaded into a truck at Kashiwazaki-Kariwa and unloaded at Fukushima Daini on March 13". At the end of March the Fukushima Daini health physics team left no stone unturned and searched the reactor buildings of all units, the truck bays of the turbine buildings and areas where electrical work was being engaged in, but did not find the APD rechargers. As a result on the morning of April 1 when the issue was discussed at the Fukushima Daini ERC restoration team mentioned that it might know where they are and the five APD rechargers from Kashiwazaki-Kariwa were found in the warehouse and transported to Fukushima Daiichi the same day.
- Furthermore, the Kashiwazaki-Kariwa health physics team learned from the headquarters health physics team leader via a integrated Fukushima accident response headquarters teleconference at 21:00 on March 31 at starting the next day on April 1 the policy of handing out of only one APD per team would be discontinued and plan to transport additional APDs fearing that the number of APDs would be insufficient if the Kashiwazaki-Kariwa APD rechargers were not found. It was confirmed prior with Fukushima Daini, which was implementing a search, that the APD rechargers had not been found, so they were asked once again to search while at the same time at around 1:30 on April 1, 190 APDs and two rechargers were secured and transported to Fukushima Daiichi. On the morning of April 1, 190 APDs and two

rechargers were handed over to the Fukushima Daiichi health physics team at J Village and transported to Fukushima Daiichi on the same day.

(2) Protective clothing/protective equipment

- As of March 15, 24,000 pairs of undergarments, 5800 pairs of coveralls/anoraks, 17,000 pairs of gloves, 1200 pairs of boots, 2600 paper masks, 200 full face masks, 160 semi-full face masks, and 1350 charcoal filters had been loaded into trucks of support workers departing from Kashiwazaki-Kariwa and transported to Fukushima Daiichi along with other aid material from Fukushima Daini over several trips.

3. Primary timeline related to radiation control

March 11, 2011	(Approximately 5,000 APDs had been stored on-site prior to the earthquake)
(14:46	Tohoku-Chihou-Taiheiyo-Oki Earthquake occurs)
	All personnel evacuates to the seismic isolated building
(15:27	The first tsunami wave arrives.)
	Most of the APDs stored at the radiation control access control checkpoints of the concentrated radioactive waste buildings in the Units 1 to 6 are rendered unusable due to water damage from the tsunami, leaving approximately 320 usable APDs.
21:51	Entry to the Unit 1 reactor building is prohibited due to rising radiation levels
March 12	
Around 4:00	Masks prepared in consideration of rising radiation levels
4:55	The government is notified that radiation levels within the power station are rising (0.069μSv/h(4:00)→0.59μSv/h(4:23) near main gate)
4:57	Workers heading to the field from the seismic isolated building are instructed to wear charcoal masks (Emergency Response Center)
5:04	instructions are given to wear dust masks in the main control room and charcoal masks in the field (shift manager)
7:00-	Radiation level measurements commenced within the seismic isolated building (performed daily thereafter)
	Prime Minister Kan visits the seismic isolated building
(Around 14:30	Unit 1 venting (PCV pressure drops))
(15:36	Unit 1 hydrogen explosion occurs)
March 13	Medical team leader instructs everyone under 40 years of age to take iodine tablets, and those over 40 years of age wishing to take the tablets do so.
(Around 9:20	Unit 3 venting (PCV pressure drops))

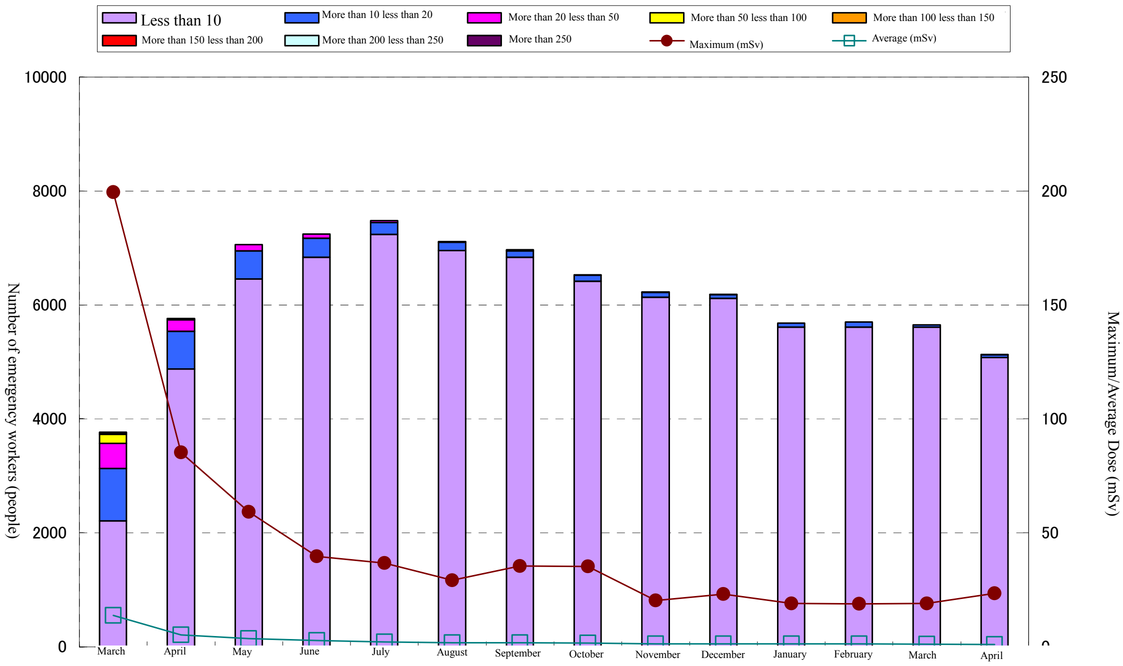
March 14	
(11:01	Unit 3 hydrogen explosion occurs)
March 15	
6:30	Site superintendent orders some ERC personnel to temporarily evacuate. Female employees (including A, B) evacuate (thereafter, female employee B works in the Fukushima Daiichi back office located at Fukushima Daini
March 15-	Due to the lack of APDs, the power station superintendent decides to give only one APD to a member of each team instead of one APD to each work member
March 17	Female employee A returns to the seismic isolated building (engages in work in the field between March 18 and 20). Shikoku Electric asked to provide APDs in accordance with agreement of cooperation between operators (450 units)
March 18	100 of the 400 APDs ordered prior to the earthquake arrive but whereas they have been calibrated by the manufacturer, additional on-site calibration cannot be implemented due to high background radiation levels in the units are for the time being stored as spares.
March 19-21	APDs from Shikoku Electric (450 units) arrive at J Village along with rechargers (5 units). Of these 100 APDs were transported to Fukushima Daiichi on March 21 but they are not used because the Shikoku Electric alarm setting device cannot be found at J Village and the alarm setting device at Fukushima Daiichi is not compatible.
March 20	Female employee A leaves the seismic isolated building
March 21	
8:40-	Measurement results of the concentration of radioactive materials in the air within the seismic isolated building begin to be confirmed (implemented daily thereafter)
March 22	Female employee A returns to the seismic isolated building and engages in work in the field. The headquarters health physics team leader instructs female

	employees to have whole body counter (WBC). A WBC owned by the Japan Atomic Energy Agency is setup at the Onahama coal center.
March 23	
Around 12:00	Power station health physics team leader orders female employees to evacuate. Female employee A evacuates (and thereafter works at the Fukushima Daiichi back office located at Fukushima Daini
March 26	Localized exhaust fans with charcoal filters setup. A buffer area is set up at the entrance to the seismic isolated building in order to prevent radioactive material from being carried inside
March 27	Windows in the seismic isolated building are shielded with lead as a countermeasure to reduce external exposure levels while staying in the seismic isolated building.
End of March	500 APDs and setting devices from Kashiwazaki-Kariwa are confirmed at the seismic isolated building.
March 31	It is decided to use the hundred APDs that were procured from the manufacturer and delivered early but not calibrated. Since the quantity of APDs for the time being is sufficient each work member is given an APD to wear starting the following day.
April 1-8	OA floor mats which radioactive material adheres to easily are replaced by tiles which are easily decontaminated and the tiles are cured with a tarp.
April 14-	An identification system that utilizes barcodes is introduced in the seismic isolated building and APDs are managed by barcodes
April 22	A rest area is established on the first floor of the Unit 6 service building so that field workers do not have to enter the seismic isolated building in order to go to the bathroom or to hydrate.
April 25	Exposure evaluation for people residing within the seismic isolated building is completed
April 27	Evaluation of internal exposure of female employee A is completed. Fukushima Daini industrial doctor confirms through exam that

	there is no impact on the female employee's health.
May 1	Evaluation of internal exposure of female employee B is completed.
May 2	Headquarters industrial doctor confirms through exam that there is no impact on the female employee's health.
May 13-	Multiple rest areas established within building
May 30	High internal radiation levels are confirmed within the thyroid gland of two male employees. The National Institute of Radiological Sciences is asked to examine the aforementioned two employees.
June 6-	In the case that the primary evaluation of an employee using a whole body counter (WBC) reveals that said employee has an internal exposure that exceeds 100mSv, that employee and any other employees engaged in the same work are prohibited from working in the field until the results of a WBC evaluation are confirmed. Employees within effective dose that exceeds 170mSv are restricted to working in the seismic isolated building.
June 8-	In addition to confirming identity through publically issued forms of identification, such as driver's licenses and basic resident register cards, barcodes are issued.
June 10	Medical exam results received from the National Institute of Radiological Sciences. (First two cases of excessive dose confirmed for two male employees)
June 20	Excessive dose confirmed for one male employee (3 in total)
July 7	Excessive dose confirmed for three male employees (6 in total)
July 29-	Picture entry permit based on publicly issued forms of ID begin to be issued
September 15-	Entry begins to be managed using entry permit.

Exposure Dose Distribution

1. External exposure dose distribution changes



*Since there are many cases where the internal exposure dose takes place over several months these are not added to monthly dose distribution but rather noted as cumulative dose.

2. Distribution of the sum of external exposure dose and internal exposure dose

Category (mSv)	March to April 2011		
	TEPCO Employees	Contractors	Total
More than 250	6	0	6
More than 200 less than 250	1	2	3
More than 150 less than 200	22	2	24
More than 100 less than 150	117	17	134
More than 50 less than 100	449	376	825
More than 20 less than 50	614	2,428	3,042
More than 10 less than 20	493	2,893	3,386
Less than 10	1,715	12,499	14,214
Total (people)	3,417	18,217	21,634
Maximum (mSv)	678.80	238.42	678.80
Average (mSv)	24.77	9.53	11.94

Worker Exposure that Exceeded Dose Limits

1. Two female TEPCO employees suffered exposure that exceeds dose limits

Two female employees engaged in work starting from the day of the earthquake in the seismic isolated building suffered a dose that exceeds 5mSv/3months.[1]

	Department	Exposure Dose	Work Period	Mask Status	Iodine Tablet Ingestion	Duties
A	Emergency Planning & Industrial Safety Department	19.55mSv (internal 13.6)	3/11-3/23	Charcoal mask worn when in the field	2 tablets (3/14)	Refueling of fire engines and desk work in the seismic isolated building
B	Administration Department	7.49mSv (internal 6.71)	3/11-3/15	N/A	N/A	Care of ailing parties in the seismic isolated building

In regards to the cause of this exposure, it is presumed that the following circumstances withheld the implementation of the policy of not allowing female employees to work within the Fukushima Daiichi Nuclear Power Station prior to March 23[2], resulting in an effective dose that exceeds legal dose limits due to the ingestion of radioactive materials present in the seismic isolated building.

- Due to the confusion that ensued after the incident, establishment of an area to remove protective clothing and of a buffer zone to prevent radioactive materials from being brought into the seismic isolated building was delayed.
- After the Unit 1 hydrogen explosion, health physics team members strictly controlled access to the seismic isolated building to prevent the double doors from being opened and closed, however it was difficult to completely prevent the influx of radioactive materials through these doors because the aforementioned doors are not

[1] In addition there are workers in the seismic isolated building that were not registered/designated as engaging radiation work. Five of these workers were female and effective dose evaluations revealed that two of these five women suffered a dose that exceeds the maximum dose limit for the general public (1mSv/year）.

[2] On March 23 the Safety Team Manager instructed female workers to evacuate in order to avoid excessive exposure by female workers. Consequently from this day no female workers were allowed to work at the Fukushima Daiichi Nuclear Power Station.

airtight and the doors themselves were slightly strained by the hydrogen explosions at Unit 1 and Unit 3 thereby creating a gap.

- External doses were being managed at 4mSv/3months so that the female employees would not suffer a radiation dose that exceeded limits (5mSv/3months). However, in addition to the fact that the dose management system did not function due to the impact of the earthquake/tsunami, the facts that doses for people staying in the seismic isolated building were not considered, and that full consideration was not given to internal exposure resulted in conditions where 5mSv/-months could not be strictly managed.

2. Six male TEPCO employees suffered exposure that exceeds dose limits

The following six employees suffered an exposure that exceeds the limit for exposure doses during emergencies (250mSv).

	Department	Exposure Dose	Work Period	Mask Status	Iodine Tablet Ingestion	Duties
C	Operator	678.80mSv (internal 590)	3/11-4/14	Dust mask until the Unit 1 explosion, and charcoal thereafter	No record	Plant operation and data collection in the MCR
D	Operator	645.54mSv (internal 540)	3/11-3/15	Dust mask until the Unit 1 explosion, and charcoal thereafter	Total: 10 tablets 3/14: 2 5/2: 2 5/3: 1 5/12: 2 5/20: 2 5/21: 1	Plant operation and data collection in the MCR
E	Operator	352.08mSv (internal 241.81)	3/11-3/31	Charcoal	Total: 3 tablets After 3/14	Plant operation and data collection in the MCR
F	Maintenance Department	310.97mSv (internal 259.70)	3/11-6/15	Dust mask until the Unit 1 explosion, and charcoal thereafter	Total: 2 tablets After 3/28	Instrument restoration in the MCR (Unit 1/2)
G	Maintenance Department	477.01mSv (internal 433.10)	3/11-6/4	Dust mask until the Unit 1 explosion, and charcoal thereafter	Total: 2 tablets After 3/21	Instrument restoration in the MCR (Unit 1/2)
H	Maintenance Department	360.85mSv (internal 327.90)	3/11-6/7	Charcoal	Total: 15 tablets After 3/24	Instrument restoration in the MCR (Unit 1/2)

Even in times of emergency, the ventilation system in the main control room (MCR) is designed to suppress worker exposure by a considerable amount. However, during this accident, the station experienced a total loss of AC power which prevented the main control room ventilation system from functioning. Shift workers (for operators) and maintenance department personnel did their best to protect themselves from radiation while being overwhelmed with work to restore the facility and get the situation under control in addition to dealing with the aftermath of the earthquake.

The precautions that were taken were the best options in the limited time available, but it is presumed that the following factors compounded and led to the ingestion of radioactive materials as a result.

- In conjunction with the fast progress of the accident, it was extremely difficult to take the appropriate protective action from the perspective of radiation management, such as selecting, wearing, and procuring the appropriate masks.
- In order to bring the situation under control, workers were spending an extended period of time in the main control room and had no other choice but to eat meals there.
- There is a possibility that the temples of eyeglasses created a gap between the mask and the skin, or at least this possibility cannot be denied.
- Workers near the emergency door of the main control room (door that leads to the outside) could not react fast enough to unforeseen circumstances, such as the explosion of the upper structure of the Unit 1 reactor building. Because it is estimated that a great amount of radioactive materials were present in the air,
- Albeit for only a short time, masks were moved about the face thereby creating gaps in the process of performing work safely.

End

Status of Core Cooling

	Fukushima Daiichi NPS						Fukushima Daini NPS			
	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 1	Unit 2	Unit 3	Unit 4
Actuation of high pressure injection systems immediately after tsunami **(IC, RCIC, HPCI)**	× **(Note 1)**	○	○	–	–	–	○	○	○	○
Standby of low pressure injection systems while high pressure injection was operating **(MUWC, DDFP, fire engines)**	×	×	○ **(Note 3)**	–	×⇒○ **MUWC**	○	○	○	○	○
Standby of depressurization via SRVs while high pressure injection was operating **(core pressure control)**	×	×	×	–	○	○	○	○	○	○
Standby of heat removal via PCV venting (W/W) while drywell is below design pressure	×	○⇒× **(Note 2)**	○	–	○	○	○	○	○	○
(Temporary) restoration of seawater system heat sink	×	×	×	–	×⇒○	×⇒○	×⇒○	×⇒○	○	×⇒○
Comment				Outage (no fuel in core)	Outage	Outage				

Note 1: IC did not function immediately after the tsunami.
Operated after 18:00, when power was temporarily restored but the functional status was unknown.

Note 2: The vent line was configured when the D/W pressure was below design pressure.
However, the valve closed due to the Unit 3 explosion, creating difficulties for subsequent operations.

Note 3: DDFP was actuated when the high pressure inject system shutdown, but there was no reactor injection because the reactor pressure was higher.

Attachment 14-1

Attachment 14-2

Fukushima Daiichi/ Daini NPS Event Progression (Overview)

Unit	Before EQ: Initial status	After EQ (earthquake): Scram	After EQ: DC power	After EQ: AC power	After EQ: IC RCIC HPCI	System status	After tsunami – High pressure injection: DC power	After tsunami – High pressure injection: AC power	After tsunami – High pressure injection: IC RCIC HPCI	After tsunami – Low pressure injection/ heat removal: RPV depressurization/ injection	After tsunami – Low pressure injection/ heat removal: PCV heat removal/venting	After tsunami – Low pressure injection/ heat removal: Heat release into seawater	Core status	Release – Response after core damage: PCV venting	Release – Response after core damage: Bldg. ventilation blowout panel	Bldg. hydrogen buildup	Bldg. explosion	Release	Comments
1F1	Operating	Success	DC	D/G startup	IC	No damage	Water damage Lost	D/G Lost	IC・HPCI lost	IC: all valve close logic operated HPCI: loss of DC power			Core damage/ H2 generated	Vented		H2 accumulation	Bldg. explosion	Released	[Fukushima Daiichi Units 1 to 6] ・No impact of earthquake on equipment necessary for safety. [Unit 1] ・Due to loss of power and other factors, there was no injection method at high temperature and pressure, causing decline in water level and core damage. ・Due to core damage, generated hydrogen accumulated in the building, causing explosion and release of radioactive material.
1F2	Operating	Success	DC	D/G startup	RCIC startup	No damage	Water damage Lost	D/G Lost	RCIC operating → RCIC lost	Difficult to switch to LP injection	・SRV operating by batteries ・Prepare for fire engine injection		Core damage/ H2 generated	Line up only	Blowout panel opened	No accumulation	No explosion	Released	[Unit 2] ・Due to power loss and adverse work environment, switchover from high pressure injection to low pressure injection was extremely difficult, during which time water level dropped, leading to core damage.
1F3	Operating	Success	DC	D/G startup	RCIC startup	No damage	DC → Spent Lost	D/G Lost	RCIC・HPCI operating → RCIC・HPCI lost	Difficult to switch to LP injection	・SRV operating by batteries ・Prepare for fire engine injection		Core damage/ H2 generated	Vented		H2 accumulation	Bldg. explosion	Released	[Unit 3] ・Due to power loss and adverse work environment, switchover from high pressure injection to low pressure injection was extremely difficult, during which time water level dropped, leading to core damage. ・Due to core damage, generated hydrogen accumulated in the building, causing explosion and release of radioactive material.
1F4	Shutdown	—	DC	D/G startup	—	No damage	*All fuel removed injection/ heat removal for SFP Water damage Lost	D/G Lost				FPC Lost	SFP fuel fully covered			H2 accumulation	Bldg. explosion	Released	[Unit 4] ・Hydrogen from Unit 3 PCV venting following into the reactor building. Accumulated hydrogen caused explosion in building.
1F5	Shutdown	—	DC	D/G startup	-	No damage	DC	Shared D/G Lost		Pressure control MUWC restored		SW sys. restored SW sys. lost	Sound		Bldg. hole opened				[Unit 5] ・Emergency power was provided by power sharing from Unit 6 EDG (AM equipment). Alternative temporary seawater pump was used for the seawater system damaged by sea water to provide residual heat removal capability. Resulted in cold shutdown.
1F6	Shutdown	—	DC	D/G startup	-	No damage	DC	D/G operating		Pressure control MUWC operating		SW sys. restored SW sys. lost	Sound		Bldg. hole opened				[Unit 6] ・Alternative temporary seawater pump was used for the seawater system damaged by sea water to provide residual heat removal capability. Resulted in cold shutdown.
2F1 2F2 2F4	Operating	Success	DC	Off-site power	RCIC startup	No damage	DC	Off-site power	RCIC operating * *2F4 also used HPCS	Pressure control MUWC operating	Vent line complete	SW sys. restored SW sys. lost	Sound						[Fukushima Daini Units 1 to 4] ・No impact of earthquake on equipment necessary for safety. [Units 1, 2, 4] ・Power supply cars and temporary cables were used to restore the seawater system pump, which was damaged by water, to provide residual heat removal capabilities. Resulted in cold shutdown.
2F3	Operating	Success	DC	Off-site power	RCIC startup	No damage	DC	Off-site power	RCIC operating	Pressure control MUWC operating	Vent line complete	SW sys. restored	Sound						[Unit 3] ・Safety-important equipment including the seawater system was not damaged by water, thus their functionalities were not lost, resulting in cold shutdown.

*1F: Fukushima Daiichi, 2F: Fukushima Daini

Attachment 15-1 (1) (1/2)

Ministry of Economy, Trade and Industry

12/03/2011 No.1

March 12, 2011

Mr. Masataka Shimizu, Director & President
Tokyo Electric Power Company

Banri Kaieda
Minister of Economy, Trade and Industry

Order in accordance with provisions of Article 64 Paragraph 3 of
The Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

The Ministry of Economy, Trade, and Industry, hereby orders the following to the Tokyo Electric Power Company, in accordance with the provisions of Article 64 Paragraph 3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166 of 1957, hereinafter referred to as "Reactor Regulation Act").

If there are any objections with this disposition, an appeal can be filed in writing against the Minister of Economy, Trade and Industry within 60 days counting from the day following the day that the disposition is known, in accordance with the provisions under Article 6 of the Administrative Appeal Act (Act No. 160 of 1962). However, appeals cannot be filed if one year has passed counting from the day following the day of disposition, even if it is within 60 days counting from the day following the day that the disposition was acknowledged.

1. Content of order and legal basis (Act and Article) of the order
In accordance with the provisions of Article 64 Paragraph 3 of the Reactor Regulation Act, it is hereby ordered that pressure inside the reactor containment vessel at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station Unit 1 and 2 be reduced.

2. Reason(s) for order

The pressure inside the reactor containment vessel at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station Unit 1 and Unit 2 is increasing. Thus, there is an urgent need to give such orders to prevent a disaster caused by nuclear fuel material, material contaminated by nuclear fuel material, or reactor.

Ministry of Economy, Trade and Industry

12/03/2011 No.2
March 12, 2011

Mr. Masataka Shimizu, Director & President
Tokyo Electric Power Company

Banri Kaieda
Minister of Economy, Trade and Industry

Order in accordance with provisions of Article 64 Paragraph 3 of
The Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

The Ministry of Economy, Trade, and Industry, hereby orders the following to the Tokyo Electric Power Company, in accordance with the provisions of Article 64 Paragraph 3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166 of 1957, hereinafter referred to as "Reactor Regulation Act").

If there are any objections with this disposition, an appeal can be filed in writing against the Minister of Economy, Trade and Industry within 60 days counting from the day following the day that the disposition is known, in accordance with the provisions under Article 6 of the Administrative Appeal Act (Act No. 160 of 1962). However, appeals cannot be filed if one year has passed counting from the day following the day of disposition, even if it is within 60 days counting from the day following the day that the disposition was acknowledged.

1. Content of order and legal basis (Act and Article) of the order
In accordance with the provisions of Article 64 Paragraph 3 of the Reactor Regulation Act, it is hereby ordered that the integrity of the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station Unit 1's reactor vessel be ensured upon consideration of appropriate methods such as filling the reactor vessel with seawater.

2. Reason(s) for order

In regards to the internal integrity of the reactor vessel at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station Unit 1, there is an urgent need to give such orders to prevent a disaster caused by nuclear fuel material, material contaminated by nuclear fuel material, or reactor.

Ministry of Economy, Trade and Industry

15/03/2011 No.9
March 15, 2011

Mr. Masataka Shimizu, Director & President
Tokyo Electric Power Company

Banri Kaieda
Minister of Economy, Trade and Industry

Order in accordance with provisions of Article 64 Paragraph 3 of
The Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors

The Ministry of Economy, Trade, and Industry, hereby orders the following to the Tokyo Electric Power Company, in accordance with the provisions of Article 64 Paragraph 3 of the Act on Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Act No. 166 of 1957, hereinafter referred to as “Reactor Regulation Act”).

If there are any objections with this disposition, an appeal can be filed in writing against the Minister of Economy, Trade and Industry within 60 days counting from the day following the day that the disposition is known, in accordance with the provisions under Article 6 of the Administrative Appeal Act (Act No. 160 of 1962). However, appeals cannot be filed if one year has passed counting from the day following the day of disposition, even if it is within 60 days counting from the day following the day that the disposition was acknowledged.

1. Content of order and legal basis (Act and Article) of the order
In accordance with the provisions of Article 64 Paragraph 3 of the Reactor Regulation Act, the following is hereby ordered in regards to the Tokyo Electric Power Company’s Fukushima Daiichi Nuclear Power Station.
(1) Extinguish the fire at Unit 4 spent fuel pool. Also, prevent re-criticality.
(2) Inject water into the reactor for Unit 2 as soon as possible. If necessary, vent the dry well.

2. Reason(s) for order

In regards to the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station, there is an urgent need to give such orders to prevent a disaster caused by nuclear fuel material, material contaminated by nuclear fuel material, or reactor.

Equipment (hardware) Measures

(1) Flooding protection measures for sites and buildings

Installation of tidal embankment, board, and wall and flood protection of doors and penetrations

(2) High Pressure Cooling Water Injection Facilities (Required within 1 hour)

Concepts

- High pressure cooling water injection is initially required due to high reactor pressure in the case that the plant experiences an abnormal shutdown.
- During this accident, some motor-driven equipment were inoperable due to station black out (SBO). Hence, a steam-driven high pressure facility is key.
- Furthermore, when choosing motor-driven high pressure cooling water injection facilities, it is important to select equipment with minimum operating requirements.

		SBO
RCIC	Stream-driven	○
SLC or CRD	Motor-driven	×
HPCS		

Reactor Core Isolation Cooling System (RCIC)

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
Pump/ turbine	Waterproofing for RCIC room	Establish manual startup procedures
DC Power Supply (Battery, power panel, etc.)	Waterproofing battery room and main bus panel location (or relocate)	Prepare power supply cars

Standby Liquid Control System (SLC) or Control Rod Drive (CRD)

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
SLC Pump or CRD Pump	—	Waterproof pump area
Water Source	—	Establish water supply procedure from pure water tank
AC Power	—	Waterproof power supply equipment including EDGs, deploy power supply cars, secure outside power source as alternative to EDGs

(3) Depressurizing Equipment (within 4-8 hours)

Concepts

- Depressurization of the reactor pressure vessel is essential to remove heat and to bring it to a cooling stage.
- During this accident, DC power necessary to operate the main steam safety relief valve for depressurizing was insufficient. In addition to securing N2 for valve operations, securing power source is necessary.

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
N2 Cylinder	—	Prepare spare cylinders
DC Power Supply (Battery, power panel, etc.)	Waterproofing battery room and main bus panel location (or relocate)	Prepare portable batteries

(4) Low Pressure Water Injection Facilities (within 4-8 hours)

Concepts

- Low pressure cooling water injection equipment consists of emergency system, make-up water condensate system (MUWC) and fire protection (FP) system. In case of SBO, only diesel-driven fire pumps (DDFP) of the FP system will be operable.
- Preparing reliable low pressure injection equipment is important including fire engines which were used during this accident.

		SBO
D/DFP	Diesel-driven	○
MUWC	Motor-driven	×

Fire Protection System (FP)

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
Diesel-driven Fire Pump	Waterproof pump room	Develop procedures to deploy fire engines, establish connecting water lines and use of seawater
Battery	Waterproof battery room	Prepare portable batteries
Diesel Fuel	Deploy fuel (incl. delivery)	—

Make-up Water Condensate System (MUWC)

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
MUWC Pump	Waterproof pump room	Develop procedures for tanks to share water
AC Power	Waterproof power supply equipment including EDG or relocate	Deploy power supply cars, secure outside power source as alternative to EDGs

(5) Heat Removal/Cooling Facilities

1) PCV venting (Within 1-2 days)

Concepts

- In case that seawater cannot be used as a cooling source, suppression chamber venting using air as cooling source is necessary.
- In order to conduct suppression chamber venting, opening motor-operated (MO) valves as well as air-operated (AO) valves are necessary.

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
AC Power (MOV, solenoid valve for AOV)	Waterproof power supply equipment including EDGs (or relocate)	Deploy power supply cars, portable AC generator or portable batteries
Compressed Air (AOV operation)	Portable air compressor (or cylinder)	Modify structure to allow manual opening of AO valve

2) Heat removal via Shutdown Cooling Mode (Within 3-7 days)

Concepts

- Shutdown cooling mode procedures by residual heat removal system (RHR) that utilizes seawater as a cooling source is necessary.
- Thus, in addition to ensuring a power source, preparing alternative pumps, or motor repairs is necessary to restore the seawater system utilized as the ultimate heat sink.

Necessary Facility	Flooding Countermeasure for Equipment	Flexible Countermeasure
AC Power (RHR pumps)	Waterproof power supply equipment including EDGs (or relocate)	- Prepare alternative pumps - Prepare mobile heat exchangers
RCW/RSW Pumps	Prepare spare motors	
AC Power (RCW/RSW)	Waterproof power room	Prepare power supply car, secure outside power source as alternative to EDGs

3) Heat removal from spent fuel pool (Within 7-10 days: Depending on decay heat from spent fuels)

Concepts

- Spent fuel pool cooling and cleanup system (FPC) is basically tsunami-resistant since it is located inside the reactor building. Hence it is important to maintain the power source.
- Furthermore, considering time to respond, monitoring using instruments is important.

Necessary Equipment	Flooding Countermeasure for Equipment	Flexible Countermeasure
FPC Pump	Waterproof pump room Install level/temperature gage in pool	- Prepare fire engines - Establish redundancy with fire protection piping
AC Power	Waterproof power supply equipment (or relocate)	- Prepare power-supply cars

(6) Ensuring power supply to the monitoring instruments (Required within 1 hour)

Concepts

- During this accident, the monitoring instruments were rendered inoperable and restoring power to the instruments took time.
- Thus, ensuring immediate power supply for instruments is important.

Necessary Equipment	Flooding Countermeasure for Equipment	Flexible Countermeasure
DC Power	Waterproof battery room and main bus panel location (or relocate)	- Prepare portable batteries - Prepare power supply cars and portable battery chargers

(7) Mitigation measures following core damage

Concepts

- During this accident, not only was the "containment" function lost, but also restoration efforts were seriously hampered due to the hydrogen explosion caused by the possible leak of hydrogen from the primary containment vessel to the building.
- In terms of defense-in-depth, measures in case of core damage will be taken considering this accident,

Items	Countermeasures
Hydrogen Accumulation Prevention	Install equipment/ establish procedures for drilling holes through the roof of the building (top vent) or opening blow-out panels to improve reactor building ventilation.
Mitigation of Radioactive Material Release	Same as suppression chamber venting (assuring venting through water filtering). Prepare procedures for water injection to PCV via fire engines.

(8) Common Countermeasures

- In addition to implementing the above responses, it is important to reinforce work-supporting gear and auxiliary equipment so activities are carried out safely and efficiently in order to enable measures to be effective.

Items	Countermeasures
Off-site Power	Review system configuration to ensure reliability of off-site power supply, assess stability of transmission tower foundations, review seismic improvement of substation/switchyard facilities, and review procedures for prompt restoration of off-site power equipment.
Debris Removal Equipment	Prepare equipment to remove debris hampering response activities.
Secure Communication Methods	Establish communication methods suitable for conditions such as allocating mobile radios and satellite phones as well as preparing batteries as power source. Develop communication equipment usable when wearing full-face masks.
Securing Lighting Equipment	Prepare headlights to allow workers to use both hands freely for safe, prompt, and reliable response and wide-area lights.
Protective Equipment	Allocate various equipment including protective clothing, masks, APDs, portable air purifiers to appropriate locations in ample supply, prioritize restoration of MCR emergency ventilation system using power supply cars, reinforce shielding of Seismic Isolated Building, and allocate required equipment such as local fans.
Develop Radiation Management Tools	Develop management tools to compile dose readings at place(s) that function as hubs including the Seismic Isolated Building.
Reinforce Environmental Radiation Monitoring Organization	Reinforce radiation measurement equipment for monitoring such as establishing alternative monitoring methods and personnel structure in case of power outage in advance.
Reinforce Tsunami Monitoring Organization	Allocate infra-red scopes in short-term. In long term, collect data with sea level monitoring system, worker notification methods, securing evacuation routes, consider potential routes to access field during emergencies in advance, and required modifications.
Enhance Functionality of Seismic Isolated Building	Segregate entrances for people and materials, accessway design to prevent ingress of radioactive material, easily decontaminated interior, maintaining function of toilets, and develop break facilities.

Other Mid- to Long-term Technical Issues

- In this study, aforementioned core damage countermeasures have been developed. In addition, mid-to-long term technical issues listed right should be considered.
- These technical issues will be studied separately.

Items	Action Plan
Improve Reliability of High Pressure Injection Systems	Organize and review approaches to improve reliability of high pressure injection systems including isolation signal interlock for isolation condenser.
Improve Reliability of Vent Line	Review methods to proactively activate rupture discs and improve reliability of the vent line while taking into account that it does not lead to unpremeditated releases.
Consider Filtered Vents	Study design of filtered vents where radioactive material is released through a filter to reduce amount of radioactive materials released.
R&D of Accident Instrumentation	In regard to reactor water level gage, conduct R&D to improve precision and develop instruments suitable for purposes required during accidents. In regard to containment atmosphere monitoring system, improve reliability and study improved precision under accident conditions.

Summary of Fukushima Daiichi NPS Units 1 to 3 Events, Causes, and Countermeasures

Attachment 16-2

Success Path	Issues from plant behavior/ response work		Unit 1	Unit 2	Unit 3	Causes	Specific countermeasures	Flexible countermeasure
Initiating event (Earthquake, tsunami)	Multiple failures or functional loss of equipment		○	○	○	Tsunami flowed into major buildings and flooded important facilities (power supply facilities)	・Prevent flooding of D/G and other equipment locations: Water-tightening of doors and waterproofing pipe and cable penetrations ・Prevent flooding from openings on buildings' exterior walls: install tidal boards, tidal walls ・Prevent flooding into power station premises: install flooding embankments	–
[High pressure injection] Inject cooling water into reactor using high pressure core injection systems	Early on after reactor shutdown, high pressure system's cooling and injection capabilities was lost	Shutdown of IC	○	–	–	・Automatic isolation interlock actuated with loss of DC power	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
		RCIC operating status unknown (loss of monitoring measurements)	–	○	–	・Loss of DC power	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
		Difficulty in confirming operating status of RCIC	–	○	–	・Loss of lighting	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
						・Collected water	・Flooding prevention measures for buildings	–
						・High dose environment	・Routinely allocate ample supply of various equipment including protective clothing masks, APDs, portable air purifiers to improve MCR environment	–
						・Difficulty with communication with field due to loss of power (PHS, paging inoperable)	・Consider establishment of communication methods fit for the situation	–
		Restart of RCIC not possible	–	–	○	・Running out of DC power	・Establish procedures to manually open steam inlet valves and others	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
		High pressure injection startup failed, restart not possible	○	○	○	・Loss and run-out of DC power	・Waterproofing battery room and main bus panel installation location (or relocate) ・Establish procedures to manually open steam inlet valves and others	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
		SLC power restoration suspended	○	–	–	・Damage of cables and power supply car due to explosion	・Provide AC power (cables to power supply cars, transformers, circuit breakers, equipment and procedures) ・Provide water source including for replenishment	–
		Parameter monitoring failed	○	○	○	・Loss and run-out of DC power	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
[Depressurization] Depressurization of reactor using depressurization equipment	Loss of power of SRV (DC power)	Parameter monitoring inoperable, labor intensive	○	○	○	・Loss and run-out of DC power (alternate measurement implemented)	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
		Difficult to operate SRVs (use of alternate batteries)	–	○	○	・Loss and run-out of DC power	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
						・Uncertain supply of nitrogen pressure	–	・Allocate spare cylinders
[Low pressure injection] Inject cooling water into reactor using low pressure core injection systems	Almost all equipment that could be used to cool and inject into the reactor loss functions	Installed facilities were inoperable	○	○	○	・Installed equipment (motors) were damaged by water	・Waterproofing installation location of emergency system low pressure injection systems ・Waterproofing installation location of MUWC ・Waterproofing installation location of diesel-driven fire pumps and providing fuel	・Allocate fire engines ・Establish connecting water line
						・Water damage to power panels and emergency buses	・Waterproofing power facilities (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
	On-the-spot actions to inject water using fire engines	Difficult to establish injection line using fire engines and other equipment	○	○	○	・Completely new applied	・Enhance software issues such as procedures and training	–
						・Rubble (due to tsunami, hydrogen explosion)	・Allocate heavy machinery to remove rubble	–
						・Loss of lighting due to loss of power	・Waterproofing battery room and main bus panel installation location (or relocate)	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
							・Provide headlight-type lights	–
							・Consider lighting equipment that can light a wider area	–
						・High dose environment	・Routinely allocate ample supply of various equipment including protective clothing, masks, APDs, portable air purifiers to improve MCR environment	–
						・Difficulty with communication with field due to loss of power (PHS, paging inoperable)	・Consider establishment of communication methods fit for the situation	–
						・Danger of hydrogen explosion	・Inject water into reactor, depressurize, and vent PCV to ensure it does not result in core d	–
[PCV vent] Depressurize PCV with PCV venting	Loss of power and compressed air to drive AO valves caused such valves to become inoperable	MO valve remote operation failed	○	○	○	・Loss of AC power	・Waterproofing of power facilities (or relocate)	–
		Difficulty with MO valve manual operation	○	○	○	・Loss of lighting due to loss of power	・Waterproof batter room installation location or relocate	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
							・Provide headlight-type lights	–
							・Consider lighting equipment that can light a wider area	–
						・High dose environment (in buildings)	・Routinely allocate ample supply of various equipment including protective clothing masks, APDs, portable air purifiers to improve MCR environment	–
						・Difficulty with communication with field due to loss of power (PHS, paging inoperable)	・Consider establishment of communication methods fit for the situation	–
		AO valve remote operation failed	○	○	○	・Loss of power to drive valves due to loss of power	・Waterproof power facilities (or relocate)	・Allocate power supply car, etc. ・Allocate portable AC generator or portable batteries
						・Loss of control air	・Allocate air compressor or cylinders	・Change structure to open AO valve manually
		AO valve remote operation failed	○	○	○	・Loss of lighting due to loss of power	・Waterproof battery room location or relocate	・Allocate portable batteries ・Allocate power supply cars and portable battery charger
							・Provide headlight-type lights	–
							・Consider lighting equipment that can light a wider area	–
						・High dose environment (S/C room)	・Routinely allocate ample supply of various equipment including protective clothing masks, APDs, portable air purifiers to improve MCR environment	–
						・Difficulty with communication with field due to loss of power (PHS, paging inoperable)	・Consider establishment of communication methods fit for the situation	–
[Heat sink restoration] Provide cooling with seawater	Seawater pump restoration impossible		○	○	○	・Existing facility (motors) damaged by water	・Allocate spare motors	Allocate movable portable heat exchange system (set of pumps and heat exchangers) including cooling equipment
						・Water damage of power panel and emergency bus	・Tsunami countermeasures for seawater system power systems	
							・Transport spare power panel with power supply car	
							・Install on top floor of building and use with power supply car	

Administrative (Software) Measures (1/2)

○Action taker, △ Provide Support, －N/A

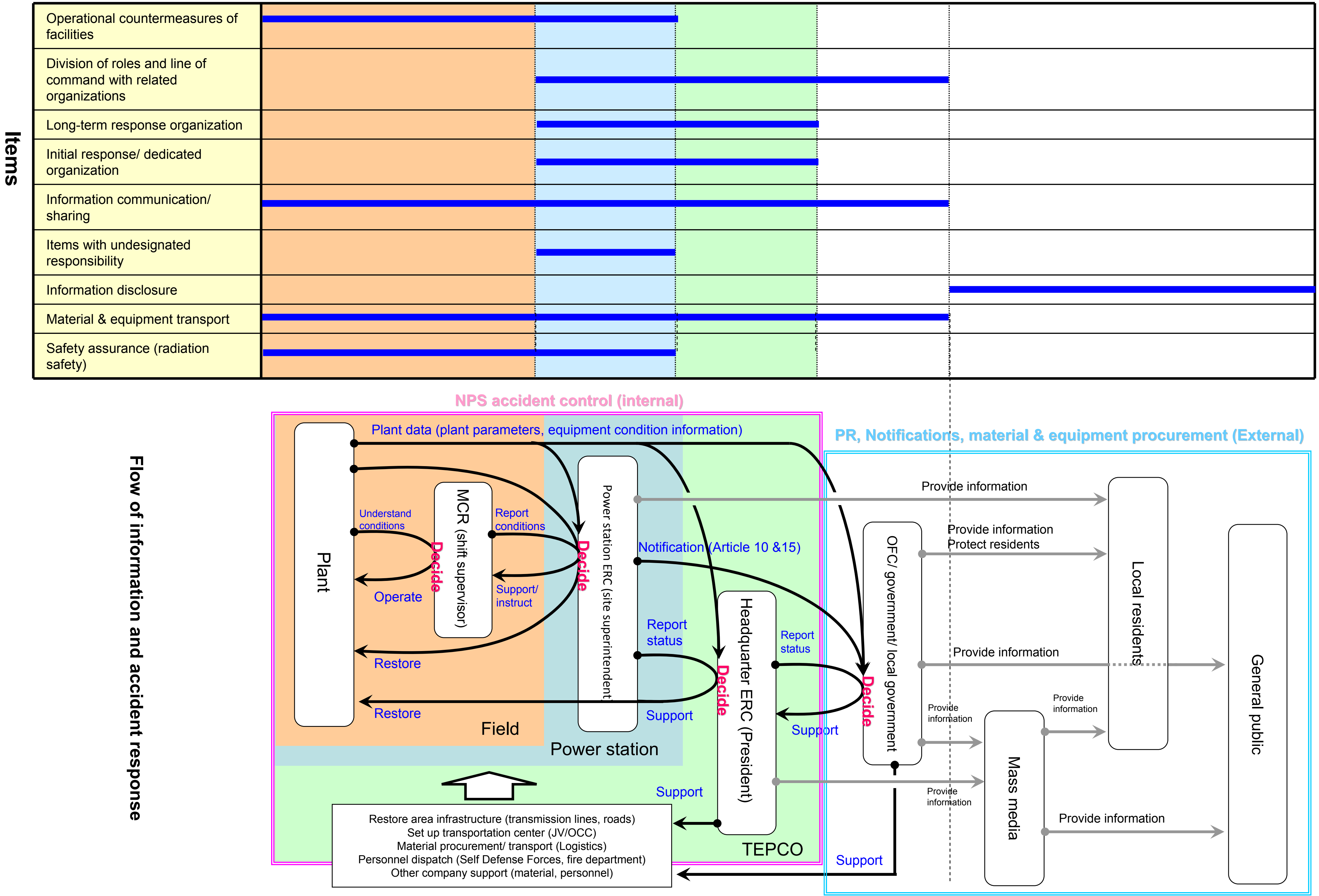
Item		Issue	Description of Countermeasure	NPS	Corporate	Gov't, others
Administrative Countermeasures Corresponding to Equipment Countermeasures		In terms of equipment, a success path, consisting of high pressure injection systems, depressurization & low pressure injection, and heat removal was developed while considering the stresses. In addition, common items required to achieve this was indicated, and countermeasures were developed to prevent hydrogen accumulation in case of core damage. In order for these countermeasures to function practically, it is necessary not only to develop "hardware," but to also prepare "software" measures such as "developing concrete implementation procedures," "appropriate staffing/ organizational structure," and "providing and training on skills and knowledge."	*Develop Concrete Procedures* •Procedures should be versatile so available systems can be chosen flexibly depending on the plant condition since plant conditions may be unexpected. •Procedures should clarify the following: access paths and location of portable equipment, equipment and materials required for operation and their location, equipment for dose reduction and their location.	○	△	－
			Appropriate Staffing/ Organizational Structure •Required injection/ cooling functions change over time, thus the structure should ensure that staffing required to operate systems to achieve such functions is available over time. •Consider infrastructure that would allow command and control for response, activity centers to support emergency response, and allow long-term accident response even with simultaneous damage of multiple units.			
			Provide and Train on Skills and Knowledge •Implement educational training to provide necessary skills and knowledge to personnel and organizations (including licenses required to operate heavy machinery, power supply cars, fire engines) and conduct training so actions can be taken depending on actual accident conditions.			
Emergency Response Organization	Emergency Response Organization (Roles and command-and-control among Administration/ national government, local government and utility)	During accident response, there was a problem that there was confusion in command-and-control from the perspective of the NPS, which resulted in a impractical response organization under which people who did not understand conditions in the field were making decisions from places that did not have information on field conditions. It is understood that this situation was brought upon by TEPCO, the Administration, and national government. In other words, the highlighted issue is the need to clarify who (Administration/ national government, local government, utility) will be responsible for what aspects and what effective actions should be implemented.	*Emergency Response Organization* •TEPCO accident response organization will be separated into internal organization (NPS accident resolution), which is directly engaged in accident response, and external interface organization (public relations, reporting/notification, equipment procurement) so that personnel directly engaged in NPS accident resolution actions can dedicate themselves to such. •The external interface organization will need to distribute information accurately and quickly and have close coordination with related organizations, therefore a mechanism to allow it to acquire plant and other information without hindering accident response actions will be considered and developed. •In order to effectively utilize support and useful information from abroad, a mechanism to sort information and select support that is truly necessary will be considered as well as appropriate allocation of employees with a technical background in the external interface organization.	○	○	－
			Command and Control •Foster clear recognition that the site superintendent has the authority for command and control. •Headquarter ERC supports the NPS so that accident resolution activities are not hindered such as confusion of command due to direct intervention in specific commands for field response provided by the site superintendent even with regards to coordination with external related organization.			
	Establish Long-Term Response Organization	In the case of this accident, the disaster progressed to the incidence of multiple unit core damage or incidences with the potential thereof. Therefore, the response will be over an extended period of time and requires actions to be taken against various situations that have never been experienced before. The organization should have shifted response efforts to an appropriate organization once it was recognized that it would be a long-term effort. However, given the unpredictable situation, TEPCO responded with all staff similar to normal accident response. Staff rotations were conducted based on voluntary discretion of each team depending on addition of personnel.	•To withstand long-term accident response, consider in advance an organization that would allow long-term 24-hour actions including decision-makers. •Assigned work should be similar to normal work as much as possible, and consideration needs to be given so that work can be conducted efficiently even with a limited number of people.	○	○	－
			•When long-term response needs to be taken for multiple units at the NPS, Headquarters will assist in providing human resource support from Headquarters and other power stations mainly focusing on personnel with experience at the relevant NPS in order to reinforce staffing.	－	○	－
	Establish Organization for Initial Response and Dedicated Actions	When looking at the accident response activities, there was a period of time where the Chairman and President were initially absent due to a business trip when the disaster hit, the CNO was travelling to Fukushima to support the NPS and to take nuclear accident response at the Off-Site Center, and the Deputy CNO was absent briefing METI and other organizations and responding to media. In addition, ERC director was pressed with phone-calls from external parties and, though only for hours, technical employees had to leave to respond to media and were unable to dedicate themselves to accident response activities.	*Secure Initial Response Organization* •The absence of top management during initial response of the accident is reflected upon gravely. In the future, activities will be coordinated with consideration given to emergency response at all times.	－	○	－
			•Develop and arrange for environments and mechanisms so that the necessary response staff can be gathered no matter what time an emergency situation arises.	○	○	－
			Command and Control CNO/ Deputy CNO •It is preferable for the Headquarter response organization to allow either the CNO or Deputy CNO to dedicate him/herself to NPS accident response so that appropriate decisions are made to support the NPS. •It is realistic and practical to dispatch an individual designated by the CNO to the ERC and to share information via a teleconferencing system.	－	○	－
Information Communication/ Sharing		Plant monitoring functions were lost and communication functions were impaired. Even if the Safety Parameter Display System (SPDS) which transmits plant data was fully operable, only limited information would be available. In addition to such telecommunication equipment problems, information communication problems prevented the Site/ Headquarter ERCs from understanding plant conditions accurately.	•Develop information communication formats using simple system drawings so that plant and system conditions can be understood visually and easily, and provide notification each time information changes.	○	○	－
			•Prepare the same template on whiteboards in the ERC and MCR. Conduct exemplary training on such information communication methods through disaster preparedness and other training.	○	－	－
Actions for which Responsible Organization is Not Designated		Because it was unexpected to use fire engines to inject water into the reactor, there was no clear division of roles for this work of reactor injection using the engine water supply.	•Individual giving orders or person supporting such individual clearly instructs who should do what. This will be checked during training to see whether it is conducted adequately.	○	－	－

Administrative (Software) Measures (2/2)

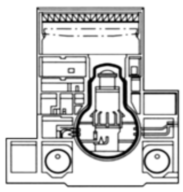
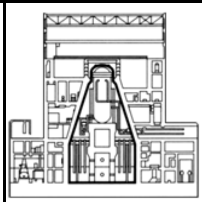
○Action taker, △ Provide Support, －N/A

Item		Issue	Description of Countermeasure	NPS	Corporate	Gov't, others
Information Disclosure		Apologies and explanations provided by top management through press conferences and other venues were insufficient. It took time to disclose information that should have been communicated quickly, particularly information related to the safety of residents in the surrounding areas and the general public because sufficient understanding of content and evaluation was not acquired and public statements required coordination with the government before disclosure.	・Top management will take the initiative and proactively provide information.	－	○	
			・Based on postulations of various formats and event progression of nuclear accidents, during a nuclear accident, the event will be disclosed promptly and reliability. Information pertinent to residents' safety will be given first priority for disclosure.	○	○	－
			・The Internet, which can communicate diverse information directly and quickly, will be utilized proactively. ・Excessive prior coordination of contents of releases should be halted and should be limited to only information sharing.	－	○	
Transportation of Materials/ Equipment		Transport of materials and equipment were hindered by factors including road damage and road blocks due to earthquake, degraded telecommunication conditions, outdoor contamination due to radioactive material and associated exposure problems. Items could not be delivered to places, people, or organizations as initially planned and thus left in unplanned locations with no direct handover. As with the transport of APDs, sets of equipment were packaged separately when delivered, causing the equipment to be non-usable because some parts could not be found though they had been delivered. It is necessary to decide steps to transport material and equipment in advance based on the lessons learned from the Fukushima accident response such as quickly setting up a logistics center near the evacuation zone perimeter when such is declared.	*Select Transport Relay Center* ・It is critical to respond flexibly to contamination, road, and other conditions. Therefore, several potential locations near the station that could serve as the transport relay center are to be selected in advance.	△	○	－
			Transport Relay Team ・Establish and prepare to dispatch a team to receive and store materials/equipment on behalf of the NPS and ensure handover to the NPS (including obtaining qualification to handle equipment required to unload items) ・Provide radiation education periodically to transport team because they are engaged in transport in contaminated areas.	△	○	－
			Transport Package Information ・To ensure materials/equipment is delivered, clarify information required for transport of materials/equipment. ・In particular, for high-importance material/equipment from internal organizations, give consideration so that personnel knowledgeable with its operation or content can travel with the material/equipment as much as possible.	△	○	－
Develop Access Control Center		In adverse conditions with no infrastructure such as electricity, water, and telecommunication equipment, departments that did not necessarily have radiation knowledge had to secure areas and equipment to set up the access control center with the support of RP personnel.	・Along with transport relay center, consider methods to establish access control center in advance (prior selection of location, radiation training for support staff, secure decontamination equipment, etc.)	△	○	－
Secure Safety During Nuclear Accident (Radiation Safety, etc.)		During the accident, there were cases in which emergency dose limits were exceeded which was related to the fact it took time to assess exceeding dose limit for women specified by law and internal exposure. APDs were also carried away by the tsunami and the APD sign-out system lost functionality, requiring labor to compile dose data. In addition, departments that did not necessarily have radiation knowledge had to secure areas and equipment to set up the abovementioned center with the support of RP personnel. During the accident, all personnel including those not engaged in radiation work normally had to act coping with radiation. There was insufficient RP personnel because conditions exceeding normal RCA conditions had expanded to include outdoor areas.	*Reinforce Radiation Management Education* ・For personnel working at NPS, even if their assigned duties do not involved radiation, provide education on minimum required knowledge on radiation management and provide training on basic handling of related equipment (survey meter, APDs) so they may conduct support activities for radiation management.	○	－	－
			Develop Approach to Female Workers ・Develop basic approach to evacuate female workers at the NPS as early as possible when nuclear accident occurs.	○	△	－
			Develop Internal Exposure Assessment Method and Response Procedures ・Re-review and develop internal exposure assessment methods and response procedure during nuclear accidents.	△	○	－
Assessment of Equipment Conditions/ Operations		Regarding Fukushima Daiichi Unit 1 isolation condenser isolation valve, the position of the valve when the tsunami hit could not be understood accurately because the position of the valve differed depending on the different stages of power loss and power to the lamps and instruments that indicate valve status was lost.	・Along with Equipment (Hardware) Countermeasure "Organize and review approaches to improve reliability of high pressure injection systems including isolation signal interlock for isolation condenser," consider and analyze behavior of equipment/systems when AC and/or DC power is lost, focusing on safety critical equipment. If useful information is obtained in terms of methods to understand equipment status, incorporate in procedures and training.	○	△	－
Suggestions to Government and Others	Nature of Off-site Center	Because the Off-site Center, which was originally planned to play a central role during nuclear accidents, did not function, integrated public relation activities based on cooperation between national & local governments and utility could not be conducted as planned. With no integrated public relations activities at the Off-Site Center, the Administration, Nuclear and Industrial Safety Agency (NISA) and TEPCO held their own press conferences with no clear division of roles. As a result, the three parties released similar information, and there were also some minor discrepancies in content.	・Renew coordination with related organizations to conduct effective, integrated public relation activities as planned under cooperation of the national & local government and utility. ・Analyze thoroughly what information is important to local residents, identify information that should be provided nationwide or to local areas, and thoroughly consider in advance how useful information can be disclosed quickly and accurately, including methods to do so. ・Cooperation is requested for reporting and informing local governments by using the Off-Site Center functionalities as a contact point in case contact with or delivery of information from TEPCO is unsuccessful.	△	○	○
	Material/Equipment Procurement	(Same as "Material/Equipment Transport" above)	・The best preparation is to develop robust roadways, but it is considered that cooperation is necessary with local police and Self Defense Forces to understand road conditions. Therefore cooperation is requested to develop an organization including Self Defense Forces and other related organizations and to conduct prior deliberations. ・Cooperation is also requested to develop a cooperative organization related to procurement of materials/equipment required for emergency response.	△	○	○
	Method to Review Emergency Dose Limits and Screening Levels	During the accident, it was difficult to communicate due to problems with the telecommunication equipment, but the decontamination levels (screening levels) were reviewed based on expert advice from the emergency exposure medical dispatch team of the Off-Site Center.	・Place an agreement with the national government in advance to allow the utility to review emergency dose limits and screening level under specified set of conditions at its own discretion.	－	○	○
	Develop External Event Standards	It may cause misunderstanding in terms of transparency and fairness when utilities engage in establishing judgment criteria for external event standards.	・Action is requested that a government research organization with high level of capability to compile information (collect, assess, and oversee) clearly provide a uniform statement as to the appropriate level of threat to postulate when designing equipment in real-life terms and to conduct regulatory reviews based on such.	－	○	○
	Use of Tsunami Data	During the accident, there was potential of tsunami due to aftershocks, which forced personnel to repeatedly evacuate while engaging in restoration activities.	・In order to obtain tsunami height data off-shore of NPSs as quickly as possible, communicate to personnel engaged in work, and to develop organization for evacuation, permission to use data from sea level height monitoring system owned by the government is requested.	△	○	○
	Investigation on Effects of Low Dose Exposure	Though there is no direct relation to the cause of the accident, there is increased concern nationwide about radioactive material contamination due to the its widespread presence caused by the nuclear accident.	・Because the effects of low dose exposure is unknown at present and it is hypothesized that probability of disability occurrence increases as exposure increases, and there is no "threshold" point at which disabilities manifest; however, it is requested that the national government takes the lead to clarify the effects in order to alleviate public concern.	－	○	○

Supplement: Relationship between "Administrative (software) Countermeasures" and "Flow of Information and Accident Response"



Plant Main Specifications in Fukushima Daiichi NPS

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Electrical output (MWe)	460	784	784	784	784	1,100
Heat output (MWe)	1,380	2,381	2,381	2,381	2,381	3,293
Construction start	1967/9	1969/5	1970/10	1972/5	1971/12	1973/3
Commercial Operation start	1971/3	1974/7	1976/3	1978/10	1978/4	1979/10
Reactor type	BWR3	BWR4				BWR5
Reactor pressure vessel inner diameter (mm)	Approx. 4,800	Approx. 5,600	Approx. 5,570	Approx. 5,570	Approx. 5,570	Approx. 6,410
Reactor pressure vessel height (mm)	Approx. 20,000	Approx. 22,000	Approx. 22,000	Approx. 22,000	Approx. 22,000	Approx. 23,000
Reactor pressure vessel total weight	Approx. 440	Approx. 500	Approx. 500	Approx. 500	Approx. 500	Approx. 750
Reactor pressure vessels design pressure*1	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])
Reactor pressure vessel design temperature (C)	302	302	302	302	302	302
Fuel assembly (no. of assemblies)	400	548	548	548	548	764
High burnup 8x8 fuel (no. of assemblies)	68	-	-	-	-	-
9x9 fuel (A type) (no. of assemblies)	-	-	516	-	-	-
9x9 fuel (B type) (no. of assemblies)	332	548	-	548	548	764
MOX fuel (no. of assemblies)	-	-	32	-	-	-
Fuel rod active length (m)	Approx. 3.66	Approx. 3.71	Approx. 3.71	Approx. 3.71	Approx. 3.71	Approx. 3.71
Control rod count (no. of rods)	97	137	137	137	137	185
Containment type (Main body)	Mark I					Mark II
						
Containment height (m)	32	34	34.1	34.1	34.1	48.0
Containment diameter(m)	17.7 (sphere part) 9.6 (cylinder part)	20.0 (sphere part) 10.9 (cylinder	20.0 (sphere part) 10.9 (cylinder	20.0 (sphere part) 10.9 (cylinder	20.0 (sphere part) 10.9 (cylinder	25.9
Suppression pool water amount (m^3)	1,750	2,980	2,980	2,980	2,980	3,200
PCV design pressure*1	Approx. 0.43 MPa[gage] (4.35kg/cm^2[gage]	Approx. 0.38 MPa[gage] (3.92kg/cm^2[gage]	Approx. 0.38 MPa[gage] (3.92kg/cm^2[gage]	Approx. 0.38 MPa[gage] (3.92kg/cm^2[gage]	Approx. 0.38 MPa[gage] (3.92kg/cm^2[gage]	Approx. 0.28 MPa[gage] (2.85kg/cm^2[gage])
Containment design temperature (degree-C)	138(D/W) 138(S/C)	138(D/W) 138(S/C)	138(D/W) 138(S/C)	138(D/W) 138(S/C)	138(D/W) 138(S/C)	171(D/W) 105(S/C)
Spent fuel pool volume (% core part)	225	225	225	290	290	230
Spent fuel pool operating temperature (degree-C)	≦65	≦65	≦65	≦65	≦65	≦65
Spent fuel pool length (north-south: parallel to coastline) (m)	Approx. 7.2	Approx. 9.9	Approx. 9.9	Approx. 9.9	Approx. 9.9	Approx. 10.4
Spent fuel pool width (east-west: perpendicular to coastline) (m)	Approx. 12.0	Approx. 12.2	Approx. 12.2	Approx. 12.2	Approx. 12.2	Approx. 12.0
Spent fuel pool depth (deepest part)	Approx. 11.8	Approx. 11.8	Approx. 11.8	Approx. 11.8	Approx. 11.8	Approx. 11.8
Spent fuel pool volume (m^3)	Approx. 1,020	Approx. 1,424	Approx. 1,425	Approx. 1,425	Approx. 1,425	Approx. 1,497
Storage capacity of spent fuel in the spent fuel pool (assemblies)	900	1,240	1,220	1,590	1,590	1,770
Amount of spent fuel in the spent fuel pool (assemblies) (End of December 2010)	292	587	514	1,331 (including 548 fuel assemblies removed from core)	946	876
Amount of new fuel in the spent fuel pool (assemblies) (End of December 2010)	100	28	52	204	48	64

*1: the unit in the reactor establishment permit is kg/cm^2[gage]

Specifications of Engineered Safety Feature Systems and Reactor Auxiliary Facilities in Fukushima Daiichi NPS

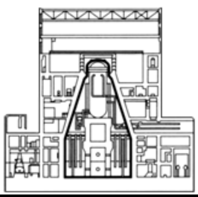
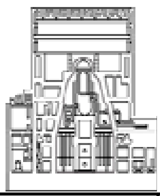
		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Core spray system (CS)	No. of systems	2	2	2	2	2	
	Flow rate (t/h/system)	550	1,020	1,141	1,140	1,140	
	No. of pumps (/system)	2	1	1	1	1	
	Pump discharge pressure *1	Approx. 2.0 MPa[gage] (20.0kg/cm^2[gage])	Approx. 3.5 MPa[gage] (35.2kg/cm^2[gage])	Approx. 3.5 MPa[gage] (35.2kg/cm^2[gage])	Approx. 3.3 MPa[gage] (33.4kg/cm^2[gage])	Approx. 3.3 MPa[gage] (33.4kg/cm^2[gage])	
	Net pump head (m)	200	204	204	204	204	
Containment cooling system (CCS)	No. of systems	2	2	2	2	2	2
	Designed flow rate (t/h/system)	705	2,960	2,600	Approx. 2,600	Approx. 2,600	Approx. 1,900
	No. of pumps (/system)	2	2	2	2	2	2
	No. of heat exchangers (/system)	1	1	1	1	1	1
High-pressure coolant injection system (HPCI)	No. of systems	1	1	1	1	1	
	Flow rate (t/h)	682	965	965	966	965	
	No. of pumps	1	1	1	1	1	
	Net pump head	85.3～16.0 kg/cm^2[gage]	853 to 160 m	854 to 160 m	854 to 160 m	854 to 160 m	
Low pressure core injection system (LPCI)	No. of systems		2	2	2	2	3
	Flow rate (t/h/pump)		Approx. 1,750	Approx. 1,820	Approx. 1,820	Approx. 1,820	Approx. 1,690
	No. of pumps (/system)		2	2	2	2	1
Residual heat removal system (RHR)	Pump						
	No. of units		4	4	4	4	3
	Flow rate (t/h)		Approx. 1,750	Approx. 1,820	Approx. 1,820	Approx. 1,820	Approx. 1,690
	Net pump head (m)		Approx. 128	Approx. 128	Approx. 128	Approx. 128	Approx. 85
	Sea water pump						
	No. of units		4	4	4	4	4
	Flow rate(m^3/h)		Approx. 978	Approx. 978	Approx. 978	Approx. 978	Approx. 920
	Net pump head (m)		Approx. 232	Approx. 232	Approx. 239	Approx. 235	Approx. 191
	Heat exchanger						
	No. of units		2	2	2	2	2
	Heat transfer capacity (kW/unit)		Approx. 9.02E+3	Approx. 9.02E+3	Approx. 9.02E+3	Approx. 9.02E+3	Approx. 19.3E+3
Shutdown cooling system (SHC)	Pump						
	No. of units	2					
	Flow rate(m^3/h)	465.5					
	Pump head (m)	45.7					
	Heat exchanger						
	No. of units	2					
	Heat exchanger capacity (kcal/h)	3.8E+06					
Reactor core isolation cooling system (RCIC)	Steam turbine						
	No. of units		1	1	1	1	1
	Reactor pressure (MPa[gage])		Approx. 7.73 - approx. 1.04	Approx. 7.73 - approx. 1.04	Approx. 7.73 - approx. 1.04	Approx. 7.73 - approx. 1.04	Approx. 7.86 - approx. 1.04
	Output (kW)		Approx. 373 - approx. 60	Approx. 373 - approx. 60	Approx. 400 - approx. 67	Approx. 343 - approx. 67	Approx. 541 - approx. 97
	Revolution (rpm)		Approx. 5,000 - approx. 2,000	Approx. 4,500 - approx. 2,000	Approx. 3,600 - approx. 1,900	Approx. 4,500 - approx. 2,300	Approx. 4,500 - approx. 2,200
	Pump						
	No. of units		1	1	1	1	1
	Flow rate(m^3/h)		Approx. 95	Approx. 97	Approx. 94	Approx. 97	Approx. 142
	Net pump head (m)		Approx. 850 - approx. 160	Approx. 850 - approx. 160	Approx. 850 - approx. 160	Approx. 850 - approx. 160	Approx. 870 - approx. 190
	Revolution (rpm)		Variable	Variable	Variable	Variable	Not described in reactor establishment
Low pressure core spray system (LPCS)	No. of systems						1
	Flow rate (t/h/system)						1,442
	No. of pumps (/system)						1
	Pump discharge pressure *1						Approx. 4.1 MPa (42.2kg/cm^2[gage])
	Net pump head (m)						218

Specifications of Engineered Safety Feature Systems and Reactor Auxiliary Facilities in Fukushima Daiichi NPS

		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
High pressure core spray system (HPCS)	No. of systems						1
	Flow rate (t/h/system)						1,441
	No. of pumps (/system)						1
	Pump discharge pressure *1						Approx. 9.1 MPa (93.1kg/cm^2[gage])
	Net pump head (m)						863-273
Isolation condenser system (IC)	No. of systems	2					
	Tank effective storage water volume (m^3/tank)	106					
	Steam flow rate (t/h/tank)	100.6					
Make-up water condensate system (MUWC)	No. of pumps	2	2	2	2	2	2
	Flow rate(m^3/h)	68.1	68.2	68.2	70	68.2	118.1
	Pump head (m)	54.86	77.72	78.0	78.0	77.7	58.5
Fuel pool cooling cleanup water system (FPC)	No. of pumps	2	2	2	2	2	2
	Flow rate (m3/h)	80	110	107.9	110	107.9	125
	Pump discharge pressure (MPa[gage])	Approx. 1.0	Approx. 0.9	Approx. 0.9	Approx. 0.9	Approx. 0.9	Approx. 0.9
Standby gas treatment system (SGTS)	No. of systems	2	2	2	2	2	2
	No. of blowers (/system)	1	1	1	1	1	1
	Air exhaust capacity (m^3/h/unit)	1,870	Approx. 2,700	Approx. 2,700	Approx. 2,700	Approx. 2,700	Approx. 4,250
	System iodine removal efficiency(%)	≧97	≧99.9	≧99.9	≧97	≧97	≧99.9
Safety relief valve	No. of valves	3	3	3			
	Total capacity (t/h)	Approx. 873	Approx. 1,236	Approx. 1,236			
	Discharge pressure (MPa[gage])	8.51 (2) 8.62 (1)	8.55 (3)	8.55 (3)			
	Discharge place	Dry well	Dry well	Dry well			
Safety relief valve	No. of valves	4	8	8	11	11	18
	Total capacity (t/h)	Approx. 1,057	Approx. 2,938	Approx. 2,913	Approx. 4,147	Approx. 4,149	Relief valve: approx. 6,532 Safety valve: approx. 7,284
	Relief function (MPa[gage])	7.27 (1)	7.44 (1)	7.44 (1)	7.44 (1)	7.44 (1)	7.37 (2)
		7.34 (2)	7.51 (3)	7.51 (3)	7.51 (3)	7.51 (3)	7.44 (4)
		7.41 (1)	7.58 (4)	7.58 (4)	7.58 (4)	7.58 (4)	7.51 (4)
							7.58 (4)
							7.64 (4)
	Safety valve function (MPa[gage])	7.64 (2)	7.64 (2)	7.64 (2)	7.64 (2)	7.64 (2)	7.78 (2)
		7.71 (2)	7.71 (3)	7.71 (3)	7.71 (3)	7.71 (3)	8.10 (4)
			7.78 (3)	7.78 (3)	7.78 (3)	7.78 (3)	8.16 (4)
					8.55 (3)	8.55 (3)	8.23 (4)
							8.30 (4)
	Discharge place	Suppression pool	Suppression pool	Suppression pool	Suppression pool	Suppression pool	Suppression pool

Note 1: the unit in the reactor establishment permit is kg/cm^2[gage]

Plant Main Specifications in Fukushima Daini NPS

	Unit 1	Unit 2	Unit 3	Unit 4
Electrical output (MWe)	1,100	1,100	1,100	1,100
Heat output (MWe)	3,293	3,293	3,293	3,293
Construction start	1975/8	1979/1	1980/11	1980/11
Commercial Operation start	1982/4	1984/2	1985/6	1987/8
Reactor type	BWR5			
Reactor pressure vessel inner diameter (mm)	Approx. 6,400	Approx. 6,400	Approx. 6,400	Approx. 6,400
Reactor pressure vessel height (mm)	Approx. 23,000	Approx. 23,000	Approx. 23,000	Approx. 23,000
Reactor pressure vessel total weight (t)	Approx. 750	Approx. 750	Approx. 750	Approx. 750
Reactor pressure vessels design pressure*1	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])	Approx. 8.62 MPa[gage] (87.9kg/cm^2[gage])
Reactor pressure vessel design temperature (C)	302	302	302	302
Fuel assembly (no. of assemblies)	764	764	764	764
High burnup 8x8 fuel (no. of assemblies)	0	0	0	0
9x9 fuel (A type) (no. of assemblies)	572	368	764	764
9x9 fuel (B type) (no. of assemblies)	192	396	0	0
MOX fuel (no. of assemblies)	0	0	0	0
Fuel rod active length (m)	Approx. 3.71	Approx. 3.71	Approx. 3.71	Approx. 3.71
Control rod count (no. of rods)	185	185	185	185
Containment type (Main body)	Mark II	Mark II Advanced		
				
Containment height (m)	Approx. 48	Approx. 48	Approx. 48	Approx. 48
Containment diameter(m)	Approx. 26	Approx. 29	Approx. 29	Approx. 29
Suppression pool water amount (m^3)	Approx. 3400	Approx. 4,000	Approx. 4,000	Approx. 4,000
PCV design pressure*1	Approx. 0.28 MPa[gage] (2.85kg/cm^2[gage])	Approx. 0.28 MPa[gage] (2.85kg/cm^2[gage])	Approx. 0.28 MPa[gage] (2.85kg/cm^2[gage])	Approx. 0.28 MPa[gage] (2.85kg/cm^2[gage])
Containment design temperature (C)	171(D/W) 104(S/C)	171(D/W) 104(S/C)	171(D/W) 104(S/C)	171(D/W) 104(S/C)
Spent fuel pool volume (% core part)	350	360	360	360
Spent fuel pool operating temperature (C)	≦65	≦65	≦65	≦65
Spent fuel pool length (north-south: parallel to coastline) (m)	Approx. 12.2	Approx. 12.2	Approx. 12.2	Approx. 12.2
Spent fuel pool width (east-west: perpendicular to coastline) (m)	Approx. 10.4	Approx. 13.6	Approx. 13.6	Approx. 13.6
Spent fuel pool depth (deepest part) (m)	Approx. 11.8	Approx. 11.9	Approx. 11.8	Approx. 11.8
Spent fuel pool volume (m^3)	Approx. 1,450	Approx. 1,620	Approx. 1,749	Approx. 1,670
Storage capacity of spent fuel in the spent fuel pool (assemblies)	2,662	2,769	2,740	2,769
Amount of spent fuel in the spent fuel pool (assemblies) (End of December	1,570	1,638	1,596	1,672
Amount of new fuel in the spent fuel pool (assemblies) (End of December 2010)	200	80	184	80

*1: the unit in the reactor establishment permit is kg/cm^2[gage]

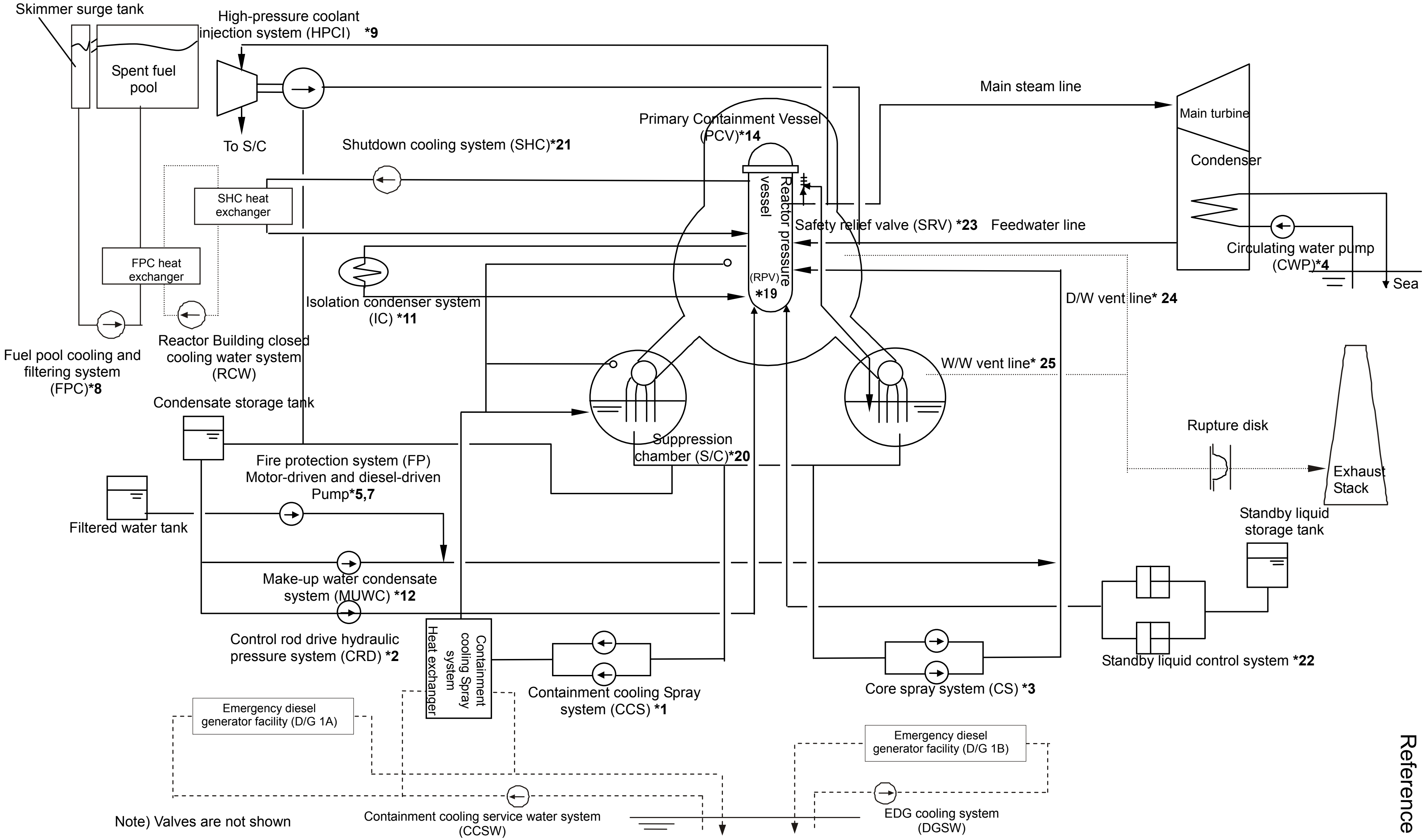
Specifications of Engineered Safety Feature Systems and Reactor Auxiliary Facilities in Fukushima Daini NPS

		Unit 1	Unit 2	Unit 3	Unit 4
Containment cooling system (CCS)	No. of systems	2	2	2	2
	Designed flow rate (t/h/system)	1,691	1,692	1,692	1,692
	No. of pumps (/system)	1	1	1	1
	No. of heat exchangers (/system)	1	1	1	1
Low pressure core injection system (LPCI)	No. of systems	3	3	3	3
	Flow rate (t/h/pump)	1,691	1,692	1,692	1,692
	No. of pumps (/system)	1	1	1	1
Residual heat removal system (RHR)	Pump				
	No. of units	3	3	3	3
	Flow rate (t/h)	1,691	1,692	1,692	1,692
	Net pump head (m)	92	86	92	92
	Heat exchanger				
	No. of units	2	2	2	2
	Heat transfer capacity (kW/unit)	19.3E+3	16.9E+3	12.3E+3	12.3E+3
	Sea water pump				
	No. of units	4	4	4	4
	Flow rate(m^3/h)	2,550	2,450	2,100	2,000
	Net pump head (m)	28	28	33	30
	Heat exchanger				
	No. of units	4	4	4	4
	Heat transfer capacity (kW/unit)	9.74E+03	9.74E+03	7.42E+03	7.42E+03
Reactor core isolation cooling system (RCIC)	Steam turbine				
	No. of units	1	1	1	1
	Output (kW)	Approx. 541 - approx. 97	Approx. 660 - approx. 125	Approx. 541 - approx. 97	Approx. 660 - approx. 125
	Revolution (rpm)	Approx. 4,500 - approx. 2,200	Approx. 4,200 - approx. 2,200	Approx. 4,500 - approx. 2,200	Approx. 4,200 - approx. 2,200
	Pump				
	No. of units	1	1	1	1
	Flow rate(m^3/h)	142.0	142.2	142	142
	Net pump head (m)	882～186	882～186	882～186	882～186
Low pressure core spray system (LPCS)	No. of systems	1	1	1	1
	Flow rate (t/h/system)	1,441	1,446～1,644	1,443	1,443
	No. of pumps (/system)	1	1	1	1
	Net pump head (m)	218	218～175	218	218
High pressure core spray system (HPCS)	No. of systems	1	1	1	1
	Flow rate (t/h/system)	368～1,460	372～1,578	369～1,462	369～1,462
	No. of pumps (/system)	1	1	1	1
	Net pump head (m)	866～273	863～197	863～274	863～274
Make-up water condensate system (MUWC)	No. of pumps	3	2	3	3
	Flow rate(m^3/h)	120	145.5	120	145.5
	Pump head (m)	90	85.5	90	85.5
Fuel pool cooling cleanup water system (FPC)	No. of pumps	2	2	2	2
	Flow rate (m3/h)	160	156	156	156
	Pump head (m)	80	80	80	80
Standby gas treatment system (SGTS)	No. of systems	2	2	2	2
	No. of blowers (/system)	1	1	1	1
	Air exhaust capacity (m^3/h/unit)	4,250	5,000	5,000	5,000
	System iodine removal efficiency(%)	≧99	≧99	≧99	≧99

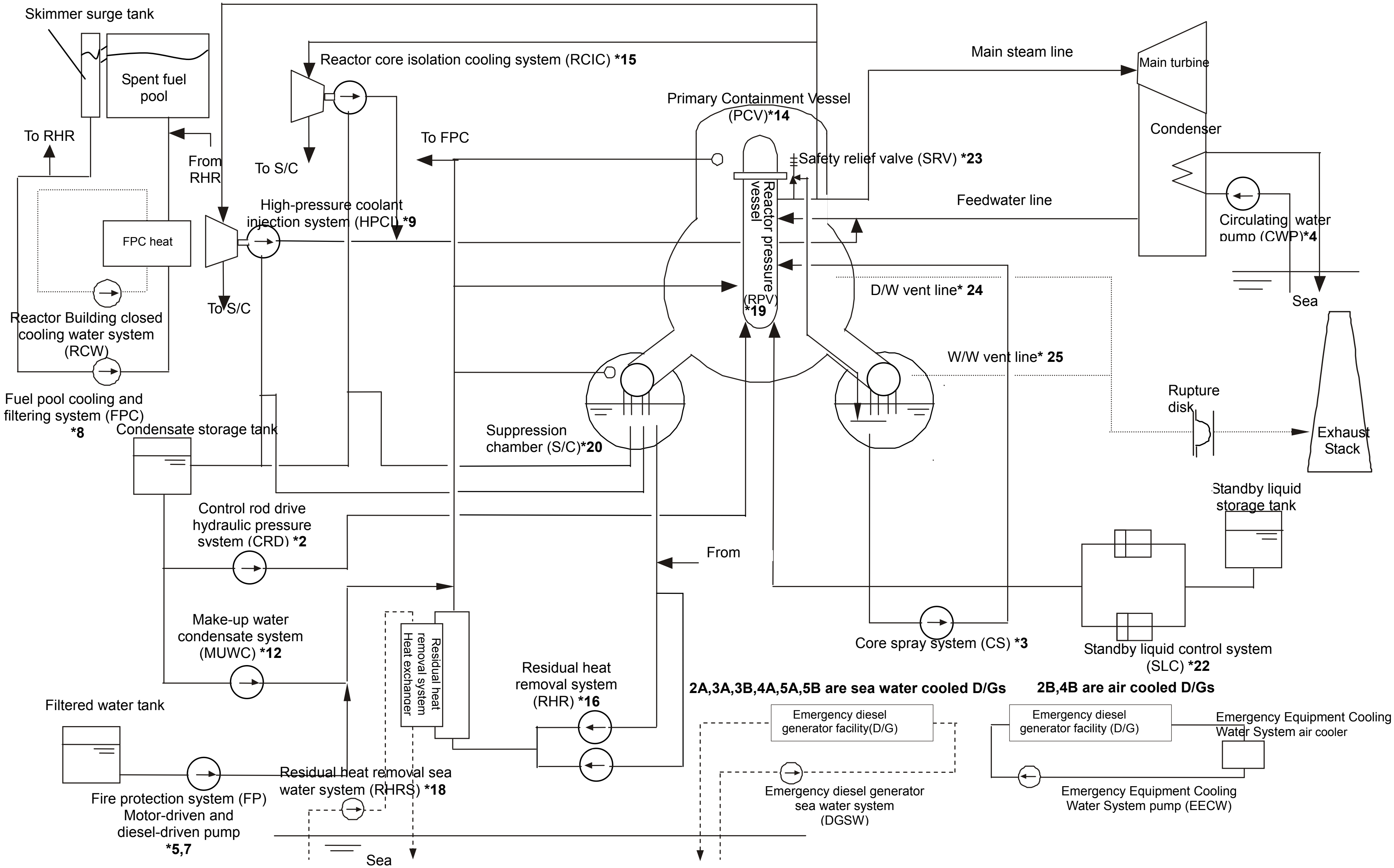
Specifications of Engineered Safety Feature Systems and Reactor Auxiliary Facilities in Fukushima Daini NPS

		Unit 1	Unit 2	Unit 3	Unit 4
Safety relief valve	No. of valves	18	18	18	18
	Total capacity (t/h)	Relief valve: approx. 6,536 Safety valve: approx. 7,286	Relief valve: approx. 6,552 Safety valve: approx. 7,332	Relief valve: approx. 6,552 Safety valve: approx. 7,332	Relief valve: approx. 6,552 Safety valve: approx. 7,332
	Relief function (MPa[gage])	7.37 (2)	7.37 (2)	7.37 (2)	7.37 (2)
		7.44 (4)	7.44 (4)	7.44 (4)	7.44 (4)
		7.51 (4)	7.51 (4)	7.51 (4)	7.51 (4)
		7.58 (4)	7.58 (4)	7.58 (4)	7.58 (4)
		7.64 (4)	7.64 (4)	7.64 (4)	7.64 (4)
	Safety valve function (MPa[gage])	7.78 (2)	7.78 (2)	7.78 (2)	7.78 (2)
		8.10 (4)	8.10 (4)	8.10 (4)	8.10 (4)
		8.16 (4)	8.16 (4)	8.16 (4)	8.16 (4)
		8.23 (4)	8.23 (4)	8.23 (4)	8.23 (4)
		8.30 (4)	8.30 (4)	8.30 (4)	8.30 (4)
	Discharge place	Suppression pool	Suppression pool	Suppression pool	Suppression pool

Reference 3 (1/5)



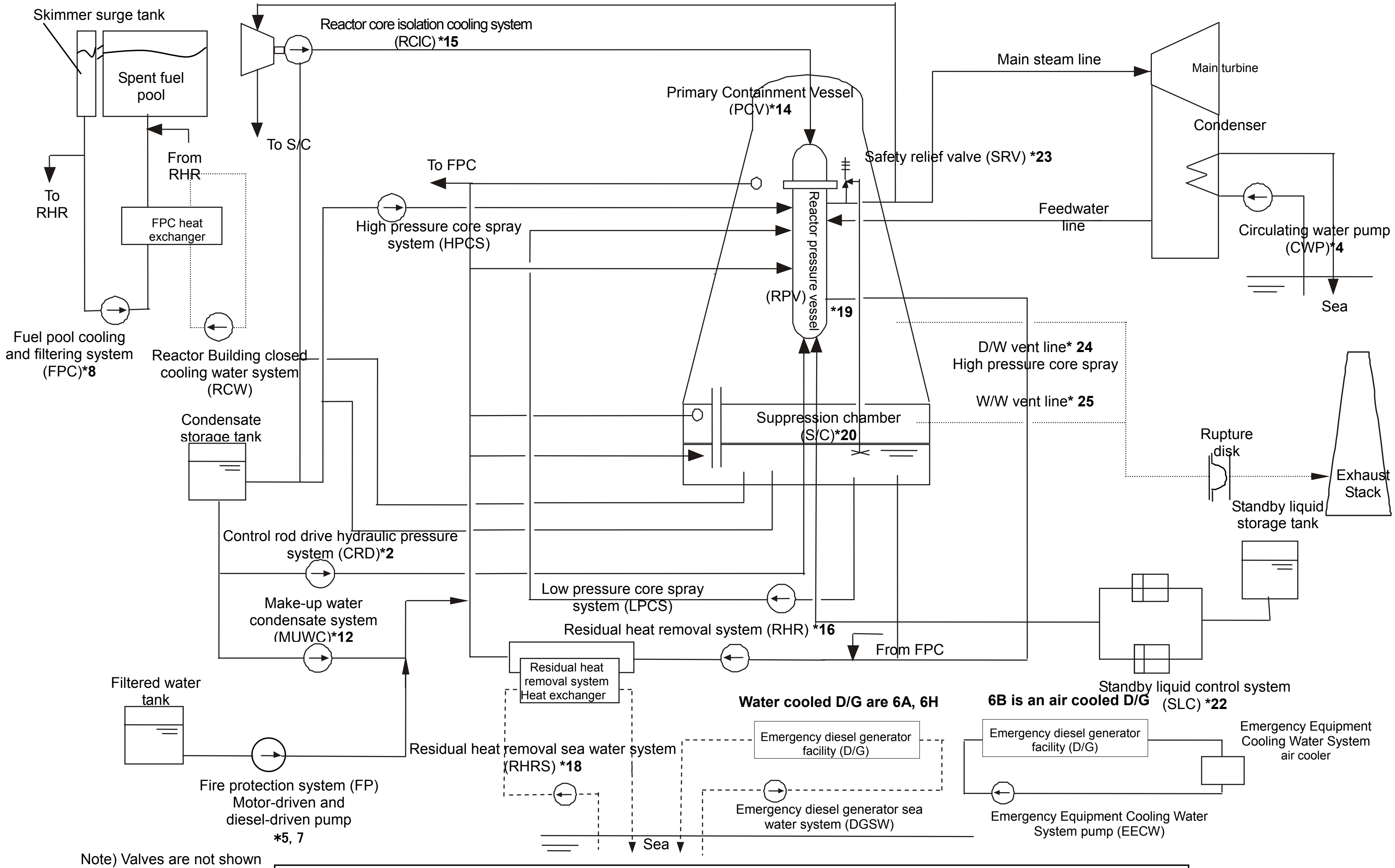
Fukushima Daiichi Unit 1 summary of facility and configuration



Note) Valves are not shown

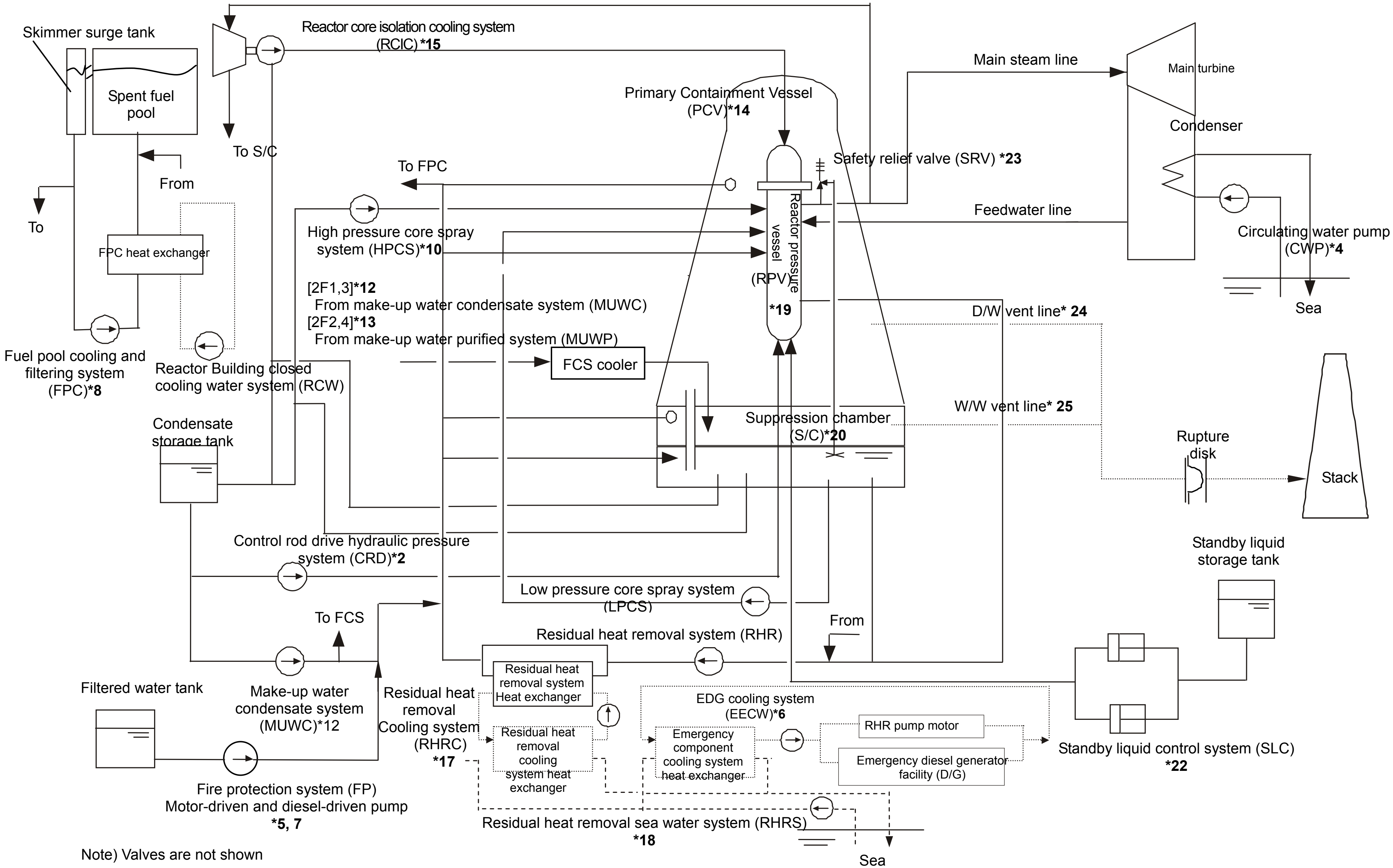
Fukushima Daiichi Unit 2 to 5 summary of facility and configuration

Reference 3 (2/5)

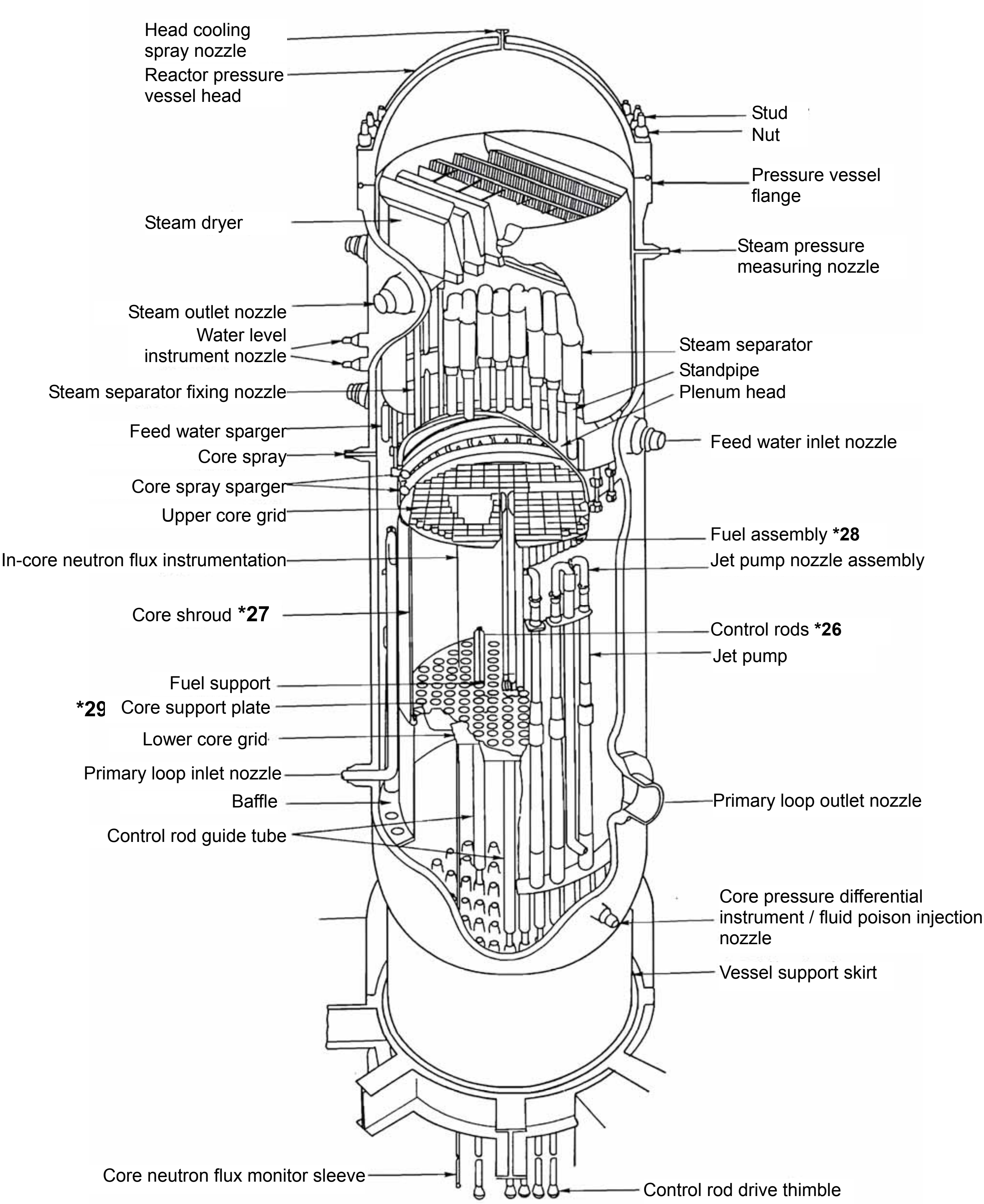


Fukushima Daiichi Unit 6 summary of facility and configuration

Reference 3 (3/5)

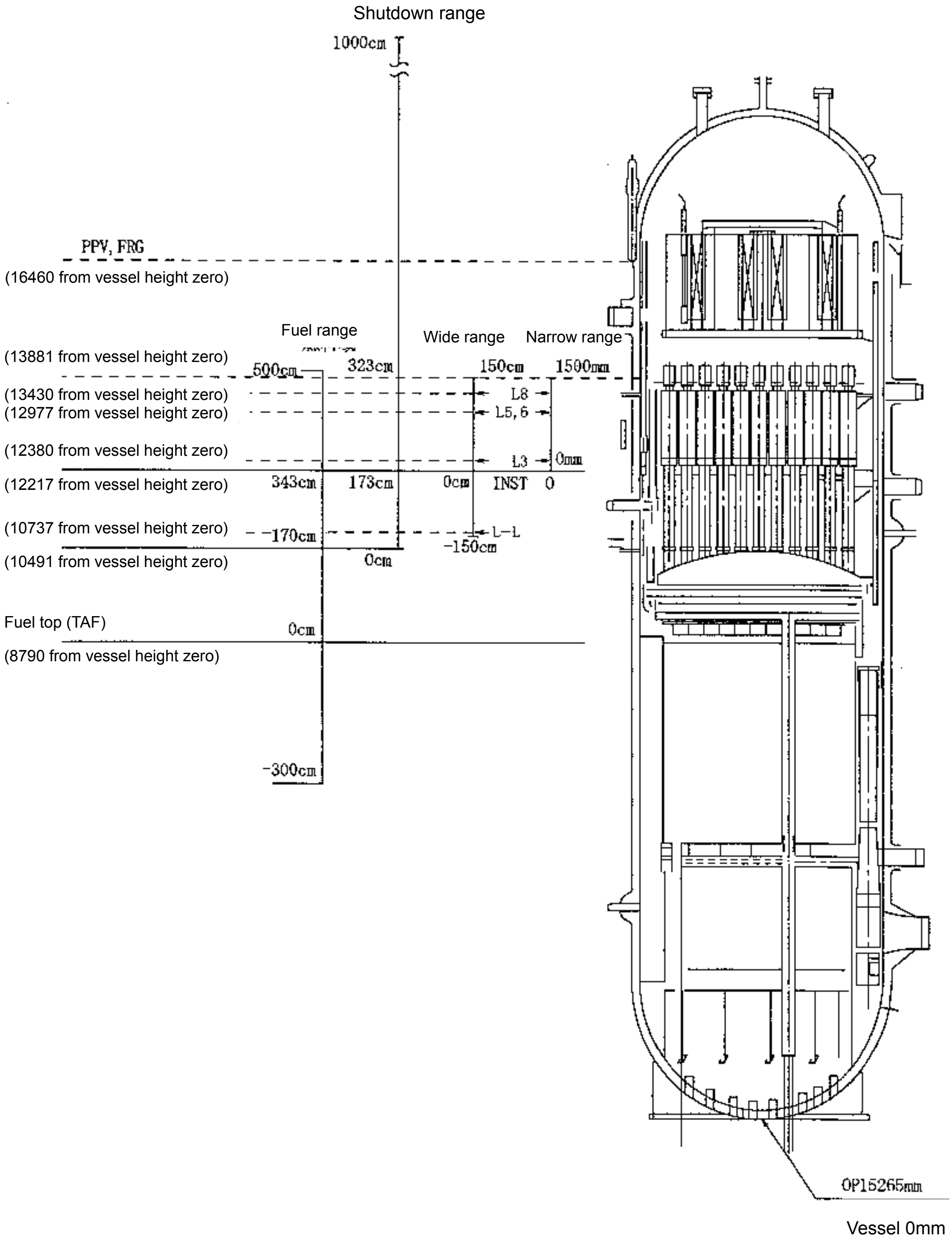


Fukushima Daini Unit 1 to 4 summary of facility and configuration

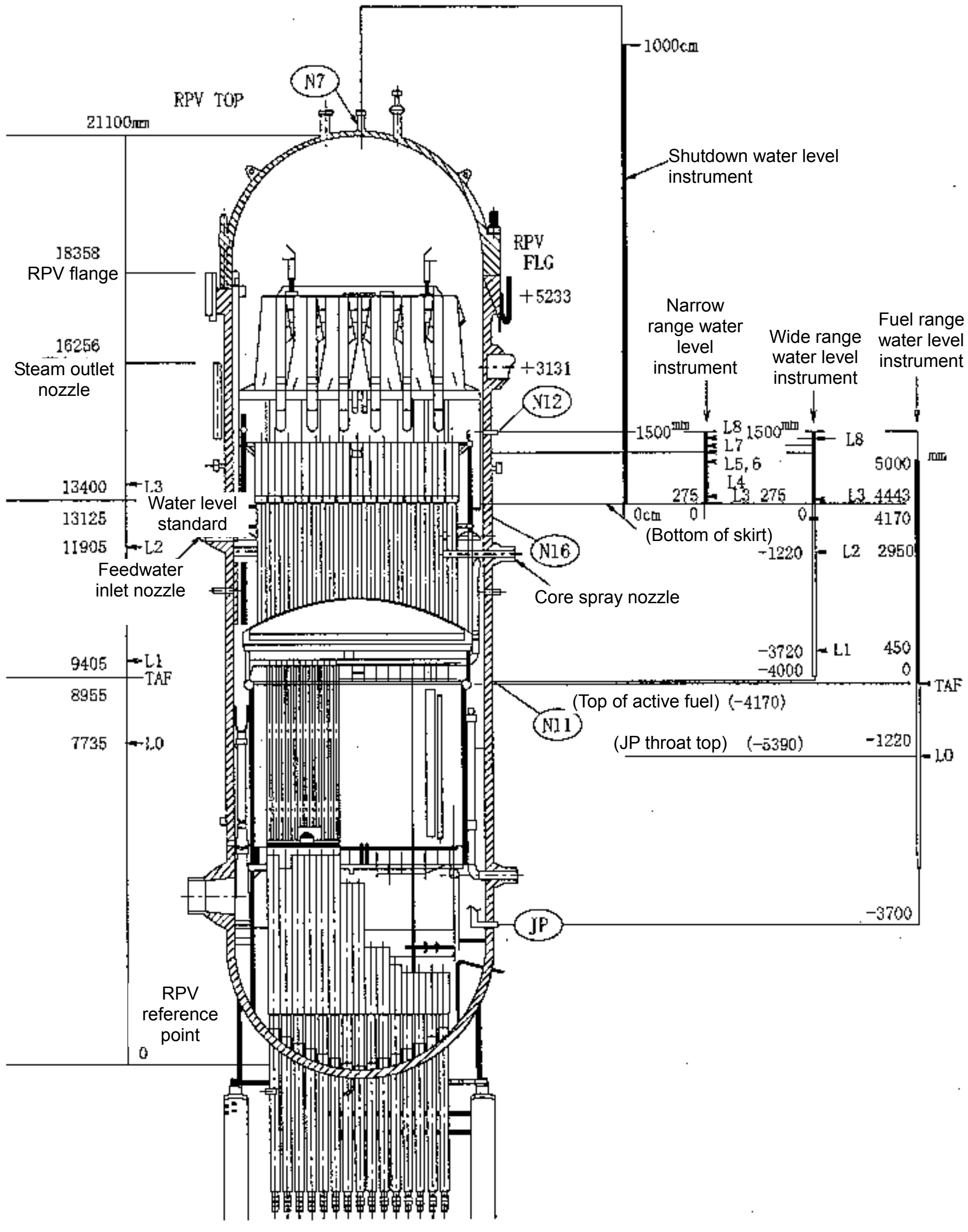


Supplement: RPV internal structures (example)

(From Fukushima Daiichi NPS Unit 2 Reactor establishment modification application)

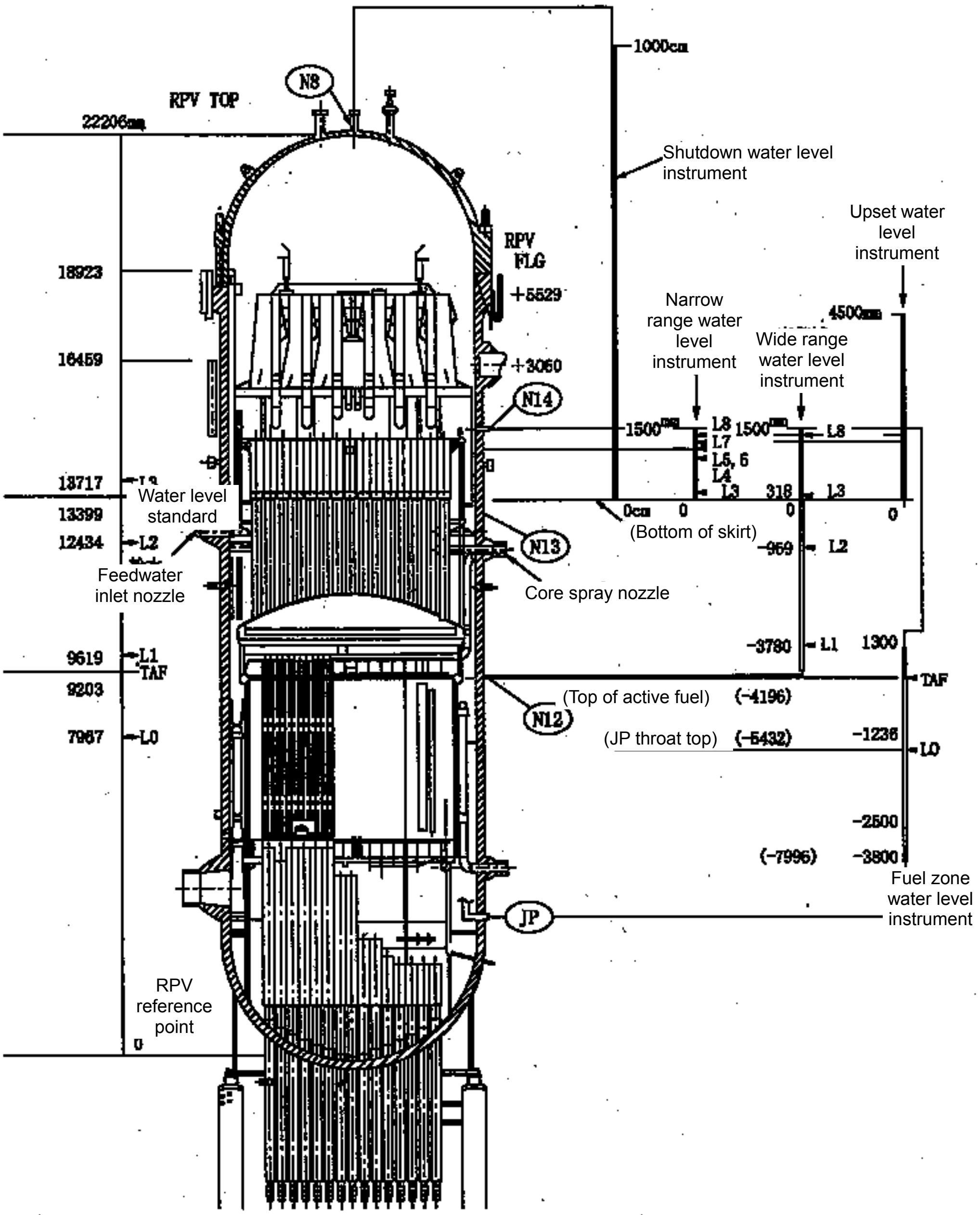


Fukushima Daiichi Unit 1 Indication range of reactor water level instrument



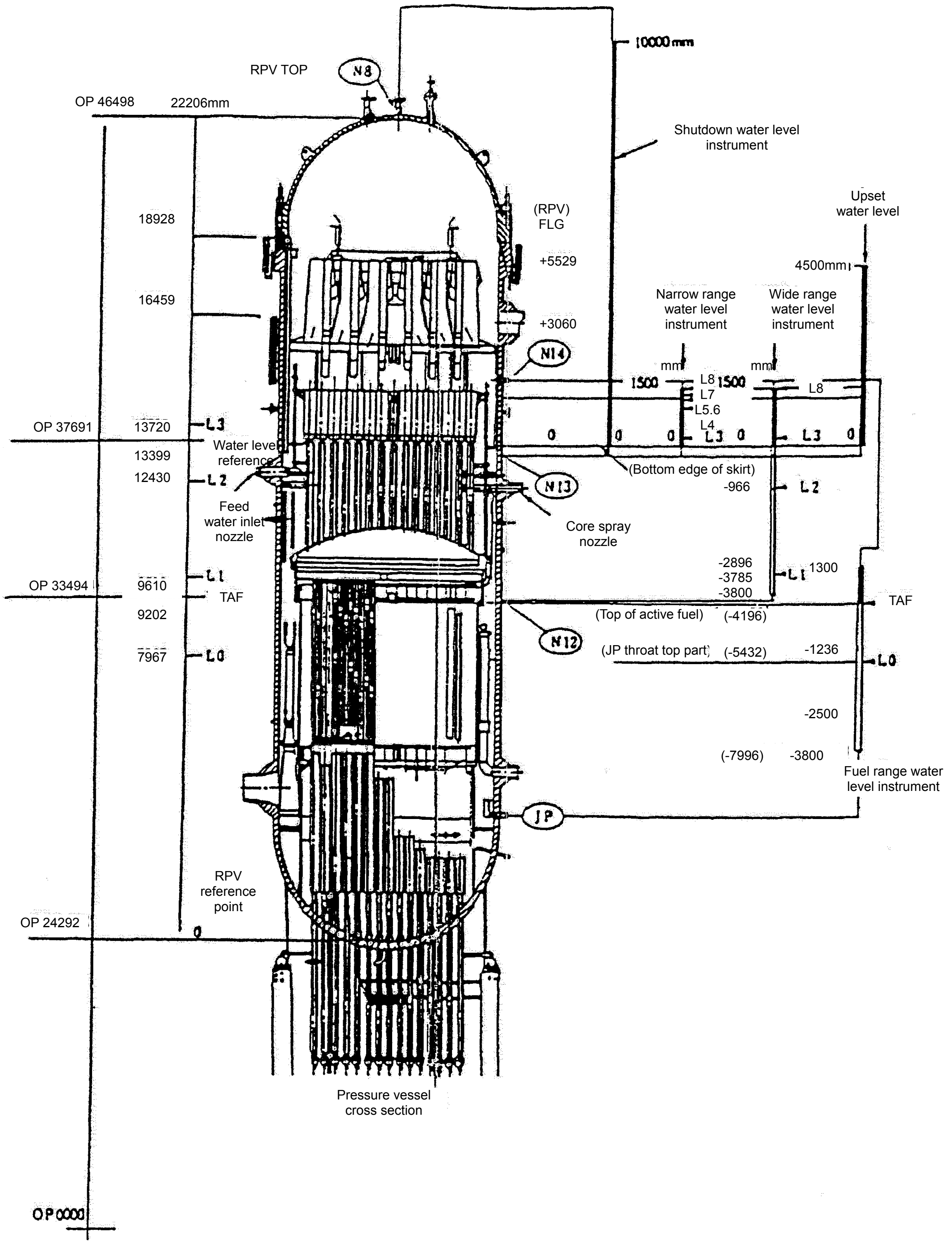
RPV cross section diagram

Fukushima Daiichi Unit 2 to 5 Indication range of reactor water level instrument

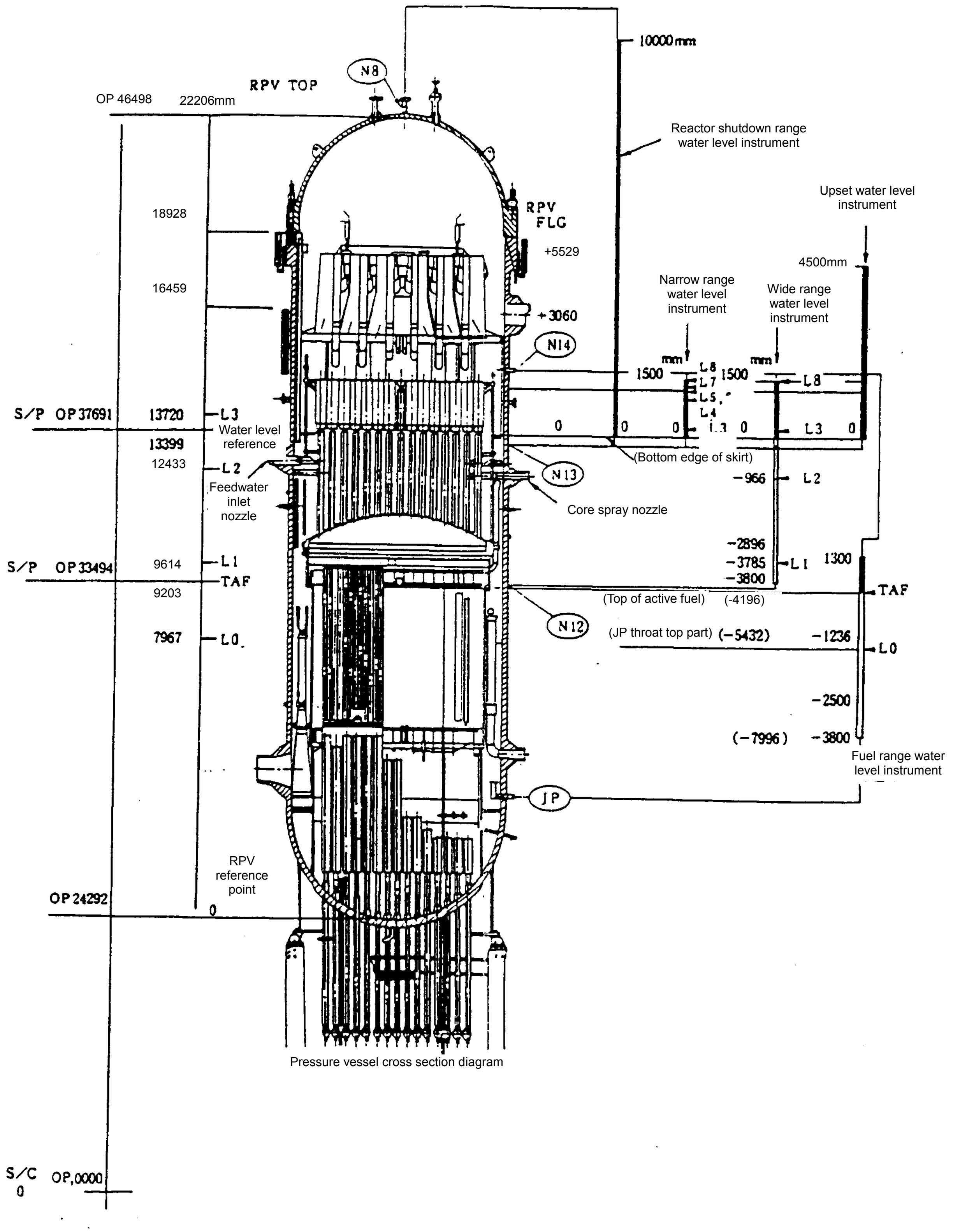


RPV cross section diagram

Fukushima Daiichi Unit 6 Indication range of reactor water level instrument



Fukushima Daini Unit 1, 2 Indication range of reactor water level instrument



Fukushima Daini Unit 3, 4 Indication range of reactor water level instrument

Glossary

※ illustration in Ref. 3

AM : Accident Management

Activities, including the preparation of operating procedures, enhancement of facilities, and training, for the purpose of preventing accidents when they happen from turning into severe accidents, or in the event that it does become a severe accident, maximizing the use of existing facilities in dealing with the situation in order to mitigate the impact as much as possible.

AO Valve : Air Operated Valve

Valves that are operated by means of compressed gas (instrument compressed air system (IA)).

APD : Alarm Pocket Dosimeter

Personal dose rate monitor with alarm that utilizes a solid state detector. Capable of recording the type of job the user is performing and the time worked.

APRM : Average Power Range Monitor

In-core neutron flux monitoring device which is used for measuring the average reactor power output from start of electrical output until rated power output. It displays the average signal output from the local power range monitor (LPRM). It outputs alarm, control rod block signals, and reactor emergency shutdown (scram) signals.

BAF : Bottom of Active Fuel

The lowest portion of the fuel assemblies where there are pellets.

BWR : Boiling Water Reactor

The nature of a BWR is that heat produced inside the reactor is used to boil water (coolant) turning it into high-temperature high-pressure steam, which is then piped directly to a turbine generator. All of TEPCO's nuclear power stations use BWRs.

CAMS : Containment Atmospheric Monitoring System

System inside the main control room for measuring, recording and controlling the concentration of hydrogen, concentration of oxygen, and gamma rays inside the reactor primary containment vessel (PCV) which starts up automatically whenever a loss of coolant accident (LOCA) signal has been output. In case any one of the preset values is exceeded, it outputs an alarm.

C/B : Control Building

Building in which the main control room is located, and from which the nuclear power station is operated.

CCS : Containment Cooling Spray System※1

When the pressure and/or temperature inside the reactor primary containment vessel (PCV) builds up too high, it sprays cooling water inside the PCV to restrain the pressure and temperature. When the water inside the pressure suppression chamber (torus) is being cooled, it is started up manually.
Installed only in Unit 1 of Fukushima Daiichi.

It is a kind of alternate injection accident management (AM) measure.

It has the following methods (modes) of operation.

(1) PCV spray mode
(2) Torus water cooling mode (operated manually when it is predicted that the torus water temperature will rise.)

CR : Control Rod※26

Board-shaped rods used for controlling the reactor output by limiting the number of neutrons generated from the fuel by absorbing excess neutrons. In thermal neutron reactors, large surface material neutron absorption cross sections such as boric acid, cadmium, hafnium and the like are used. In emergencies, the reactor is shut down by quickly inserting the control rods into the core (scram).

CRD : Control Rod Drive※2

Facility used for withdrawing and inserting control rods (CR) when signals from the reactor manual control system have been outputted. (Normally, it functions to withdraw or insert the CR) Also, in case of emergency, it can be operated manually or by means of an automated reactor protection system (RPS) signal to quickly insert (scram) the withdrawn CR into the reactor so as to prevent fuel damage.

CS : Core Spray System※3

A type of an emergency core cooling system (ECCS) that in case of loss of coolant accident (LOCA), cooling water is sprayed from the upper part of the reactor core in order to prevent damage to the fuel and fuel cladding when the fuel overheats. This type of device is installed in Unit 1 to Unit 5 at Fukushima Daiichi.

C/S : Combination Structure

A single building combining the radioactive waste building (RW/B) and the off gas building, to the conventional reactor building (R/B).

CWP : Circulating Water Pump※4

Steam that has done its job of turning the main turbine is cooled and condensed by the main condenser. Seawater is used to do the cooling, and this seawater system is known as the circulating water (CW) system. This pump sends in the seawater used by the CW system.

D/D FP : Diesel Driven Fire Pump※5

Pump installed in the fire protection system. Automatically starts up when the fire protection system pressure drops and the motor driven fire protection pump cannot be operated.

D/G : Diesel Generator

When a malfunction results in the loss of normal electric power supply, the D/G starts up and supplies the power needed inside the power station. The D/G supplies power to systems and equipment essential to safety through the emergency bus power, thus powering facilities such as the emergency core cooling system (ECCS) so that the equipment needed to safely shut down the reactor are supplied with the electric power they need.

D/W : Dry-well

The empty space inside the PCV except for the space inside the suppression chamber (S/C).

DWC : Dry-well Cooling System

Facility for cooling the dry-well (D/W) while the reactor is in operation and even during outage it prevent the PCV temperature from becoming too severe.

ECCS : Emergency Core Cooling System

General term for the system inclusive of all sorts of devices (pumps) capable of emergency injection of cooling water into the reactor core, so that when recirculation pipes such as reactor coolant pressure boundary pipes break and a loss of coolant accident (LOCA) occurs, decay heat and residual heat are removed from the core so as to prevent damage to the fuel cladding due to the over-heating of the fuel, and also restricts water reaction with zirconium to within acceptable levels.

EECW : Emergency Equipment Cooling Water System※6

Facility for providing fresh cooling water to emergency air conditioning coolers and the emergency diesel generator system so as to maintain functionality needed for various emergency equipment when loss of coolant accident (LOCA) occurs (also supplies cooling water to residual heat removal (RHR) system pump motors).

EOP : Emergency Operating Procedure

Operating procedures aimed at the ultimate prevention of core meltdown or reactor core damage which could become the source of extremely high radioactivity release, and for dealing with simultaneous accidents that exceed design guidelines and are thought to have a very small possibility of occurring.

ERC : Emergency Response Center

Structure established by NISA of the Ministry of Economy, Trade and Industry in plant siting areas where nuclear facilities are sited for use when large-scale natural disasters occur.

FCS : Flammability Control System

When a loss of coolant accident (LOCA) occurs, the fuel temperature becomes excessively high and the fuel cladding reacts with water to produce flammable gas (hydrogen) which collects inside the PCV. Because hydrogen density above a certain level reacts with oxygen (air), burning up in an explosive manner, this system controls the density of hydrogen gas maintaining a level within safe limit.

FP : Fire Protection System※7

Fire protection system inside the power stations. In addition to normal fire hydrants, there are also carbon dioxide gas systems for oil fires. Capable of injecting cooling water into the reactor as a part of accident management (AM).

FPC : Fuel Pool Cooling and Filtering System※8

After spent fuel is removed from the reactor, fuel assemblies still contain fission products and the like which produce heat and radioactivity, and need to be kept cool enough so as not to lose integrity without hindering fuel reprocessing. While keeping the pool cool, this clean-up water system removes impurities and maintains water quality at a set level.

Ge Solid State Detector

A radiation detector that is manufactured using germanium semiconductor is called a Ge solid state detector. The principle on which it works is that when voltage is applied to a diode in the commutation direction and in the opposite direction, an electric current is drawn out based on the paired negative-charged electrons and positive holes composed of radiation within the radiation measurement field. In solid state detectors, the energy required to obtain the paired electron-hole is small, though the resulting resolution obtained is excellent.

HPCI : High Pressure Coolant Injection System※9

One of the systems of the emergency core cooling system (ECCS) capable of injecting cooling water into the reactor by means of steam turbine-driven high pressure pump when there is an accident involving a relatively small pipe rupture so that the reactor does not undergo rapid decompression.

The pump flow rate (i.e. capacity) is approximately ten times greater that of the reactor core isolation cooling system (RCIC), but smaller than either the reactor shutdown cooling system (SHC : 1F1) or the residual heat removal system (RHR : approximately 1800m^3 per hour in the case of Fukushima Daiichi Unit 2 to Unit 5). HPCI are installed in Fukushima Daiichi Unit 1 to Unit 5.

HPCS : High Pressure Core Spray System※10

One of the systems of the ECCS that in case of an accident, it prevents rapid depressurization of the reactor. ECCS has its own independent power source (diesel generator) that powers the motor-driven high pressure pumps for spraying coolant into the reactor core.

HPCS has been installed in units constructed after Fukushima Daiichi Unit 6 (Used in all units at Kashiwazaki-Kariwa (KK), except Unit 6 and Unit 7. KK Unit 6 and Unit 7 use HPCF (High Pressure Core Flooder System).)

HVAC : Heating and Ventilating Air Conditioning and Cooling System

System for improving the working environment inside the power station, as well as maintaining an appropriate temperature and humidity for instrument control devices so as to furnish appropriate processing equipment (filters and the like) appropriate for preventing radiation contamination of the air. The ventilation systems of the reactor building (R/B), turbine building (T/B), main control room (MCR), and radwaste building (RW/B) are separate and each is independent.

IA : Instrument Air-System

Facility for supplying compressed gas to air-driven devices and control equipment in each of the buildings. The compressed gas is purified by removing moisture, dust and the like in order to ensure that this system functions properly.

IAEA : International Atomic Energy Agency

An international organization created by the United Nations as a governmental advisory body aimed at promoting world peace, health, and prosperity through the peaceful use of atomic energy. Its main functions are to hold international conferences, conduct joint research, provide facilities for nuclear materials, training and the exchange of information among scientists and engineers, and especially to enforce safeguards against military applications of atomic power (TEPCO's power stations undergo inspections as a part of this purpose).

IC : Isolation Condenser※11

Device for reducing pressure inside the reactor core when the reactor pressure rises, and to convey the steam from the reactor to condense it back into water (only Fukushima Daiichi Unit 1 is equipped with IC).

ICRP : International Commission on Radiological Protection

An international committee made up of world renowned authorities on medical science, health, and hygiene whose purpose is to provide advice on international guidelines on radiological protection. The Japanese central government also enacts laws in accordance with the advice on radiation dose limits, acceptable concentrations and the like given by the committee.

INES : International Nuclear Event Scale

An international scale created through the cooperation of IAEA and OECD/NEA for the purpose of understanding the significance to the public of malfunctions and accidents at nuclear power stations from the perspective of safety. Accidents are evaluated on a scale of seven grades.

ITV : Industrial Television

Television cameras installed for the purposes of reducing radiation exposure of nuclear power station workers, monitoring job performance and leakage of radioactive fluids, monitoring control panel alarms, and monitoring conditions of water intake facilities during the winter. In general industry, monitoring cameras installed in the field are generally referred to as ITV.

JANTI : Japan Nuclear Technology Institute

An organization in the nuclear industry for making preparations for technological foundations, promoting voluntary maintenance activities and the like. JANTI carries out third party reviews of each nuclear operator and operates and manages the Nuclear Information Archives (NUCIA).

MAAP CODE : Modular Accident Analysis Program

Severe accident analysis program of EPRI (Electric Power Research Institute of the United States)

M/C : Metal-Clad Switch Gear

Motive power electric power panel used for high voltage lines inside power stations that houses magnetic blow-out circuit breakers, vacuum circuit breakers, protective relays, and peripheral gauges in a compact package. The configuration is comprised of three types: ordinary use, shared, and emergency use.

MCC : Motor Control Center

Motive power panel for in-house low voltage circuits that feed various low power consuming units such as distribution line circuit breakers, electromagnetic contactors, and protective relays all housed in a compact unit, used as power station auxiliary unit power panel. The configuration is comprised of three types: ordinary use, shared, and emergency use.

MCR : Main Control Room

The room where nuclear power station monitoring and remote operations are carried out.

MCR HVAC : Main Control Room Heating Ventilation, Air Conditioning and Cooling System

System that automatically isolates the main control room from outside air when there is a radioactive material leakage accident in the reactor building, and also recirculates the air inside the main control room, maintaining a clean atmosphere inside the main control room.

M/G Set : Motor Generator Set

Device for driving the generator with an electric motor.

MO Valve : Motor Operated Valve

Valve that opens and closes valve drive parts using electric motors when an electrical signal is received from the system logical circuits.

MP : Monitoring Post

Installed at a number of places in the vicinity of power station sites, measuring the γ ray (gamma ray) dose rate in the air. Vehicles that take measurements while on the move are called monitoring cars.

MSIV : Main Steam Isolation Valve

The main steam pipe passes through the reactor pressure containment vessel (PCV) to the turbine. Therefore, containment isolation valves are installed at the points where the main steam pipe goes into and comes out of the PCV so that if there is a piping rupture, the isolation valves are fully closed, and this prevents steam containing radioactive materials from escaping to the outside.

MUWC : Make-Up Water System (Condensate)※12

System for supplying various kinds of water (the water source is the condensate storage tank, which in principle is water that has been used in the reactor and purified, and therefore contains small amounts of radioactivity, although the density is low) needed for operation of the power station via pumps (for pumping condensate).

Its purpose is not for emergency use, but from the standpoint of accident management (AM), it can be used for injection of cooling water into the reactor. The pumping flow rate capacity is less than that of the RCIC (approximately $70m^3$ per hour).

MUWP : Make-Up Water System (Purified)※13

System to supply the required volume and pressure of fresh water for equipment, piping, valves and the like installed in each of the buildings and other peripheral facilities for smooth operation and maintenance of the power station.

OJT : On the Job Training

Training received while engaging in actual work.

O.P. : Onahama Point

The point of reference at Onahama Port construction site, a unit of measurement used by Fukushima Daiichi and Fukushima Daini NPSs that refers to height, where the average tidal level over a period of one year is calculated in the Fukushima Prefecture Onahama district, and this level is set to zero.

O.P. = 0.727m below Tokyo Bay average mid-sea level (T.P.)

P/C : Power Center

Compact housing for air circuit breakers (ACB), protective relays and peripheral gauges used by the motive power panels for in-house low voltage circuits. The configuration is comprised of three types: ordinary use, shared, and emergency use.

PCIS : Primary Containment Isolation System

System that closes containment isolation valves at the penetration seals of the reactor primary containment vessel (PCV) to insure the public safety of the vicinity surrounding the power station whenever there is an accident whereby radioactive material could leak out from the PCV.

PCV : Primary Containment Vessel※14

Container, or vessel, that is made of steel and houses the reactor pressure vessel and other main reactor facilities. It is a facility that contains radioactive materials within the power station site and restricts radioactivity from leaking out to the area surrounding the power station site whenever there is a loss of coolant accident, and it comprises the dry-well (D/W) which contains no water and the pressure suppression chamber (also called wet well (W/W)).

P&ID : Piping and Instrumentation Diagram

Schematic diagram of the facilities in the power station broken down by systems, using a fixed set of symbols to show piping, valves, pumps, instruments and the like.

PSA : Probabilistic Safety Assessment

Assessment that estimates the probability of malfunction facility configuration and the likelihood of event progression after a hypothetical abnormality that has the possibility of occurring at any nuclear power station.

R/B : Reactor Building

Building which houses the reactor primary containment vessel (PCV) and other reactor auxiliary facilities and in case of accident, even if radioactive materials leak out from the reactor PCV, they are prevented from escaping outside the building by maintaining negative pressure inside the building.

RCIC : Reactor Core Isolation Cooling System※15

System for depressurizing the reactor by removing fuel decay heat by injecting cooling water into the reactor using turbine driven pumps running on reactor steam in case the main condenser becomes inoperable due to closing of the main steam isolation valve (MSIV) for whatever reason while the reactor is in normal operation. The reactor water level is maintained even when the feedwater system breaks down using the emergency cooling water injection pumps. The RCIC pump flow rate is relatively small, approximately one tenth that of the HPCI with capacity of about 96m^3 per hour (in the case of Fukushima Daiichi Unit 2 to Unit 5).

RCW : Reactor Building Closed Cooling Water System

System inside the reactor building that circulates cooling water (fresh water) that has been cooled by exchanging heat with seawater for cooling auxiliary units (pump bearings, heat exchangers and the like).

RHR : Residual Heat Removal System※16

System (one of the sub-systems of the emergency core cooling systems (ECCS)) for cooling the coolant (removing fuel decay heat) using heat exchangers and pumps and, for regulating the reactor water level by injecting cooling water into the reactor in emergencies, after the reactor has been shut down, and has the capacity to bring the reactor to cold shutdown state. Both the pump flow rate and heat exchanger are high capacity, and the system can operate in the following modes:
(1) Reactor shutdown cooling mode
(2) Low pressure water injection mode (ECCS)
(3) Primary containment vessel (PCV) spray mode
(4) Suppression chamber cooling mode
(5) Emergency thermal load mode

RHRC : RHR Cooling Water System※17

Facility for supplying fresh water for cooling to the residual heat removal

(RHR) system heat exchanger, RHR pumps and low pressure core spray system (LPCS) pump mechanical seal cooling equipment and the like. Installed at Fukushima Daini Unit 1 to Unit 4 and Kashiwazaki Kariwa Unit 1.

RHRS : RHR Sea Water System※18

Cooling water of the residual heat removal system is cooled by passing through a heat exchanger. Residual heat removal system is the system that supplies seawater for cooling the RHR system cooling water.

RPS : Reactor Protection System

In case there is a transient threat to reactor safety by inoperative equipment or operator error, or such a threat is preconceived, this system immediately initiates emergency shutdown (scram).

RPV : Reactor Pressure Vessel※19

Vessel where steam is generated by nuclear reaction of the fuel which contains fuel assemblies, control rods (CR), and other core internals.

RW/B : Radioactive Waste Disposal Building

Building that houses facilities for processing radioactive waste.

S/B : Service Building

Building where the checkpoint, safety management room, and main control room essential to the operation of the power station are located.

S/C : Suppression Chamber (Suppression Pool)※20

Apparatus found only in boiling water reactors (BWR) which regularly retains approximately 3000m^3 of cooling water (in the case of Fukushima Daiichi Unit 2 to Unit 5, and approximately 4000m^3 in the case of Fukushima Daini Unit 2 to Unit 4), and when there is a loss of coolant accident (LOCA) steam and reactor water escapes resulting in the rise of pressure inside the primary containment vessel, venting is performed by leading the reactor water and steam through venting pipes to the suppression chamber (S/C) facility where they are cooled, reducing the pressure inside the primary containment vessel. It is also used as a water source by the emergency core standby cooling system (ECCS).

SCRAM : Safety Control Rod Ax Man

Refers to an emergency shutdown of a reactor, either by manual or automatic signal, by quickly inserting the withdrawn control rods into the reactor core when there is an abnormal state of the reactor.

SFP : Spent Fuel Pool

Pool situated next to the reactor where fuel that has been used for producing power and new fuel are stored and managed.

SHC : Shut Down Cooling System※21

Facility installed only at Fukushima Daiichi Unit 1 that removes decay heat after the reactor is shut down by cooling the coolant (reactor water) through a heat exchanger. The reactor water is cooled, and the reactor is brought to cold shutdown (the reactor water is under 100 degrees ℃). (All units at Fukushima Daiichi other than Unit 1 have RHR systems that have this cooling function "shut down cooling mode.")

SLC : Stand by Liquid Control System※22

System used as a backup to control rods whereby 5-boric acid (sodium borate solution) which has a high capacity for neutron absorption is injected into the reactor to stop the reaction in case the control rods fail to insert for whatever reason while the reactor is in operation.

SOP : Severe Accident Operating Procedure

Operating procedures for dealing with the situation after there has been reactor core damage.

SPEEDI : System for Prediction of Environmental Emergency Dose Information

System for rapid prediction of large quantities of radioactive materials being released from a nuclear power station or the threat of such a release when there is an emergency situation that may result in large quantities of radioactive material in the air when the density and exposure radiation levels will have an impact on the surrounding environment based on the source of the discharge, meteorological conditions, and geographical data.

SRV : Safety Relief Valve※23

Relief valve that allows steam to escape into the pressure suppression chamber (the steam is cooled and condensed by the water in the S/C when it receives a signal either generated automatically or manually from the main control room in order to protect the pressure vessel in the case that the reactor pressure rises abnormally high, and in addition, it also functions as an emergency core cooling system (ECCS) and an automatic depressurization system (ADS).

SGTS : Stand by Gas Treatment System

System that maintains negative pressure inside the reactor building to reduce the amount of radioactive iodine and particulate radioactive material escaping to the outside as well as automatically closing off the normal use ventilation system when an accident occurs and radioactive materials leak out inside the reactor building.

SW : Auxiliary Sea Water System

System that uses seawater for cooling the cooling water used by the turbine auxiliary unit cooling water system (TCW) and reactor auxiliary unit cooling water system (RCW).

TAF : Top of Active Fuel

The zero point on the fuel zone water gauge. The highest portion of the fuel assemblies where there are pellets.

T/B : Turbine Building

Building that houses the main turbine, generator, main condenser, reactor feedwater pumps, and turbine auxiliary units.

T.P. : Tokyo Bay mid-sea level

Tokyo Bay mid-sea level, a unit of measurement used at Kashiwazaki-Kariwa NPS to express elevation. T.P. is based on the value calculated from tide level measurements recorded at Reiganjima, Tokyo between 1873 and 1879, and this value is set at zero.

T.P. = Onahama Point (O.P.) + 0.727 meters

WANO : World Association of Nuclear Operators

The base point for emergency measures to prevent the exacerbation of an accident when nuclear disasters occur, incorporating the central government, local governments, and nuclear facility operators who formulate measures for maintaining public safety. A "nuclear disaster joint policy council" is established at the off-site center. The center is located within 20 km from the nuclear facility.

WBC : Whole Body Counter

Device that measures the radioactivity of one’s whole body for the internal exposure of individuals by measuring the radioactive materials absorbed into the body from the outside of the body. (Also known as "human counter.") Depending on the type of detector, it can be used as a normal monitoring device (plastic scintillation detector), or for a complete detailed examination (NaI scintillation detector).

Sensitivity of the whole body counter that employs the NaI scintillation detector is relatively weak, and therefore it takes a long time to take a measurement, but it is capable of calculating and analyzing the radioactivity level (Bq) according to each type of nuclide. It is mainly used for radiation level evaluation.

Sensitivity of the whole body counter that employs the plastic scintillation detector is high, so it completes the measurement in a short time, but the results show the counting rate (cpm) for all γ (gamma) rays (cannot distinguish types of nuclides). It is mainly used for screening.

Alarm Typer

A type of data output by a process computer system that shows records of the time when an abnormality event occurs and plant systems response actions. In principle, the records are printed out on paper and retained.

Safety Protection System

Facility that detects abnormal conditions of the reactor facility, and activates facilities such as the reactor shutdown system and engineered safety systems and the like. The safety protection system facility requires both redundancy and autonomy.

Interlock

Mechanism for detecting required conditions to either allow or disallow certain facility operations in order to prevent trouble due to human error.

Shared Auxiliary Facility (common pool building)

Building that houses spent fuel common pool facilities. The spent fuel shared auxiliary pool facility went into service on October 1, 1997 to supplement each of the spent fuel pools with extra capacity that each of the units at Fukushima Daiichi NPS that is equipped with, and was built with the aim of increasing spent fuel storage capacity by approximately 250% to 450%.

Off-site Center

The base point for emergency measures to prevent the exacerbation of the accident when nuclear disasters occur, incorporating the central government, local governments, and nuclear facility operators who formulate measures for maintaining public safety. A "nuclear disaster joint policy council" is established at the off-site center. The center is located within 20 km from the nuclear facility.

Off-site Power

When reactors are in normal operation, the electric power used by each unit is supplied from that unit's own main generator in operation, but when the reactor in operation is being shut down, the power needed for shutdown and cooling can no longer be supplied with power from its own stopped main generator so it draws power from the power system through power transmission lines or from the main generator of adjacent units in operation. These transmission lines and other facilities related to the power system as well as main generators from adjacent units are called off-site power.

Switchyard

Relay station having the purpose of delivering power generated at the power station to the power system. Switching of the power circuit is carried out with a switch gear. In addition to the on-site switchyard, the power transmission line system also has switchyards en route.

Free Surface of the Base Stratum

In order to decide on the design basis seismic ground motion for a free surface of the base stratum, a virtually flat surface is assumed, void of outer surface structures on the base ground surface with no remarkable high or low spots and is relatively flat, covering a wide open expanse ground foundation surface. The term 'base stratum' as it is used here refers to a hardened base with shearing wave velocity Vs = 700m/s or more that has not undergone significant weathering.

PCV Vent

A measure for reducing the pressure inside the primary containment vessel (PCV) by discharging a portion of the gas (mostly nitrogen) inside the PCV which contains radioactive materials into the atmosphere as a measure to protect the PCV by preventing the abnormal buildup of pressure inside it.

The reactor PCV is divided into two parts; a dry-well (D/W) and a wet well (W/W), which is also known as suppression chamber (S/C or S/P).

Each chamber has its own vent line, and the line has large AO valves and small AO bypass valves. After the two lines merge, there are MO valves and rupture disks, and the line leads to the stack.

In addition to condensing the steam from the D/W or the reactor pressure vessel (RPV) by means of the water contained inside the W/W, the W/W vent also has the effect of removing radioactive materials.

※24 D/W vent line, ※25 W/W vent line

PCV floor sump

Cistern installed in the lowest basement floor for the purpose of collecting waste water discharged from the primary containment vessel (PCV). In case of leakage inside the PCV, the water level has a tendency to rise a great deal.

Probabilistic Tsunami Hazard Analysis Method

The probabilistic tsunami hazard analysis method is a method of evaluating the probability of the water level of a tsunami rising above a specified height at a specified location within a specified period of time in the future. The analysis results show the tsunami hazard represented by curved lines (the relation between tsunami water level and probability of exceeding that level) through systematically processing all types of uncertainties regarding the assumptions of tsunami water levels.

Transient System

The transient system is activated by the occurrence of any abnormal event, and as a supplement to the chart, it collects numerical value data showing the plant conditions starting from a few minutes before the event until 30 minutes after the system was activated.

Lower Plenum

Area at the bottom part of the reactor. When the plant is in steady operation, the coolant flowing in the downward direction inside the reactor pressure vessel changes direction here and flows upward into the reactor core. BWRs have control rod guide tubes.

Gals (gal)

Unit of acceleration (equal to cm/s^2). It refers to the ratio of change in the speed due to seismic ground motion during a specific period of time while the ground surface is shaking.

Dry Storage Cask

Container for storing spent fuel. Naturally cooled via air cooling.

Design Basis Seismic Ground Motion Ss

Refers to the ground motion that, although the likelihood is small, has the possibility of an earthquake occurring while the facility is in common use, from the standpoint of seismology and earthquake engineering which includes studies of the geological structures in the vicinity of the site and earthquake activities, and is deemed appropriate to presume that there could possibly be a severe impact on the facility.

Cask Storage Building

Building where casks are held in dry storage.

Feed Water Heater

Equipment for warming the condensate or feedwater using steam bled off from the turbine steam in order to improve the thermal efficiency of the turbine plant.

Feedwater and Condensate System

System that supplies water to the reactor during normal operation. Steam used for driving the turbine is cooled by the main condenser to become condensate, and is supplied to the reactor.

Back Wash Valve Pit

A valve is installed in circulating water system (CWP) lines to reverse the direction of seawater flowing through the condenser tubes in order to clean out the inside of the condenser tubes. The CWP pipes supply seawater to the condenser through underground pipes, and the back wash valve pit is located outdoors.

Emergency Response Policy Decision-making Meetings

The meetings held at the off-site center where adjustments for the most important matters within the Joint Council for Nuclear Emergency Response are made. The group makes proposals to the central government's Nuclear Disaster Response Headquarters for adjustments of local personnel evacuation and accident recovery work measures, expansion or contraction of the area where emergency response measures are enforced, and rescinding of the declaration of state of nuclear emergency.

Ministry of Economy, Trade and Industry Nuclear Disaster Alert Headquarters

An organization established under the directive of the Minister of Economy, Trade and Industry when an event to be reported under Article 10 of the Nuclear Emergency Act occurs. It makes preparations for emergency monitoring, and serves as a framework for alerts and collection of information, and conducts prevention activities. When a Declaration of State of Nuclear Emergency is issued, the responsibility it transferred over to the Ministry of Economy, Trade and Industry Nuclear Disaster Response Headquarters.

Ministry of Economy, Trade and Industry Nuclear Disaster Local Alert Headquarters

An organization established at the off-site center whenever an event to be reported under Article 10 of the Nuclear Emergency Act occurs. It collects and reports information on the nuclear disaster and implements emergency measures, and after a Declaration of State of Nuclear Emergency is issued, the responsibility it transferred over to the Ministry of Economy, Trade and Industry Nuclear Disaster Response Local Headquarters.

Nuclear Disaster Response Local Headquarters

An organization established at the off-site center under Article 17 Section 8 of the Nuclear Emergency Act which works as part of the local Nuclear Disaster Response Headquarters, collecting information on accidents and events, making contact and adjustments with local public organizations. After a declaration of state of nuclear emergency has been issued in accordance with Article 15 of the Nuclear Emergency Act, it takes over from the local accident response liaison conference.

Joint Council for Nuclear Emergency Response

The Council established at the off-site center guided under the leadership of the Vice Minister of Economy, Trade and Industry for strengthening cooperation between the central government and local public organizations, when the Prime Minister declares a state of nuclear emergency. The organization endeavors to share information and consults on matters of emergency response. (Under Article 23 of the Nuclear Emergency Act)

Act on Special Measures Concerning Nuclear Emergency Preparedness (Nuclear Emergency Act)

The law that went into effect as of June 16, 2000 in order to protect the life, health and property of citizens from nuclear disasters by taking radical steps to strengthen nuclear disaster measures, as the result of lessons learned from the September 30, 1999 JCO criticality accident.

Nuclear Operator Disaster Prevention Business Plan

The operation plan for disaster preparation created by nuclear operators in accordance with Article 7 of the Nuclear Emergency Act. The plan lists: nuclear disaster prevention measures for nuclear operator offices; emergency response measures and post-nuclear disaster measures; nuclear disaster prevention managers and nuclear disaster prevention personnel for preventing the spread of the nuclear disaster and making efforts for recovery after the nuclear disaster; nuclear disaster prevention organization; education and training for disaster prevention personnel; radiation measurement facilities; disaster prevention materials and equipment; and disaster drills.

Reactor Pressure Vessel Pressure Leakage Test

A test to check leakage reactor coolant pressure boundary while the reactor is in normal operation by raising the pressure. This test which is conducted at each periodic inspection is carried out so as to not allow the temperature inside the reactor to fall below the minimum operating temperature.

Reactor Coolant Pressure Boundary

During normal reactor operation, coolant is introduced into the reactor and the pressure conditions become the same as those of the reactor, but when an aberration occurs, a pressure barrier is formed, and when this barrier is broken, loss of coolant takes place, and this facility is known as the reactor coolant pressure boundary.

AC Power Source

Alternating current (AC) is a flow of electricity that reverses its direction of current at a uniform rate of time. Electric power that is usually delivered to Japanese homes is AC.

Basic Act on Disaster Control Measures

The law that determines basic matters of physical and financial measures for the formulation of disaster prevention plans, disaster prevention, disaster response measures, disaster recovery, and clarifies the responsibilities of the central government, local public organizations and other public institutions in regard to disaster prevention. Enacted in 1961. Under this law, disasters are defined as "storms, downpours, blizzards, floods, high tides, earthquakes, tsunamis, volcanic eruptions, and other abnormal natural phenomena" as well as "large-scale fires or explosions" and large-scale disasters resulting from causes as stipulated by government ordinance. It also includes nuclear disasters such as "large scale discharge of radioactive materials" and the like.

Maximum Response Acceleration

The maximum acceleration of a structure's shaking (response) when seismic ground motion is applied to the structure. This term is different from the maximum acceleration of seismic ground motion, which is a shaking motion of the ground itself.

Primary Loop Recirculation Pump

Recirculation system pump that pulls cooling water out of the reactor from the reactor pressure vessel and then circulates it back into the reactor again. By varying the revolution speed of the pump, the reactor output can be increased or decreased.

National Institute of Advanced Industrial Science and Technology

The National Institute of Advanced Industrial Science and Technology is Japan's largest public research institute conducting research on six varied scientific fields that supports the Japanese industry: environment and energy; life science; information technology and electronics; nanotechnology, materials and manufacturing; metrology and measurement standards; and geoscience. Headquarters are located in Tokyo and Tsukuba, and excluding the Tsukuba center, there are eight locations around the country with each regional center specializing in a particular type of research. The total number of staff members is approximately 3,000. More than 2,000 researchers coordinates with industry, academia and government to achieve innovations from research and development, based on the concept of an "open innovation hub".

Residual Heat (decay heat)

Heat generated from the decay of radioactive material. Even when the reactor is shut down, heat is output from the decaying of fission products containing radioactive materials, so in order to preserve the integrity of the core, the decay heat must be removed, and for this purpose the reactor is equipped with the residual heat removal system (RHR) and shutdown cooling system (SHC).

Headquarters for Earthquake Research Promotion (HERP)

The achievements of earthquake research and study were not sufficiently communicated to the general public or agencies responsible for disaster prevention, and thus a framework for its utilization was not in place. Being conscious of this problem and as to take responsibility for clarifying an administrative framework that ought to be connected to earthquake research and study, the government took a unified approach in promotion, and on the basis of the same law, the Headquarters for Earthquake Research Promotion (HERP) was established at the Prime Minister's office (currently: Ministry of Education, Culture, Sports, Science and Technology) as a special organization. The organization is comprised of the Director General (Minister of Education, Culture, Sports, Science and Technology) and headquarters staff (undersecretaries of relevant government agencies), and under the staff are the Policy Board and the Earthquake Research Committee, which is made up of personnel of relevant organizations and persons of learning and experience. Due to the countermeasures against earthquake disaster that were being comprehensively promoted nationwide in July 1995, the parliament enacted the Earthquake Disaster Prevention Countermeasures Law.

Subsurface Structural Model

A model that reflects physical properties of the ground surface to the free surface of the base stratum that is needed in order to perform stripped wave analysis. It is appropriately determined based on the records from seismometers placed within the ground.

Severe Accident

An accident that has the potential of releasing a large volume of radioactive materials outside the nuclear power station due to the reactor core being severely damaged (such as large amount of fuel damaged or core meltdown and the like) by the simultaneous multiple failures of equipment used for core cooling during an accident and other measures to mitigate the effects of the accident.

Free base

Ground that is thought to not have any impact on buildings and the like due to shaking of the ground by earthquakes.

Concentrated Radwaste Building

At nuclear power stations, all sorts of wastes are generated during startup (shutdown) operations, normal operation, periodic inspections and other station conditions. Of such wastes, those that contain radioactive materials or those that potentially could contain radioactive materials are called radioactive wastes. To begin with, radioactive wastes are "collected" and appropriately "processed" within the power station, and then after that, the wastes need to be disposed of in a permanent manner. The radioactive waste facility is a facility for "collection", "processing" and "disposal," and the complex of buildings which possessed such facilities before the earthquake is called the concentrated radwaste building.

Those facilities were dismantled after the earthquake, and now the established water treatment facility is in use.

Intake Screen

The place where seawater is taken in to cool the high temperature steam after it has been used for turning the generator.

Core Shroud※27

Cylindrical structure that covers the fuel and its surroundings inside the reactor pressure vessel (RPV) in BWRs. Made of stainless steel. In addition to supporting disk-shaped parts that hold the fuel in place, it also fulfills the role of adjusting the flow of cooling water. It can be called either shroud or core shroud.

Zircaloy

Zirconium-based alloy used in nuclear power. It does not readily absorb neutrons, and has excellent anti-corrosion and heat-resisting properties, and for those reasons it is used as the material for fuel cladding and support lattice in nuclear reactors.

Epicentral Distance

Earthquakes occur when bedrock below the ground surface slips out of place. The spot where the bedrock begins disruption is called the "hypocenter," and the ground surface directly above it is called the "epicenter." The distance away from the epicenter is known as the epicentral distance.

Focal Area

Earthquakes occur when bedrock below the ground surface slips out of place. The area where bedrock disruption occurs when earthquakes occur (fault) is called the focal area. Generally speaking, the focal area is within a radius of about several tens of kilometers in the case of a magnitude 7 earthquake, about 100 to 200 km for magnitude 8, and around 500 to 1000 km in the case of magnitude 9. The hypocenter points to the spot where disruption of the bedrock occurs, and the focal area is where the seismic waves radiate out from the disruption point and ultimately points to the entire area where destruction occurs.

Shindo (Japanese Seismic Intensity Scale)

One of the methods of expressing the strength of seismic motion at a given geographical location. Traditionally, shindo was an abstract estimated representation based on a contextual setting of what person could feel with their senses, but since April 1996, the strength is automatically recorded by seismic meters and reported as news flashes.

The seismic intensity levels as reported by the Japan Meteorological Agency (JMA) have ten stages; "shindo zero", "shindo 1", "shindo 2", "shindo 3", "shindo 4", "shindo 5 lower", "shindo 5 upper", "shindo 6 lower", "shindo 6 upper", and "shindo 7".

Self Contained Breathing Device Set

An ambulatory respiratory protective device set carried on the back (CO^2 absorption device, oxygen tank, thermal gel all in one case) and a face mask. The device filters exhaled air and recirculates it while replenishing oxygen by mixing pure oxygen from the tank into the circulating air and supplying this to the face mask.

Nationwide Ocean Wave information network for Ports and HAbourS (NOWPHAS)

NOWPHAS (Nationwide Ocean Wave information network for Ports and HAbourS) is a nationwide wave and coast information network created and operated jointly by the Ports and Harbours Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, Regional Development Bureaus, Hokkaido Bureau, Okinawa General Office, the National Institute for Land and Infrastructure Management, and the Port and Airport Research Institute. Since 1970, the Port and Airport Research Institute has shouldered the responsibility for carrying out research on ocean wave data collected, processed, and analyzed by NOWPHAS. As of December 2009, nationwide coastline wave data from 72 observation points (72 points observe wave height and cycle, 61 points observe wave direction) around the country is collected in real time by the Port and Airport Research Institute. NOWPHAS wave data is widely utilized by the Meteorological Agency for promoting marine safety as well as work on harbors, coastlines, airport projects, and other planning and project investigation/design and construction by compiling long-term statistical analysis data, not to mention coastal area development and utilization and disaster prevention.

Exit Monitor

Device installed at the exit of controlled areas to check for contamination by radioactive materials when anyone leaves the area.

Alternate Water Injection

Water injection measures for when a severe accident happens when even the emergency core cooling system (ECCS) fails. In this accident, the make-up water condensate system, fire protection system, and fire engines were used for injecting cooling water.

Downcomer

Downcomer generally refers to the decreasing flow in ducts and piping sections. In this report, it is used in the meaning of circular space between the interior wall of the reactor pressure vessel and the reactor core (shroud). During normal operation, narrow channel and wide channel water gauges measure the reactor water level in this downcomer section.

Dumper

Facility for regulating or shutting off the flow volume of the heating, ventilating, and air conditioning system.

Charcoal Mask

Protective mask equipped with high efficiency activated charcoal air filter for absorbing radioactive iodine attached to the filter for collecting particulate radioactive materials.

Central Disaster Prevention Council

As one of the cabinet's chief important policy measures bodies, the Central Disaster Prevention Council is made up of the Prime Minister, all cabinet ministers, representatives from designated public agencies, and knowledgeable persons of learning and experience, who plan basic disaster prevention plans and debate on important matters concerning disaster prevention.

The role of the Central Disaster Prevention Council is as follows:

○creating and implementing basic disaster prevention plans and earthquake disaster prevention plans

○creating and implementing plans for emergency measures when extraordinary disasters occur

○debating on important matters concerning disaster response and questions from the Prime Minister and disaster control minister (Basic Disaster Prevention Policy, comprehensive policy coordination, proclamation of state of emergency, etc.)

○reporting opinions to the Prime Minister and disaster control minister in regard to important matters on disaster

Direct Current Power Sources

Direct current (DC) means electric current that always flows in the same direction. Whereas the electric power used in the power station that is supplied from external sources and the emergency diesel generators is alternating current, the power supplied by batteries is direct current.

Tsunami Reproduction Calculation (Inversion Analysis)

Numerical simulation for reproducing tsunami wave transmission effects. Of the numerical tsunami simulation values, the actually recorded or observed signature height, flood height, run-up height, and tidal level records were used to determine the tsunami wave source model parameters so as to conduct reverse analysis, and this is called tsunami inversion analysis.

Tsunami Magnitude

Mt stands for "tsunami magnitude". Whereas magnitude (M) is a representation of the scale of an earthquake calculated using the distribution of strength (seismic ground motion) of the seismic waves (degree of swaying), Mt indicates the intensity of an earthquake calculated using the distribution of height of the tsunami. The calculation coefficient for the determination of Mt is determined so as to be the same as the moment magnitude (Mw) (Abe, 1981). The run-up height data of the tsunami is used in such a way that even though there is no tidal level observation data for historical earthquakes it can still be applied (Abe, 1999), and the reliability of estimated Mw of historical earthquakes is high. Mw is the magnitude determined from what is called the volume of the seismic moment representing the physical scale of the hypocenter.

Surveillance Test

Tests regularly performed to check the functionality of the power station's systems and equipment.

Solenoid Valve

Valves that are operated by the magnetic force of electromagnets (solenoids).

Torus Room

The shape of the room in which the large donut-shaped tunnel (suppression chamber (S/C)) for holding water to be used as a water source for the emergency core cooling system resides is torus-shaped. Therefore the room in which the tunnel resides is called the Torus room, and it is installed at the bottom part of the reactor primary containment vessel and surrounds it.

Fuel Assemblies **※28**

A bundle of fuel rods for facilitating the handling of fuel whose shape takes the flow of coolant into account.

Fuel Rod Cladding

Tubular cover around the exterior of the fuel rods, approximately 11 millimeters in outer diameter and approximately 0.7mm thick, made of a metal alloy containing zirconium metal.

Stack

Facility for nuclear power stations and fuel reprocessing plants to safely release exhaust gas into the atmosphere. High efficiency filters and the like are used to purify the gas containing radioactive materials before release into the atmosphere. The concentration of radioactive materials in the exhaust gas is measured and monitored at all times.

Stripped Wave Analysis

Analysis that strips all influences of the upper ground surface in order to compare/analyze the seismic observation records acquired from the ground at the site with design basis seismic ground motion Ss defined for the free surface of the base stratum.

Stripped Wave

The seismic motion estimated using the above stripped wave analysis.

Wave Source Model

The data on length of fault line, breadth, location, depth, and amount of creep needed for making numerical tsunami simulation. Also known as tsunami fault model.

Regulatory Guide for Reviewing Safety Design of Light Water Nuclear Power Reactor Facilities (Safety Design Review Guidelines)

The guidelines of the Nuclear Safety Commission (NSC) for examining the propriety of the basic policy on Safety Design of Nuclear Reactor Facilities. This is ordinarily referred to as Safety Design Review Guidelines. The reactor facility structures, systems and equipment are expected to fulfill the prescribed functions for ensuring safety not only in normal operation, but even under abnormal conditions that exceed the normal operation parameters.
(established in 1990)

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

The regulatory guide established by the Nuclear Safety Commission of the central government in order to implement seismic design of nuclear power stations. The initial guidelines were established in 1978 by the Nuclear Safety Commission based on safety examination experience at that time, but later, it was revised in 2006 to reflect newly accumulated knowledge on seismology and earthquake engineering, and remarkable improvements and progress in seismic design engineering.

Failsafe Functions

System designed on the basis of a view toward safety at all times, even when some part of the system experiences malfunction.

Blowout Panel

If a high energy pipe of the primary system ruptures outside the reactor primary containment vessel, the pressure inside the reactor building and outside the primary containment vessel rises due to the escaping steam. It is necessary to ascertain that the external pressure applied to the primary containment vessel does not exceed the design external pressure due to the pressure buildup inside the reactor building in order to maintain the integrity of the primary containment vessel. The purpose of the blowout panel is to reduce R/B pressure by trying to force the steam go outside using the driving force provided by the interior/exterior pressure differential of the reactor building.

Paging

Facility installed at multiple locations inside the power station consisting of a handset station and speaker for internal communication within the power station. The facility is simple to use, and it can be used for clearly audible internal public address and two-way communications even under highly noisy conditions.

Radiation Monitor

Device for round-the-clock measuring and monitoring the radiation environment at establishments where radioactive materials are handled.
It monitors gamma rays, dose rate of neutron rays and concentration of radioactive dust in the air, concentration of radioactive gas, radioactive nuclide

concentration in water, and the like.

Hotline

Device for direct communication. The hotline connects the main control rooms (two lines to each main control room) with the seismic isolated building (using metallic lines). (Example: two bidirectional lines between the Unit 1 and Unit 2 main control rooms and the seismic isolated building)

Magnitude

A unit of measurement that expresses the intensity of an earthquake. In principle, one earthquake has only one magnitude. The JMA magnitude used by the Japan Meteorological Agency (JMA) pays particular attention to earthquake damage of large-amplitude seismic waves on cycles of less than five seconds. Recently, the term "moment magnitude", which focuses on seismic waves with longer frequency, has come into use.

Management Review

Checking to see that the quality management system is adequate, appropriate, and effective by evaluating opportunities for improving the quality management system, and evaluating the necessity for making changes to the management system inclusive of quality policy and quality goals for the purpose of wide implementation of the PDCA cycle of the organization.

Water/zirconium reaction

When fuel cladding becomes very hot, the zirconium contained within it reacts with the reactor coolant (water), and produces hydrogen gas.
($Zr+2H_2O \rightarrow ZrO_2+2H_2$)

Seismic Isolated Building

Learning from the Niigata-Chuetsu-Oki Earthquake, when an earthquake of shindo (Japanese scale) level 7 class occurs, so as to prevent anything from hindering emergency response, important facilities for emergency response such as communications and electric power sources are gathered here.

Unloading Wharf

One of the harbor facilities of the power station, The quay onto which equipment and machinery transported in by ship are unloaded.

Rupture Disk

Safety device that is designed to operate at a pre-determined pressure.

Filtered Water Tank

Tank for storing filtered water after initial filtration. It is the water source for fire protection systems and water for various other uses.

Core Support Structure

The core support structure incorporates core shroud, top guides, core support plates, fuel supports, and control rod guide tubes. The core support structure supports and holds fuel assemblies in position to protect the integrity of the fuel assembly structure appropriately for the overload balance during normal operation, times of transient abnormal operational, and times of accident.

Core Support Plate ※29

Stainless steel disk reinforced by joists upon which the fuel assemblies are loaded in a BWR core support structure.

End