(3)Fukushima Daiichi NPS, Unit 3

1) Order of accident progress and provisional expedient (chronological sequence)

a From the earthquake until the arrival of the tsunami

As described in Chapter 3, the plant was in full power operation before the earthquakes. After the earthquakes hit, the nuclear reactor at Unit 3 scrammed at 14:47 on March 11 due to the great acceleration of the earthquakes and automatically shut down the reactor as all control rods were inserted to bring the reactor into subcritical. In addition to Okuma Line 3, which was powered off due to repair work started before the earthquake, the breaker at Shintomioka Substation tripped and the breaker for receiving electricity at the switchyard in the power station was damaged, disrupting the power supply from Okuma Line 4. By causing the loss of external power supply, two emergency DGs started automatically.

At 14:48, the loss of power to instruments caused by the loss of external power supply triggered a closure signal at the main steam isolation valve (MSIV) in accordance with the fail-safe design. Regarding the closure of the MSIV, the Tokyo Electric Power Co., Inc. (TEPCO) considered that the main steam pipes did not rupture with the records of the flow rate of the main steam, which would be observed as the increase of the flow rate when the main steam piping breaks. The Nuclear and Industrial Safety Agency (NISA) also agrees that such a judgment would be reasonable.

The closure of the MSIV resulted in increasing of RPV pressure and at 15:05, the reactor core isolation cooling system (RCIC) was manually activated as a precautionary measure. At 15:28, the pressure increase stopped due to the high water level in the reactor.

b Effects of the tsunami

At 15:38, as a result of the impact of the tsunami, two emergency DGs stopped operating and all AC power was lost due to the drenching/submersion of the cooling seawater pumps, the metal-clad switchgear and the emergency bus of Unit 3.

The inability to use the residual heat removal system seawater pumps meant the loss of residual heat removal system (RHR) functions, resulting in a failure to shift the decay heat in the PCV to the sea, the final heat sink.

However, the DC bus of Unit 3 escaped being drenched. Power was not supplied through AC-DC transfer from the DC bus, but rather the backup storage batteries supplied power to the loads (RCIC valves, recorders, etc.) that required direct current for an extended time compared to those of other units.

Because of the drawdown resulting from the shutdown of the RCIC at 15:25, the RCIC started again at 16:03 and stopped at 11:36 on March 12.

The reason why the RCIC stopped at 11:36 on March 12 is unknown at this time, but the storage batteries for valve manipulation might have become exhausted as more than 20 hours had passed since the RCIC started operation.

Afterwards, the HPCI started automatically at 12:35 on March 12 due to the low water level of the core and stopped at 2:42 on March 13. At that time, the plant-related parameters did not indicate any water level, and so the core coolant injection system stopped as the water level in the core was unknown.

At 3:51, after more than one hour had passed since the HPCI stopped, the power was restored to the water level gauge, which showed that the water level for the reactor fuel was -1600 mm (TAF-1600 mm).

It is thought that the HPCI stopped as a result of the lower reactor pressure.

TEPCO judged that the situation corresponded to a “loss of reactor coolant functions” event stipulated according to the provisions of Article 15, paragraph 1 of the NEPA for Nuclear Disaster and notified NISA and other parties in accordance with the requirements of the Act.

c Reactor pressure changes

The reactor pressure transitioned fairly stably after the scram, but at around 9:00 on March 12, the reactor pressure began to show larger fluctuations. From 12:30 to about 19:00, it decreased by more than 6 MPa.

From around 19:00 on March 12, the reactor pressure was being stable around one MPa, but from 2:00 to 2:30 on March 13, being decreased once and then increased to 7 MPa by around 4:00 on the same day. During the initial stage of this reactor pressure change, the HPCI was working, but by stopping the HPCI. When it stopped, the reactor pressure may have risen suddenly.

Considering that the reactor pressure dropped for more than six hours from 12:30 on March 12, it is considered unlikely that a large-scale pressure leak occurred. Steam may have leaked from the HPCI, since the pressure began to drop at around the same time as the HPCI started and the reactor pressure began rising after the HPCI stopped.

At around 9:00 on March 13, the reactor pressure dropped rapidly down to approximately 0 MPa. This may have occurred because of rapid depressurization resulting from the operation of the major steam SRV.

d Emergency measures

In order to lower the PCV pressure after the HPCI stopped at 2:42 on March 12, TEPCO carried out wet venting from 8:41 the same day. From approximately 9:25 on the same day, though TEPCO started injecting fresh water containing boric acid through the fire extinguishing system by using fire engines, the RPV water level still dropped. Even taking this injection into account, this meant that no injection had occurred for six hours and 43 minutes since the HPCI stopped. At 13:12 the same day, water injection was changed to seawater.

To reduce the PCV pressure, wet venting was carried out at 5:20 on March 14.

e Explosion at the building and subsequent measures

An explosion, which was likely a hydrogen explosion, occurred at the upper part of the reactor building at 11:01 on March 14. The explosion destroyed the operation floor and all floors above it, the north and south external walls of the floor below the operation floor, and the waste processing building. At this time, radioactive materials were released into the atmosphere and the radiation dose in the vicinity of the site increased.

On March 25, fresh water from the pure water storage tank was once again used as an alternative injection to the reactor. As of the end of May, the total injection volume had reached approx. 20,625 m^3 (approx 16,130 m^3 of fresh water and approx. 4,495 m^3 of seawater).

On March 28, reactor injection was performed by temporary motor-driven pumps, and on April 3, their power supply was switched to a permanent power supply. The injection system was thus shifted to a stable system.

While verifying the integrity of load systems through the repair of the transformer at Shin Fukushima Substation and the bypass operation between Line 1 of the Yorunomori Line and Line 3 of the Okuma Line, the power supply has been gradually restored. On March 18, power supply was restored as far as the site metal-clad switchgear, and on March 22, the lighting of the main control room was restored.

The main chronological sequence is shown in Table IV-5-3. Plant data, such as the RPV pressure, is shown in Figures IV-5-7 to IV-5-9.

2) Evaluation using severe accident analysis codes

a Analysis by TEPCO

When TEPCO's analysis showed that the flow volume of the alternative injection water was low, it resulted in damage to the RPV due to melted fuel. TEPCO has used these results in addition to the existing PRV temperature measurement results to evaluate that the greater part of the fuel has in fact been cooled at the bottom of the RPV.

TEPCO estimated that during this process the reactor fuel was exposed for about four hours from 2:42 on March 13, when the HCPI stopped (about forty hours after the earthquake hit), and two hours later, damage to the core began. Later, as the reactor water level was not able to be maintained around the fuel, flow volume for the alternative water injection was assumed. The decay heat began melting the core and the melted fuel shifted to the lower plenum and then some 66 hours after the earthquake, it started to damage the RPV.

The analysis results show that, along with the damage to the core and the core melt of reactor fuel, the embedded radioactive materials were released into the RPV and moved to the S/C, with the noble gases almost all being released into the environment through PCV vent operation, and approximately 0.5% of the radioactive iodine was released.

Note that TEPCO carried out an additional analysis, which assumed leakage from the HPCI steam system as the RPV and D/W pressures had dropped while HPCI was operating. The analysis results show that the RPV pressure changes and the D/W pressure changes were generally in alignment, but, including the problems with instrumentation, it is not possible to pinpoint the reason the RPV and D/W pressures dropped, nor their current status.

b Crosscheck by NISA

In the crosscheck analyses, NISA analyzed using the MELCOR codes based on the conditions (basic conditions) that TEPCO adopted. In addition, a sensitivity analysis and other analyses were carried out in terms of the relationship with the pump output pressure and determined that the injected water volume for the alternative water injection was in line with the RPV pressure.

The crosscheck under basic conditions indicated nearly the same tendencies as seen by TEPCO. It showed that the fuel was exposed at about 13:08 (41 hours after the earthquake) and three hours later core damage started. The time period the RPV was damaged was about 79 hours after the earthquake.

The analysis results show that the amount of radioactive materials was approx. 0.4% to 0.8% of radioactive iodine was released, and the other nuclides were approx. 0.3% to 0.6%. However, the released amount changes according to the settings for seawater injection flow amounts, etc., and the operating status is unclear, so there is the possibility that this will change depending on the operating status.

Regarding the assumption by TEPCO of operational status for the high pressure water injection system, as there is no quantitative setting basis shown, it is difficult to evaluate what exactly has happened, and further investigation is required. However, regardless of the high pressure water injection system operating status, the reactor pressure has been restored due to stopping the high pressure water injection system and if the reactor water level can be maintained, then there will be no major effects on the core status and of course no effects on the evaluation of core status.

3) Estimation of RPV and PCV situations

a Confirmation of plant information

The study was done on plant data obtained during the period from March 15 to May 31, when the plant was in a comparatively stable condition, and the plant data from this period was handled as shown below.

An instruction may have been issued to maintain a higher water level in the fuel area since the PCV temperature was high when the PCV pressure was remaining at a high level, and the normal water level dropped due to the evaporation of water in the PCV condensation tank as well as the instrumentation piping. As Unit 3 showed the same tendency that Unit 1 later showed, the water level in the RPV was considered immeasurable.

The RPV pressure was nearly equal to the measured values of the A and B systems, so it was considered to show a close approximation of the actual pressure. For the period when negative pressure was shown, it was considered to be within an error range as such pressure is immeasurable by the pressure gauge.

After March 30, the RPV temperature stayed around 100°C in connection with the RPV pressure and so it was considered to generally show an actual temperature. However, some pieces of data showing high temperature values were excluded from the evaluation as they did not meet with the trend of other measured values.

The plant data up to March 15, which is very limited, was added to the data from March 15 on, and excepting the data regarding the reactor water level, was referred to under the assumption that it reflected the actual situation.

As stated above, there may have been an instruction to keep the water level high in the reactor fuel area. As it is impossible to determine when deviation from the instruction began to occur, only the changes in the situation were referred to roughly in considering information on equipment operation and so forth.

b Estimation of RPV and PCV situations during comparatively stable period

-Situation of RPV boundary

According to the information of the Tokyo Electric Power Co., Inc. (TEPCO), the total injection amount to RPV up to May 31 is considered to be about 20,700 tons. The total amount of vapor generated from the start of injection is about 8,300 tons when the decay heat is estimated on the outside in the decay heat evaluation formulation. If the pressure boundary is secured, a difference of about 12,400 tons at least may be kept there. As the capacity of RPV is 500 m^3 at most, the injected water may not only evaporate within RPV and leak as vapor, but also may leak as water. The injection to RPV was executed through the nozzles of recirculating water inlet and water supply equipment. The water injected through the nozzle of water supply equipment would gather once in the outside of shroud (from about 17:00 May 21 to about 23:00 May 28) and then would move to the bottom of RPV via the jet pump diffuser to cool the reactor fuel. The water is very likely to leak to outside at this portion.

From about 23:00 May 29 and on, the injection was switched and continued only through the nozzle of water supply equipment.

The RPV pressure has been close to the atmosphere pressure from March 22 and similar to the D/W pressure of PCV, and so it is now estimated that RPV seems to connect to PCV through the gas phase portion.

-Situation in RPV (reactor core status and water level)

Some RPV temperatures exceeded the measurable range (higher than 400°C) due to the lower injection flow rate caused by the increase of RPV pressure on March 20, but the temperature dropped through the securing of injection flow rate on March 24 and stayed around 100°C. Accordingly a considerable amount of reactor fuel may remain within the RPV. It cannot be denied at this moment that the bottom of the RPV might get damaged, through which part of reactor fuel might drop to the D/W floor (lower pedestal) and might accumulate there.

The temperature tends to rise in general from the beginning of May. Considering that it partially exceeds 200°C and is higher than the saturation temperature for the RPV pressure, part of reactor fuel may still remain unsubmerged and be cooled by vapor.

-Status of PCV

As the pressure of D/W and S/C exceeded the maximum operating pressure (0.427 MPag) of the PCV to reach about 0.5 MPag on March 13, it is assumed at this moment that the performance of the gaskets of flanges and the seals of penetrations deteriorated. The D/W pressure is maintained around the atmospheric pressure (0 MPag). Therefore, it is assumed at this moment that the vapor generated by decay heat may be released to the outside through D/W.

As the pressure of gas phase portions of S/C stayed at a higher level than the atmospheric pressure and the D/W pressure is close to the atmospheric pressure, the temperature of water that flows from the lower part of D/W down to S/C is 100°C at a maximum. Accordingly, it is now estimated that the 0 MPag or higher pressure of the gas phase portions of S/C is due to noncondensable gasses. Right now, TEPCO is studying how to estimate the water level of D/W.

4) Estimation of situations of RPV, PCV and others at a given moment over time

After the earthquake, water injection continued through the reactor core isolation cooling system (RCIC). Around 12:00 on May 12, the RCIC stopped operation.. Alternatively, water injection was made through the high-pressure coolant injection system (HPCI) but the reactor pressure decreased and thus the reactor water level is estimated to have increased. Before dawn on the morning of March 13, however, the reactor pressure dropped and HPCI stopped operation.

The stoppage of HPCI is estimated to have triggered the reactor pressure to exceed the operation pressure of about 7 MPa. But the main steam safety relief valve (SRV) is estimated to have been activated to release the vapor to S/C to maintain the pressure at around the 7 MPa level, during which time it is estimated that the reactor water dropped and the reactor fuel was damaged.

It is estimated that the main steam SRV opened to lower the reactor pressure, and at 9:25 on March 13 alternative injection was carried out and wet vent operation done in response to the increase in PCV pressure. It was reported that the alternative injection from fire engines was executed, but this measure could not demonstrate the required performance due to the relation with the reactor pressure, etc. as the water level has not been restored yet. More detailed investigations and analyses of the conditions/situations of equipment would be necessary in order to find out to what extent such measures worked.

5) Analysis of accident event progress

Regarding the progress of events in the accident at Unit 3, previous analyses showed that the RCIC and HPCI ceased to function, so PCV spraying using fire engines and wet vent operation were carried out. In addition, there is the possibility that, based on the water level situation following the start of fresh water injection and RPV pressure reduction operations, not enough water was injected and it is estimated that the lack of sufficient cooling led to core melt, with the melted fuel moving down to the bottom of the RPV.

From the balance between the injected water volume and volume of steam produced, it is estimated that the water injected into the RPV is leaking.

Based on the RPV temperature measurement results, it is considered that a considerable amount of fuel is cooling on the RPV bottom.

The situation of the reactor building after the explosion is not known in detail for certain yet due to the limited site verification. As a result of the execution of numerical fluid dynamic analysis in addition to the severe accident analysis, the release of the gas that contained the hydrogen generated through the reaction between zirconium in the clad of fuel rods and the water in the reactor might accumulate hydrogen sufficient enough to reach the detonation range in the upper space of reactor building to cause the explosion. Along with the explosion, the oil for the MG sets for the control of the rotating speed of recirculation pumps burnt concurrently at the heavily damaged west side of the 4th floor of reactor building. For the waste processing building, it cannot be denied now that it might be damaged not only by the blast waves but also by the explosion of the hydrogen that flew in through the piping penetrations. The high dose contamination that hinders works in the vicinity of the building was found on part of debris scattered by the explosion. The severe accident analysis, while it does not assume any leakage from the PRV, suggests that it might be the result of radioactive materials that leaked from the PCV adhering to the reactor building structure, as the PCV maximum operating pressure was exceeded.

As it is impossible to identify to what extent each system functioned actually, it is also impossible to determine the event progress situation at this moment. From the results of the severe accident analysis, however, it can be estimated that radioactive materials were released into the environment by the wet vent operation starting at noon on March 13, and almost all the noble gases in the core were released, and the iodine and cesium in the core were released at ratios of approx. 0.5% to 0.8% for each.

Table IV-5-3 Fukushima Daiichi NPS, Unit 3 – Main Chronology (Provisional)

* The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

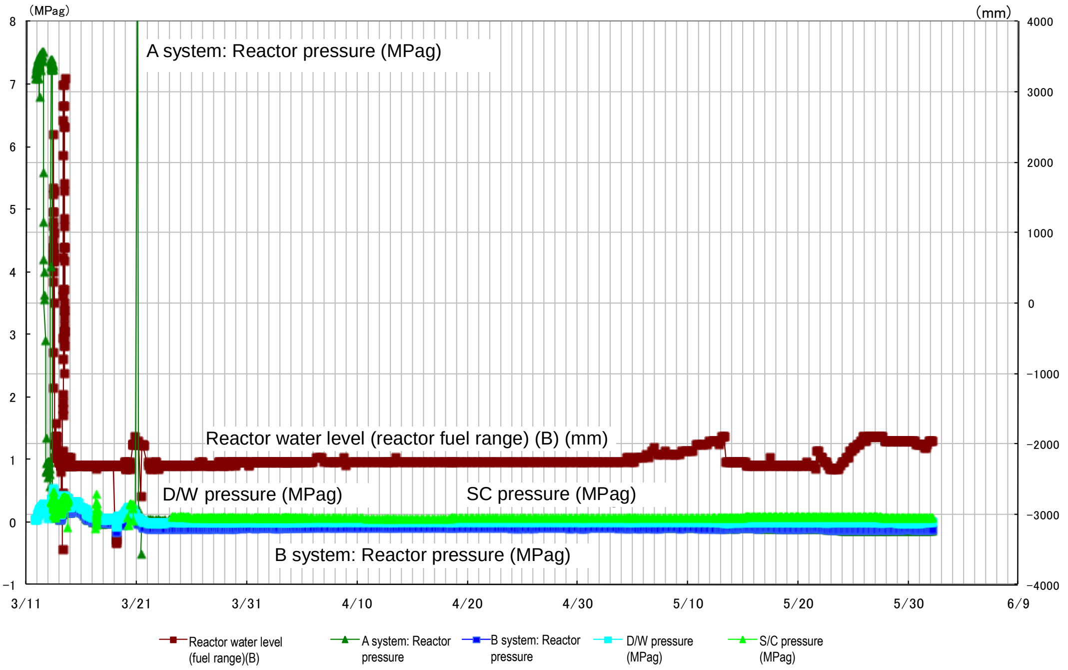
	Unit 3	
	Status before the earthquake: in operation	
3/11		
	14:47	Reactor scram (high seismic acceleration) Control rods fully inserted (sub-critical) Turbine trip Loss of the external power supply
	14:48	Emergency diesel generator (emergency DG) turned on Main steam isolation valve (MSIV) closed
	14:52	Safety relief valve (SR valve) repeatedly opened and closed from this point onwards
	15:05	Reactor core isolation cooling system (RCIC) manually turned on
	15:25	RCIC trip (L-8)
	15:38	All AC power supply lost
	15:42	TEPCO judged that an event falling under Article 10 of the NEPA (loss of all AC power supplies) had occurred.
	16:03	RCIC manually turned on
	20:30	RCIC in operation Lighting in Central Operating Room (temporarily secured and in preparation)
	23:35	Water level on the decrease (400 mm at 22:58→350 mm (wide range))
3/12		
	11:36	RCIC trip
	12:35	High pressure coolant injection system (HPCI) turned on (L2)
	12:45	Reactor pressure on the decrease (7.53 Mpa at 12:10→ 5.6 MPa)
	20:15	Reactor pressure on the decrease (0.8 MPa)
3/13		
	2:42	HPCI stopped
	4:15	Reactor water level was judged to have reached the top of active fuel (TAF).
	5:10	Due to stoppage of HPCI, injection by RCIC into the reactor was attempted. As RCIC could not be turned on, the event was judged by TEPCO to fall under Article 15 of the NEPA (loss of reactor cooling function).
	6:00	Water level in the reactor: -3500 mm (wide range)
	7:39	Spraying onto the PCV began. Water level as of 7:45: TAF -3,000 mm. Reactor pressure: 7.31 MPa. DW pressure: 460 kPa. SC pressure: 440 kKPa.
	8:41	The second valve (AO valve) was set to "open" for venting.
	9:08	Operation to reduce pressure in the RPV by relief valve (SRV) It appears that some time after this point the safety relief valve (SRV) was closed and opened, due to issues with maintenance of air pressure for driving SRV and excitation on the electro-magnetic valve on the air supply line.
	About 9:20	Decrease trend of pressure inside PCV detected
	9:25	Injection of fresh water (borated) into the reactor through the Fire Extinguishing Line began.
	11:17	Vent line AO valve found closed (through loss of pressure in the tank) From this point on, it was difficult to keep the AOV open due to issues with maintenance of air pressure for driving AOV and excitation on the electro-magnetic valve on the air supply line, and the operation to open it was repeated multiple times.
	12:30	Operation to open the AO valve on the pressure chamber side.
	13:12	Fresh water injection to the reactor was switched to seawater injection.
	22:15	Diesel-driven fire pump (D/DFP) stopped (before it ran out of fuel)

	Unit 3	
	Status before the earthquake: in operation	
3/14		
	1:10	Seawater injection suspended as supply of seawater for the reactor was running low.
	3:20	Injection of seawater resumed.
		Measurement by the Containment Atmospheric Monitoring System (CAMS) was 1.4x10^2Sv/h (DW); the core damage probability was estimated to be about 30%.
	5:20	The valve (AO valve) was set to "open" for venting.
	6:10	D/W pressure was 460 Kpa abs
	9:05	D/W pressure was 490 Kpa abs
	About 11:00	An explosion that appeared to be a hydrogen explosion occurred in the upper part of the reactor building (what appeared to be white smoke rose).
	11:25	Reactor pressure (A) was 0.185 MPa. DW pressure was 360 KPa. SC pressure was 380 KPa. Water level (A) was -1800 mm.
3/15		
	16:00	AO valve on the SC side found closed
	16:05	AO valve on the SC side opened
3/16		
	1:55	AO valve on the SC side opened
	About 8:30	A great deal of white smoke was emitted from Unit 3.
3/17		
	9:48	Seawater spraying onto the spent fuel pool by helicopter started.
	10:01	Seawater spraying onto the spent fuel pool by helicopter stopped. Approx 30 t.
	About 19:05	National Police Agency riot police started to spray water onto the spent fuel pool with a high-pressure water cannon truck.
	19:13	National Police Agency riot police stopped spraying water onto the spent fuel pool with a high-pressure water cannon truck. Approx. 44 t.
	19:35	The riot police started to spray water onto the spent fuel pool with their fire engine
	20:09	The riot police stopped spraying water onto the spent fuel pool with their fire engine. Approx. 30 t
	21:00	AO valve on the SC side found to be closed.
	About 21:30	AO valve on the SC side opened.
3/18		
	About 5:30	AO valve on the SC side found closed
	14:00	The Self-Defense Force started spraying water onto the spent fuel pool with their fire engine.
	14:38	The Self-Defense Force stopped spraying water onto the spent fuel pool with their fire engine. Approx. 40 t.
	14:42	US Armed Forces started spraying water onto the spent fuel pool with their water truck.
	14:45	US Armed Forces stopped spraying water onto the spent fuel pool with their water truck. Approx. 2 t.
3/19		
	0:30	The Tokyo Fire Department started spraying water with their fire engines onto the spent fuel pool.
	1:10	The Tokyo Fire Department stopped spraying water with their fire engines onto the spent fuel pool. Approx. 60 t.
	11:30	AO valve on the SC side found closed.
	14:10	The Hyper Rescue Unit of the Tokyo Fire Department started spraying water onto the spent fuel pool.
3/20	3:40	The Hyper Rescue Unit of the Tokyo Fire Department stopped spraying water onto the spent fuel pool. Approx. 2430 t. Radiation levels before the water was sprayed were 3417 μSv/h (at 14:10) and after water spraying were 2758 μSv/h (at 3:40)
	11:00	Pressure inside PCV rose.
	About 11:25	11:25 AO valve on the SC side opened..
	About 21:36	The Hyper Rescue Unit of the Tokyo Fire Department started spraying water to cool the spent fuel pool.
3/21	3:58	The Hyper Rescue Unit of the Tokyo Fire Department stopped spraying water onto the spent fuel pool. Approx. 1137 t.
	About 15:55	Grayish smoke rose from the south-eastern part of the rooftop of the reactor building.
3/22		
	10:36	The emergency low-pressure distribution panel (Power Center (P/C) 4D) received power.
	15:10	The Hyper Rescue Unit of the Tokyo Fire Department started spraying water to cool the spent fuel pool.
	15:59	The Hyper Rescue Unit of the Tokyo Fire Department stopped spraying water onto the spent fuel pool. Approx. 150 t.
	22:28	Main Bus Panel for measurement received power (120 VAC).
	22:46	Lighting in Central Operating Room recovered

	Unit 3	
	Status before the earthquake: in operation	
3/23	11:03	Seawater injection from the fuel pool cooling and clean-up system (FPC) to cool down the spent fuel pool started.
	13:20	Seawater injection from the fuel pool cooling and clean-up system (FPC) to cool down the spent fuel pool stopped. Approx. 35 t.
	About 16:20	Slightly blackish smoke was emitted from the reactor building.
3/24	About 5:35	Seawater injection from the FPC to cool down the spent fuel pool started
	About 16:05	Seawater injection from the FPC to cool down the spent fuel pool stopped. Approx. 120 t.
3/25	13:28	Water spraying onto the spent fuel pool by the Kawasaki City Fire Bureau supported by the Tokyo Fire Department started.
	16:00	Water spraying onto the spent fuel pool by the Kawasaki City Fire Bureau supported by the Tokyo Fire Department stopped. Approx. 450 t.
	18:02	Seawater injection into the reactor was switched to fresh water injection.
3/26		
3/27	12:34	Seawater spraying onto the spent fuel pool by TEPCO's Concrete Pump Truck (hereafter, "concrete pump truck") started.
	14:36	Seawater spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 100 t.
3/28	17:40	Transfer of pooled water from the Condensate Storage Tank (CST) to the Suppression Pool Water Surge Tank (SPT) started.
	20:30	Water injection into the reactor is switched from the fire truck pump to injection using the temporary electric pump.
3/29	14:17	Water spraying onto the spent fuel pool by the Concrete Pump Truck starts (from here, fresh water is used).
	18:18	Water spraying onto the SFP by the Concrete Pump Truck stops (from here, fresh water is used). Approx. 100 t.
3/30		
3/31	8:37	Transfer of pooled water from the CST to the SPT completed.
	16:30	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	19:33	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 105 t.
4/1		
4/2	9:52	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	12:54	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 75 t.
4/3	11:50	The power supply for the temporary motor-driven pump used for water injection into the reactor was switched from a temporary one to a permanent one.
4/4	17:03	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	19:19	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 70 t.
4/5		
4/6		
4/7	6:53	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	8:53	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 70 t.
4/8	17:06	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	About 18:30	AO valve on the SC side found closed.
	20:00	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 75 t.
4/9		
4/10	17:15	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	19:15	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 80 t.
4/11	About 17:16	As a result of an earthquake, the external power supply for Units 1 and 2 (Tohoku Nuclear Power Line) was lost, and the water injection pump for the reactor was suspended.
	18:04	The water injection pump for the reactor was restarted.

	Unit 3	
	Status before the earthquake: in operation	
4/12	16:26	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	17:16	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 35 t.
4/13		
4/14	15:56	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	16:32	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 25 t.
4/15	10:19	Work began to move the power distribution panel for injection pumps and other equipment to higher ground against tsunami.
	17:00	Work completed to move the power distribution panel for injection pumps and other equipment to higher ground against tsunami.
4/16		
4/17	11:30	An unmanned robot inspection of the reactor building started.
	14:00	An unmanned robot inspected the reactor building finished.
4/18	12:38	Work began to replace the hose used to inject water into the reactor with a new one. The reactor injection pump was stopped.
	13:05	The replacement of the hose used to inject water into the core with a new one was completed. The reactor injection pump was restarted.
	14:17	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	15:02	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 30 t.
4/19	10:23	Tie line between Units 1 and 2 and Units 3 and 4 was completed. (The Tohoku Genshiryoku Line and the Okuma Line can be used interchangeably.)
4/20		
4/21		
4/22	14:19	Water spraying onto the spent fuel pool by the Concrete Pump Truck started.
	15:40	Water spraying onto the spent fuel pool by the Concrete Pump Truck stopped. Approx. 50 t.
4/23		
4/24		
4/25	18:25	The power supply for the injection pump for the reactor was restored to an external one.
4/26	12:00	Fresh water sprayed into the spent fuel pool by the Concrete Pump Truck. A water surface was detected.
	12:25	Water injection using the fuel pool cooling and clean-up system (FPC) to cool down the spent fuel pool started.
	14:02	Water injection using the FPC to cool down the spent fuel pool stopped. Approx. 47.5 t.
4/27		
4/28		
4/29		
4/30	10:31	To reinforce the external power supply for Units 3 and 4 (Okuma Line No. 3) from 6.6 KV to 66 KV, the 480 V power supply panel for Unit 4 and the 480 V power supply panel shared with the spent fuel pool were suspended.
	11:34	The 480 V power supply panel for Unit 4 and the 480 V power supply panel for the spent fuel pool were restored, and power supply reinforcement work was completed.
5/1	13:35	To prevent the stagnant water inside the sea-side shafts in the trenches of Units 2 and 3 from spilling over and seawater from coming into them as a result of tsunami, work began to fill the trench shafts with crushed stone, concrete, etc.
5/2	12:53	The pump used to inject water into the reactor core was switched to a fire engine pump in order to install an alarm system to the former.
	14:53	With an alarm system installed, the pump used to inject water into the reactor core was put back to use.
5/3		
5/4		
5/5		
5/6		
5/7		

	Unit 3	
	Status before the earthquake: in operation	
5/8	11:38	Measurement of water level in spent fuel pool.
	12:10	Water injection to the spent fuel pool from the FPC started
	14:10	Water injection to the spent fuel pool from the FPC stopped. 60 t. Measure of water level in the spent fuel pool and sampling started
	14:50	Measure of water level in the spent fuel pool and sampling finished
5/9	12:14	Water injection to the spent fuel pool from the FPC started
	12:39	Along with injection of water from the FPC to the spent fuel pool, injection of a corrosion inhibitor (hydrazine) is started.
	14:36	Along with injection of water from the FPC to the spent fuel pool, injection of a corrosion inhibitor (hydrazine) is stopped.
	15:00	Injection of fresh water using the fuel pool cooling and cleaning system to cool the spent fuel pool is stopped. Approx. 80 t. (Water level of spent fuel pool measured after water injection)
5/10		
5/11	8:47	The power supply for the pump to inject water into the reactor core was switched to a temporary diesel generator.
	About 12:30	It was confirmed that there was an inflow of water into the cable pit near the screen.
	15:55	The power supply for the pump to inject water into the reactor core was switched back to the in-house power supply from the temporary diesel generator.
	18:40	Work began to stop the inflow of water into the cable pit near the screen.
	18:45	The inflow of water into the cable pit near the screen is confirmed to have stopped.
5/12	16:53	As part of the process of switching the source for the injected water from the Fire Extinguishing Line to the Feedwater System, about 3 tons/h of water was injected from the Feedwater System in addition to the 9 tons/h from the Fire Extinguishing Line.
5/13		
5/14		
5/15		
5/16	15:10	Along with injection of water using the temporary electric pump to the spent fuel pool, injection of a corrosion inhibitor (hydrazine) is started.
	17:30	Along with injection of water using the temporary electric pump to the spent fuel pool, injection of a corrosion inhibitor (hydrazine) is stopped.



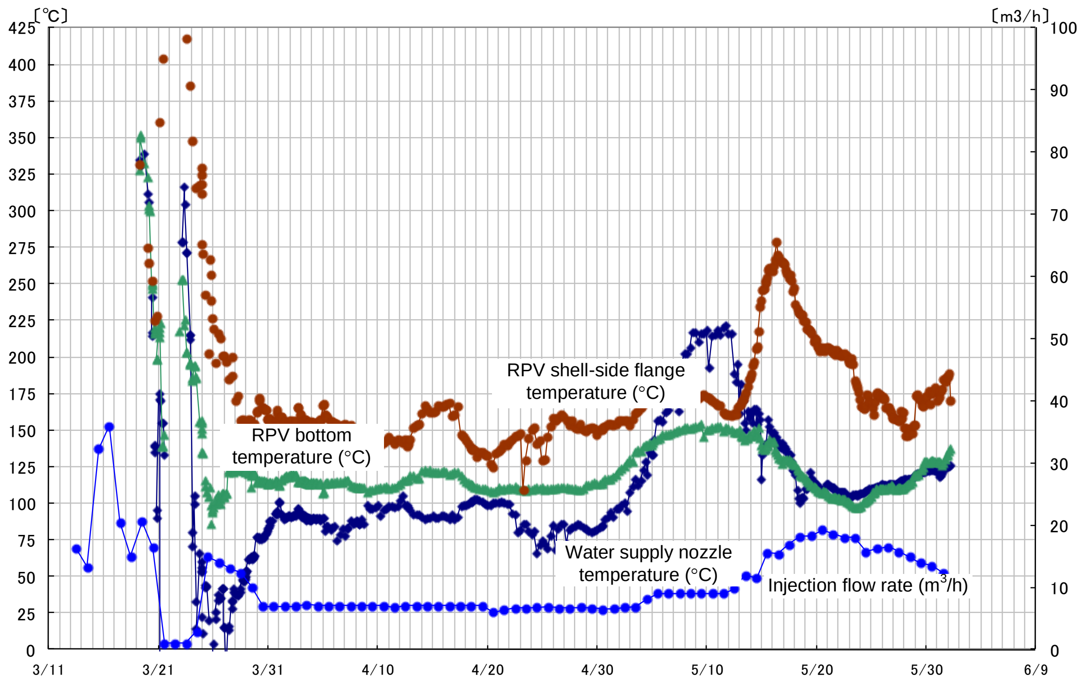
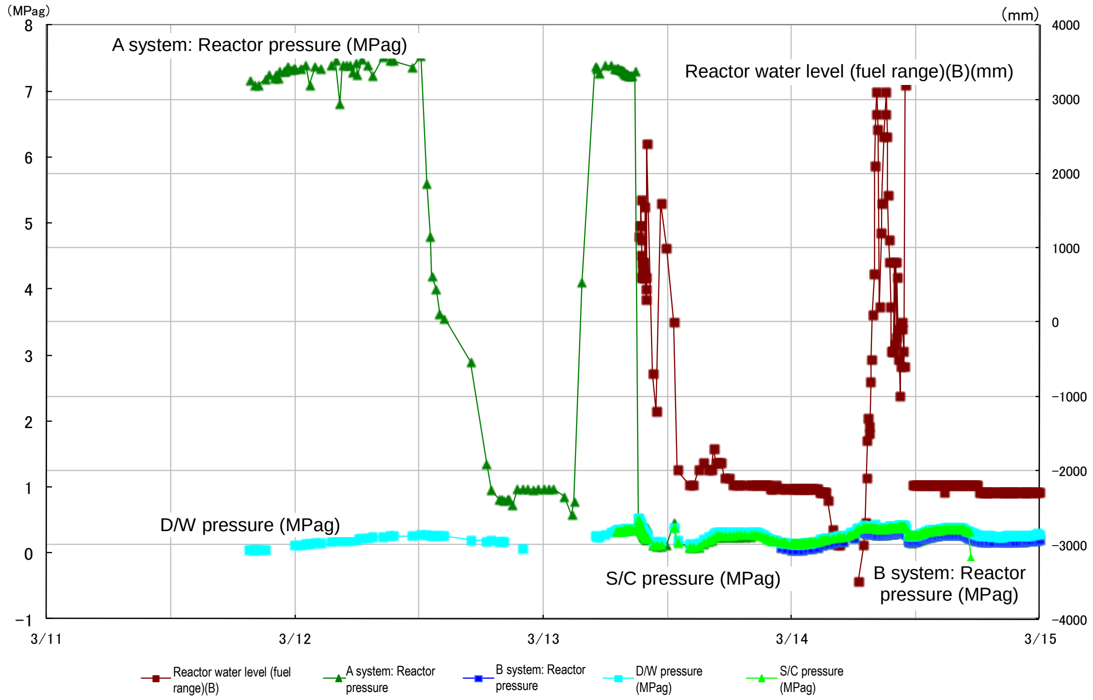


Figure IV-5-7 Changes of Main Parameters (1F-3) (March 11 to May 31)



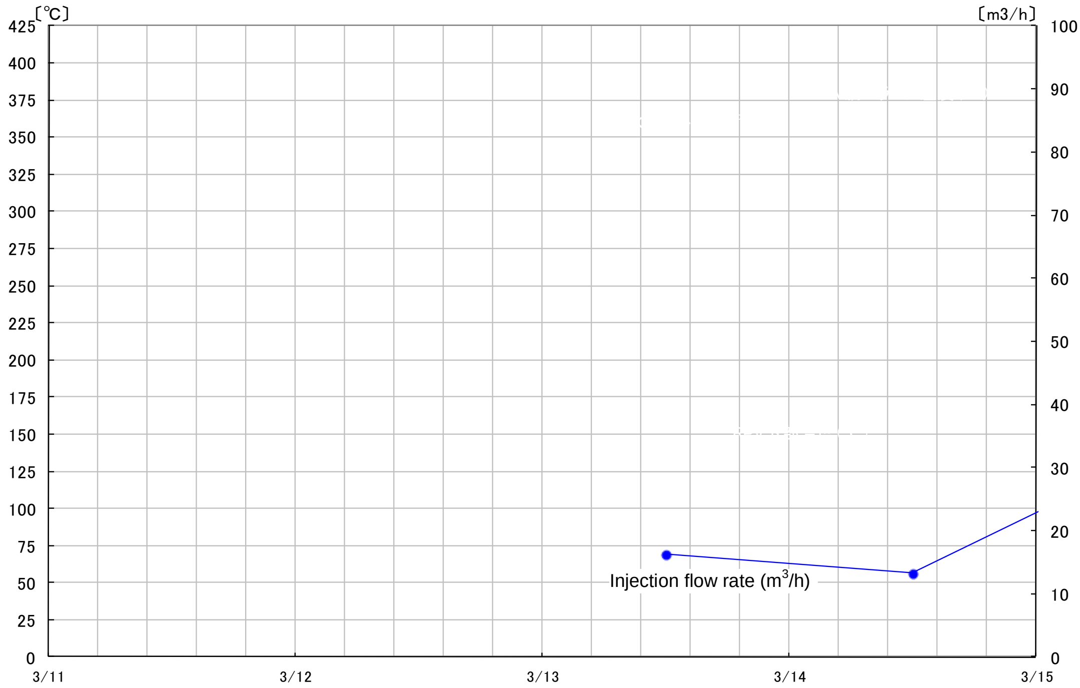


Figure IV-5-8 Changes of Main Parameters (1F-3) (March 11 to March 15)

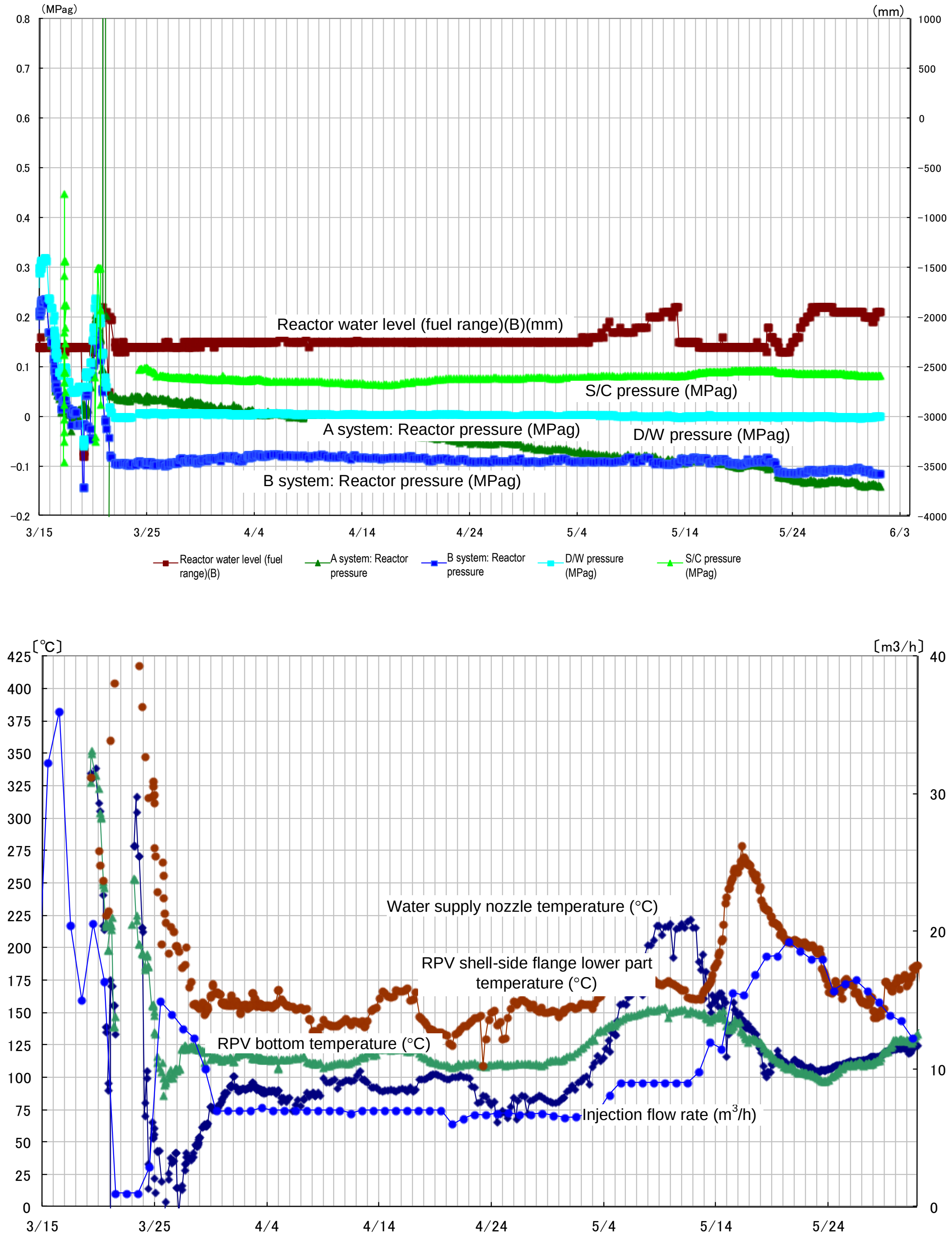


Figure IV-5-9 Changes of Main Parameters (1F-3) (March 15 to May 31)

(4)Fukushima Dai-ichi NPS, Unit 4

1) Order of accident event progress and emergency measures (chronological sequence)

a From the earthquake to the arrival of the tsunami

As described in Chapter 3, Unit 4 was in the periodic inspection and all fuel assemblies were removed from the reactor to the spent fuel pool due to the shroud replacing works of RPV. Therefore, the fuel with relatively high decay heat for one full core was stored in the spent fuel pool. 1,535 pieces of spent fuel assemblies were stored there, which amounted to 97% of its storage capacity of 1,590 pieces.

It was known that the spent fuel pool was fully filled with water as the cutting work of the shroud had been carried out at the reactor side and the pool gate (a divider plate between the reactor well and the spent fuel pool) was closed.

In addition to Okuma Line 3, to which no power was being supplied due to modification work before the earthquake, the Shintomioka Substation breaker tripped and that for receiving electricity at the switchyard in the power station was damaged by the earthquake, disrupting the power supply from Okuma Line 4 as well to cause the loss of external power supply.

As Unit 4 was undergoing periodic inspection, and its process computer and transient recorder were being replaced, the record to verify the startup of the emergency DG does not exist. Judging from the facts that the level of fuel oil tank decreased and the equipment powered by the emergency DG were operating, one emergency DG (the other was being checked) is estimated to have started.

The loss of external power supply stopped the cooling water pump for the spent fuel pool but it was possible to use the RHR system and others that would be powered by the emergency DG when the external power supply was lost.

However, such switching required on-site manual operation and so did not take place before the arrival of the tsunami.

b Effects of the tsunami

At 15:38, Unit 4 went into the situation of the loss of all the AC power supply when one emergency DG stopped its operation due to the drench of the seawater pumps and metal-clad switch gear caused by the tsunami, and the cooling and water supply functions of the spent fuel pool failed.

c Building explosion and subsequent emergency measures

At 4:08 on March 14, the cooling function of Unit 4's spent fuel pool was lost and the water temperature rose to 84°C. At around 6:00 on March 15, an explosion assumed to be a hydrogen explosion occurred in the reactor building, and the whole part upward from the one floor below the operation floor as well as the western wall and the wall along the stairs were collapsed. Furthermore, at 9:38, a fire was identified in the northwest part of the fourth floor of the reactor building, but TEPCO confirmed at about 11:00 that it had gone out on its own. A fire was also reported to have broken out in the northwest part of the third floor of the building around 5:45 on March 16, but TEPCO was not able confirm this fire on-site at around 6:15.

The cause of the explosion at the reactor building has not been clearly identified because of various limitations for confirmation at the field. For example, assuming that the stored spent fuel had been exposed because of the low water level and the raised temperature, the explosion should have been caused by the hydrogen generated through the reaction of water vapor with the zirconium in the clad of fuel rod; if so, such a phenomenon should have occurred earlier than at the stage when the temperature had risen and the water level had been lowered as estimated from the decay heat of the stored spent fuel. Therefore, at present, the following must be taken into account: cracks produced in the spent fuel pool and the additional decreases in the water level, such as the overflow caused by flushing due to the increase in temperature. As shown in Table IV-5-4 of the analysis result of nuclides in the water extracted from the spent fuel pool using a concrete pump truck, it is assumed no extensive damage in the fuel rods occurred. No damage to the pool, including water leaks and cracks, was found from visual inspections of the pool's condition. On the other hand, at the adjacent Unit 3, it is assumed that a large amount of hydrogen was generated as a result of the core damage, and a part of it was released by the PCV vent line. Also, as shown in Figs. IV-5-10 and IV-5-11, the exhaust duct of the PCV vent line is connected at the exhaust duct of Unit 4 before the exhaust pipe, and a stop valve to prevent reverse flow is not installed at the emergency gas treatment facility. Therefore, it is thought that the hydrogen discharged by venting at Unit 3 may have flowed in.

As mentioned above, the results of analyzing nuclides from the spent fuel pool and visual inspections have revealed that Unit 4's spent fuel pool remains nearly undamaged.

Subsequent water injections are described later in the section regarding the spent fuel pool.

(Currently under analysis)
The main events are described in chronological order in Table IV-5-5.

Table IV-5-4 Analysis of Nuclides from Unit 4's Spent Fuel Pool

Extracted on	Major Nuclides Detected	Concentration(Bq/cm^3)
April 12	Cesium 134	88
	Cesium 137	93
	Iodine 131	220
April 28	Cesium 134	49
	Cesium 137	55
	Iodine 131	27
May 7	Cesium 134	56
	Cesium 137	67
	Iodine 131	16

Table IV-5-5　Fukushima Daiichi NPS Unit 4　Main Chronology (Provisional)

* The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

	Unit 4	
	Status before earthquake: Stopped	
3/11	14:46	Stopped for regular inspection
	15:38	All AC power supply lost
	20:30	Lighting in Central Operating Room temporarily secured
3/12		
3/13		
3/14	4:08	Spent fuel pool temperature: 84°C
3/15	6:00 to about 6:10	6:00-6:10 (approx.) A large blast is heard. Damage is discovered in the vicinity of the 5th floor roof of the reactor building.
	6:56	The roof top appears distorted.
	8:11	Damage to the reactor building is confirmed. As radiation exceeded 500 μSV/h near the main gate, the operator judged it to be a reportable event under Article 15 (Release of radioactive materials through fire or explosion)
	9:38	A fire is confirmed to have broken out in the vicinity of the north-west corner of the reactor building's third floor. The fire brigade is notified.
		Fire suppression activities are scheduled to be carried out with the US Armed Forces and the In-house Fire Brigade System.
3/16	About 11:00	When the situation with the reactor building fire is confirmed on-site it is confirmed that the fire had gone out naturally.
	5:45	Flames are confirmed to be rising from the vicinity of north area of the fourth floor of the Unit 4 building.
		The fire brigade is notified and it prepares to put out the fire.
	6:15	Reconfirmation of the reactor building fire fails to confirm any fire.
	10:43	Clouds of what appears to be white steam are coming out from Unit 3, so outside work is stopped, and workers are directed to evacuate to the Emergency Action Room (2.9 mSv/h, 10:55 at the main gate)
3/17		
3/18		
3/19		
3/20	8:21	The SDF starts spraying water into the spent fuel pool to cool it down.
	9:40	The SDF stops spraying water into the spent fuel pool to cool it down. Approx 80 t.
	18:30	The SDF sprays water into the spent fuel pool.
	19:46	The SDF sprays water into the spent fuel pool. Approx. 80 t.
3/21	6:37	The SDF starts spraying water into the spent fuel pool.
	8:38	A US Armed Forces water truck sprays water until 8:41. Approx. 2.2 t
	8:41	All 13 units stop spraying. Approx. 90 t.
3/22	10:35	The emergency low-pressure power panel (Power Center (P/C) 4D) receives electricity
	17:17	Water spraying onto the spent fuel pool by TEPCO's Concrete Pump Truck (hereafter, "concrete pump truck") starts.
	20:32	Water spraying onto the spent fuel pool by the Concrete Pump Truck stops. Approx. 150 t.
	21:52	Power reaches main bus board power for measuring
3/23	10:00	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	13:02	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 125 t.
3/24	14:36	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	17:30	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 150 t.

	Unit 4	
	Status before earthquake: Stopped	
3/25	6:05	Spraying seawater to cool the spent fuel pool using the Spent Fuel Pool Cooling and Clean-up Line (FPC) starts.
	10:20	Spraying seawater to cool the spent fuel pool using the FPC stops. Approx. 20 t.
	19:05	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	22:07	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 150 t.
3/26		
3/27	16:55	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	19:25	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 125 t.
3/28		
3/29	11:50	Power reaches the Central Operating Room lights
3/30	14:04	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	18:33	Water spraying from the Concrete Pump Truck is continued until the water level can be confirmed with the gauges. Fresh water is sprayed. Approx. 140 t (fresh water used from here on).
3/31		
4/1	8:28	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	14:14	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 180 t.
4/2	14:25	Transfer of pooled water from the Concentrated Water Processing Facility (Concentrated RW) to the Turbine Building (T/B) starts.
4/3	10:00	Number of pumps for transferring from concentrated RW to T/B increased from 1 to 5.
	17:14	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	22:16	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 180 t.
4/4	9:22	Transfer from the concentrated RW to the T/B stops to check the rise in level of the vertical shaft for Unit 3.
4/5	17:35	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	18:22	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 20 t.
4/6		
4/7	18:23	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	19:40	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 38 t.
4/8		
4/9	17:07	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	19:24	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 90 t.
4/10		
4/11		
4/12	12:00	Sampling work starts in the spent fuel pool to check the status of the fuel stored there.
	13:04	The spent fuel pool sampling work is completed.
4/13	0:30	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	6:57	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 195 t.
4/14	18:10	The results of the April 13 analysis of radioactive material nuclides on the water taken from the pool on April 12 are reported.
4/15	14:30	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	18:29	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 140 t.
4/16		
4/17	17:39	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	21:22	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 140 t.
4/18		

	Unit 4	
	Status before earthquake: Stopped	
4/19	10:17	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	10:23	Tie line completed between Units 1, 2 and Units 3, 4 (Can use both the Tohoku-Genshiryoku Line and the Okuma Line)
	11:35	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 40 t.
4/20	17:08	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	20:31	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 100 t.
4/21	17:14	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	21:20	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 140 t.
4/22	17:52	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	23:53	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 200 t.
4/23	12:30	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	16:44	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 140 t.
4/24	12:25	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	17:07	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 165 t.
4/25	18:15	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	0:26	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 210 t.
4/26	10:23	As part of the power supply reinforcement work for changing over from the Units 3 & 4 System to the Units 1 & 2 System, work starts on stopping the 480 V power panel for Unit 4.
	16:50	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	20:35	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 130 t.
4/27	12:18	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	15:15	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 85 t.
4/28	11:43	Measurement of the water level in order to spray water using the Concrete Pump Truck into the spent fuel pool starts.
	11:54	Measurement of the water level in order to spray water using the Concrete Pump Truck into the spent fuel pool stops
	11:55	Spent fuel pool sampling starts.
	12:07	Spent fuel pool sampling stops.
4/29	10:29	Spent fuel pool water level measured
	10:35	Spent fuel pool temperature measured
4/30	10:14	Spent fuel pool water level and temperature measurement started.
	10:28	Spent fuel pool water level and temperature measurement stopped.
	10:31	To reinforce the external power supply for Units 3 and 4 (Okuma Line No. 3) from 6.6 KV to 66 KV, the 480 V power supply panel for Unit 4 and the 480 V power supply panel shared with the spent fuel pool were suspended.
	11:34	To reinforce the external power supply for Units 3 and 4 (Okuma Line No. 3) from 6.6 KV to 66 KV, the 480 V power supply panel for Unit 4 and the 480 V power supply panel for the spent fuel pool were restored, and power supply reinforcement work was completed.
5/1	10:32	Spent fuel pool water level and temperature measurement started.
	10:38	Spent fuel pool water level and temperature measurement stopped.
5/2	10:10	Spent fuel pool water level and temperature measurement started.
	10:20	Spent fuel pool water level and temperature measurement stopped.
5/3	10:15	Spent fuel pool water level and temperature measurement started.
	10:23	Spent fuel pool water level and temperature measurement stopped.
5/4	10:25	Spent fuel pool water level and temperature measurement started.
	10:35	Spent fuel pool water level and temperature measurement stopped.

	Unit 4	
	Status before earthquake: Stopped	
5/5	11:55	Spent fuel pool water level and temperature measurement started.
	12:05	Spent fuel pool water level and temperature measurement stopped.
	12:19	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	20:46	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 270 t.
5/6	12:16	Spent fuel pool water level and temperature measurement.
	12:16	Spent fuel pool water level and temperature measurement.
	12:38	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	17:51	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 180 t.
5/7	11:00	Water level measured. Temperature measured, sampling
	14:05	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	17:30	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 120 t.
5/8	16:18	Draining of water from the condenser hot well in the turbine building in order to prepare for work on the injection line into the reactor of Unit 3 starts
5/9	16:05	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	19:05	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 100 t.
5/10		
5/11	16:07	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	19:38	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 120 t.
5/12	12:20	Reconnection of the 480 V power panel for Unit 4 and the 480 V power panel for the spent fuel pool in order to boost the external power supply (the Okuma No. 3 Line) for Units 3 and 4 from 6.6 KV to 66 KV to receive power from the TEPCO Genshiryoku Line is completed.
5/13	16:04	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	16:20	Along with spraying water into the spent fuel pool, injection of an anti-corrosion agent (hydrazine) is started.
	18:41	Along with spraying water into the spent fuel pool, injection of an anti-corrosion agent (hydrazine) is stopped. Amount of hydrazine is 0.12 m3.
	19:04	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops. Approx. 100 t.
5/14		
5/15	16:25	Spraying from the Concrete Pump Truck to cool the spent fuel pool starts.
	16:26	Along with spraying water into the spent fuel pool, injection of an anti-corrosion agent (hydrazine) is started.
	18:30	Along with spraying water into the spent fuel pool, injection of an anti-corrosion agent (hydrazine) is stopped. Amount of hydrazine is 0.3 m3.
	20:25	Spraying from the Concrete Pump Truck to cool the spent fuel pool stops.
5/16		

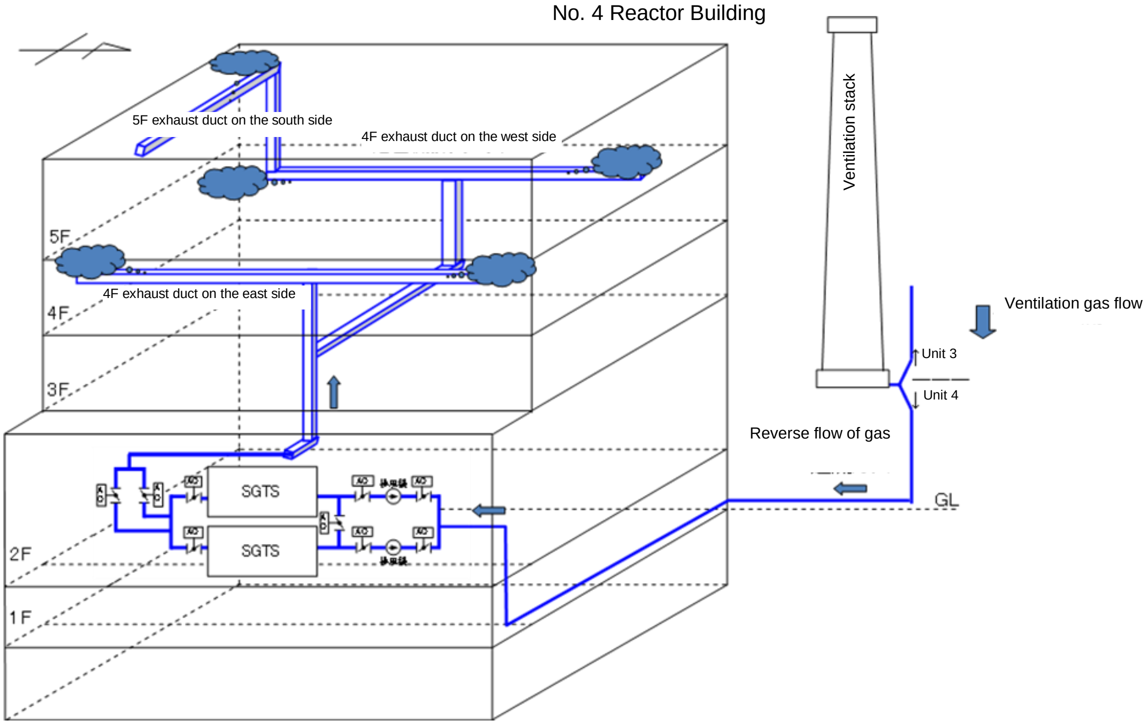
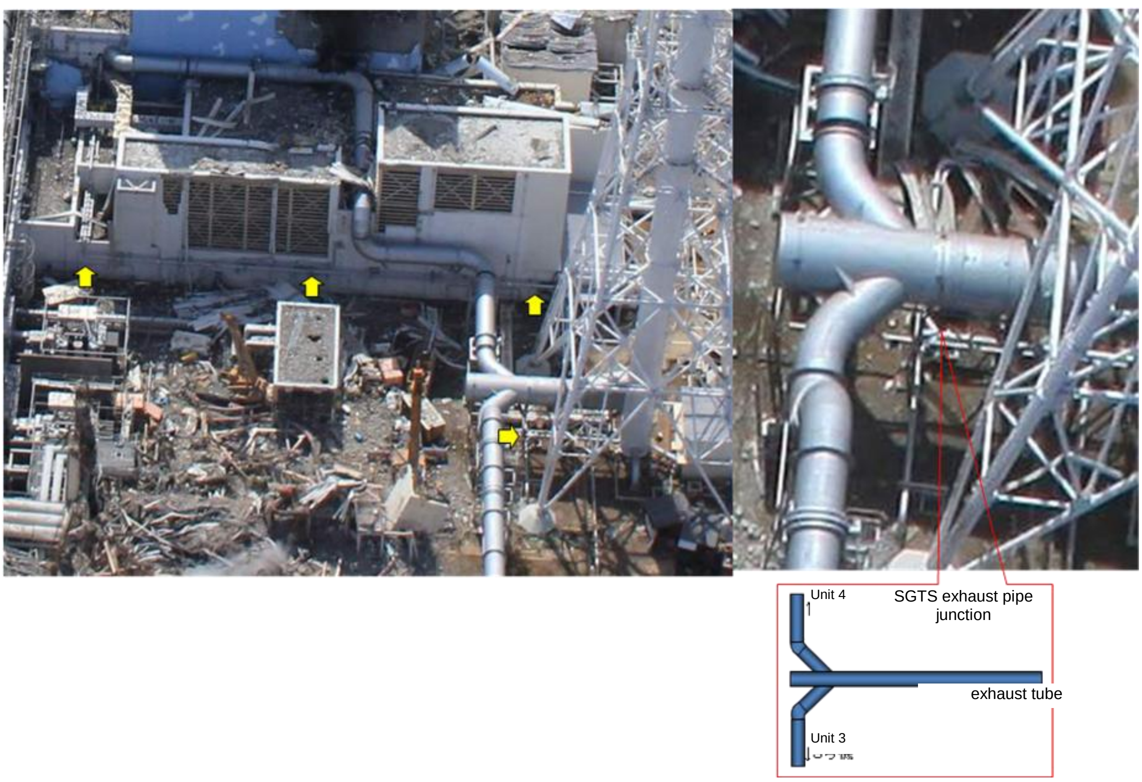


Fig. IV-5-10 Hydrogen flow route from Unit 3 to Unit 4 (estimated)

Fig. IV-5-11 Standby Gas Treatment System exhaust pipe



(5) Unit 5 at the Fukushima Daiichi NPS

1) From the outbreak of the earthquakes until the strike of the tsunami

Unit 5 had been suspended due to a periodic inspection since Jan. 3, 2011. On the day of the earthquake, RPV pressure leakage tests had been conducted with fuel being loaded in the reactor. Further, two 66-kV lines from Yorunomori 1 and 2 of were secured as an external power supply.

On March 11, the 66kV transmission line towers at Yorunomori Line 27 were collapsed when the earthquake hit them and the external power supply was lost. Thus, two emergency DGs were automatically activated.

2) Impact of the tsunami

At 15:40, AC power was totally lost because the two emergency DGs halted due to the flooding of the seawater pumps or damage to the metal-clad switch gear resulting from the tsunami. Loss of function of the seawater pumps disabled the RHR system, resulting in a failure to transfer the decay heat to the ocean, the final heat sink.

In the reactor, the pressure had increased to 7.2 MPa because of the pressure leakage test; however, the equipment that had been applying pressure on the reactor pump halted because of the loss of power supply, leading to a temporary pressure drop. Then, the decay heat caused the pressure to moderately increase, resulting in a pressure of around 8 MPa. At 6:06 on March 12, pressure reduction was performed on the RPV, but the pressure continued to increase moderately because of the decay heat.

3) Control of pressure and water level in the reactor

On March 13, water was successfully injected into the reactor using the condensate transfer pump at Unit 5, which received power from the emergency DG at Unit 6. Accordingly, after 5:00 on March 14, the reactor pressure and the water level were controlled by reducing pressure with the SRV and repeatedly refilling the reactor with water from the condensate storage tank through the condensate transfer pump in parallel.

On March 19, a temporary seawater pump was installed to activate the RHR system. The spent fuel pool and the reactor were alternately cooled by switching the components of the RHR, and the reactor achieved cold shutdown at 14:30 on March 20.

The major events that occurred are described in chronological order in Table IV-5-6.

Table IV-5-6 Fukushima Daiichi NPS, Unit 5 - Main Chronology (Provisional)

	Unit 5	
	Situation before the earthquake: stopped	
3/11	14:46	Stopped for periodic inspection (pressure inspection under way)
	15:40	Loss of all AC power supply
3/12	6:06	Pressure reduction operation on the RPV
3/13		Condensate transfer pump started up by means of power supply from Unit 6
3/14		
3/15		
3/16		
3/17		
3/18		
3/19	5:00	Residual Heat Removal system (RHR) pump (C) started up
		Completed making (three) holes on the roof in order to prevent hydrogen gas from accumulating within the reactor building
3/20	14:30	Cold shutdown
3/21	11:36	Receiving electricity for metal-clad (M/C) (6C) from starter transformer 5SA (Receiving on-site electricity (for 6.9 kV control panel of power source (6C)) from Yorunomori Line)
3/22	20:13	Receiving electricity for Power Center P/C (P/C) 5A-1 from metal-clad (M/C) (6C)
3/23	17:24	As to Residual Heat Removal Seawater system operated by the temporary pump, test operation after switching its power from temporary to permanent resulted in trip.
3/24	8:48	Receiving electricity in the important seismic isolation building
	16:14	The temporary seawater pump of the Residual Heat Removal Seawater system started up, Residual Heat Removal system pump started up by reactor shut-down cooling mode (SHC mode) at 16:35.
3/25		
3/26	23:30	SHC mode (reactor shut-down cooling mode)
3/27		
3/28		Pumped the accumulated water in RHR pump room and CS pump room up to the torus room (continued since March 28th)
		Drainage from Reactor Building (R/B) (start transfer from CS room → torus room (continued since March 28th))
3/29		
3/30		
3/31		
4/1		
4/2		
4/3		
4/4		
4/5	17:25	Accumulated water discharge to the ocean through the Sub Drain Pit started
4/6		
4/7		

4/8	12:14	Accumulated water discharge to the ocean through the Sub Drain Pit stopped. Amount of discharged water：950 m3
4/9		
4/10		
4/11		
4/12		
4/13		
4/14		
4/15		
4/16		
4/17		
4/18		
4/19		
4/20		
4/21		
4/22		
4/23		
4/24		
4/25		Implemented the tie line with Units 1 and 2 systems generating line
	12:22	Stopped Residual Heat Removal system (RHR) pump cooling the reactor for the preparation for suspension of the power supply
	16:43	Residual Heat Removal system (RHR) pump which had been stopped started up again
4/26		
4/27		
4/28		
4/29		
4/30		
5/1		
5/2	12:00	Stopped Residual Heat Removal system (RHR) pump and temporary Residual Heat Removal system (RHR) pump for the test charging of the start-up voltage regulator of Units 5 and 6 in connection with the work for recovery of the permanent power supply
	15:03	Test charging of the start-up voltage regulator of Units 5 and 6 terminated and Residual Heat Removal system (RHR) pump started up again in connection with the work for recovery of the permanent power supply
5/3		
5/4		
5/5		
5/6		
5/7		
5/8		
5/9		
5/10		
5/11		
5/12		
5/13		
5/14		
5/15		
5/16		

The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

(6) Unit 6 at the Fukushima Daiichi NPS

1) From the outbreak of the earthquakes until the strike of the tsunami

Unit 6 had been suspended due to a periodic inspection since Aug. 14, 2010. The reactor was in a cold shutdown condition with the fuel being loaded. Further, two 66-kV lines from Yorunomori Line 1 and 2 had been secured as an external power supply.

On March 11, the 66-kV transmission line towers at Yorunomori Line 27 collapsed when the earthquake hit them and the external power supply was lost. Thus, three emergency DGs were automatically started.

2) Impact of the tsunami

At 15:40, two emergency DGs (6A, 6H) halted due to the flooding of the seawater pumps and damage to the metal-clad switchgears resulting from the tsunami. However, one emergency DG (6B) continued to function. Because the emergency DB (6B) was installed in the DG building at a relatively high location rather than the turbine building, it remained in operation. Thus, Unit 6 did not lose AC power completely. Because of the tsunami, the seawater pumps lost their functions.

The pressure in the reactor moderately increased due to the decay heat; however, the rate of increase was more modest than that of Unit 5 because a longer period of time had elapsed after the halt.

3) Control of pressure and water level in the reactor

On March 13, water was successfully injected into the reactor using the condensate transfer pump, which received power from the emergency DG. Accordingly, after March 14, the reactor pressure and the water level were controlled by reducing pressure with the SRV and repeatedly refilling the reactor with water from the condensate storage tank through the condensate transfer pump in parallel.

On March 19, a temporary seawater pump was installed to activate the RHR system. The spent fuel pool and the reactor were alternately cooled by switching the RHR system interchangeably, and the reactor achieved cold shutdown at 19:27 on March 20.

The major events that occurred are described in chronological order in Table IV-5-7.

Table IV-5-7 Fukushima Daiichi NPS, Unit 6 – Main Chronology (Provisional)

* The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

	Fukushima Daiichi Nuclear Power Station
	Unit 6
	Situation before the earthquake: stopped
3/11	14:46 Stopped for periodic inspection 15:36 2 diesel generators (DG) trip
3/12	
3/13	Condensate transfer pump started up
3/14	Decompression by the safety bypass valve
3/15	
3/16	
3/17	
3/18	
3/19	4:22 The second unit of Emergency Diesel Generator (A) started up 5:11 Fuel Pool Cooling and Cleaning System (FPC) pump started up Completed making (three) holes on the roof in order to prevent hydrogen gas from accumulating within the reactor building 21:26 Temporary Remaining Heat Removal Seawater System (RHRS) pump started up 22:14 Remaining Heat Removal System (RHR) (B) started up
3/20	19:27 Cold shutdown
3/21	11:36 Receiving electricity to metal-clad (M/C) (6C) from starter transformer 5SA (Receiving on-site electricity (6.9 kV control panel of power source (6C)) from Yorunomori Line)
3/22	19:17 Started receiving electricity from external power supply (2 systems of emergency control panel of power source (6C, 6D) of 6.9 kV on-site power supply system received electricity from the external power supply, Yorunomori Line)
3/23	
3/24	
3/25	15:38 In operation with power supply for (one) substitute pump for RHRS switched from the temporary to the permanent 15:42 In operation with power supply for (one) substitute pump for RHRS switched from the temporary to the permanent
3/26	
3/27	10:14 RHR operating, reactor shut-down cooling mode (SHC mode)
3/28	
3/29	
3/30	
3/31	

4/1	13:40	Waste Processing Facility (R/W) underground ® drainage to hot well (H/W) (13:40 April 1st to 10:00 April 2nd）
4/2		
4/3		
4/4	21:00	Accumulated water discharge to the ocean through the Sub Drain Pit started.
4/5	17:25	As for the second Sub Drain Pit and succeeding Sub Drain Pits after that, groundwater is being discharged to the ocean by means of three operational pumps.
	18:37	One Sub Drain Pump stopped operation because an unusual sound was detected.
4/6		
4/7		
4/8		
4/9	18:52	Discharge of the low-level radioactive groundwater in Sub Drain Pit stopped with approximately 373 tons of aggregate amount of discharged water
4/10		
4/11		
4/12		
4/13		
4/14		
4/15		
4/16		
4/17		
4/18		
4/19		Transfer from Turbine Building (T/B) ® hot well (H/W)
4/20		
4/21		
4/22		
4/23		
4/24		
4/25		Implemented the tie line with 1/2 systems generating line
4/26		
4/28		
4/29		
4/30		
5/1	14:00	Started the work to transfer accumulated water in the turbine building to an outside temporary tank.
	17:00	Transferred 120 m3 of accumulated water in the turbine building to an outside temporary tank.
5/2	11:03	Stopped the temporary Residual Heat Removal Seawater system (RHRS) pump (for investigation of intake channel).
	13:20	Investigation of the intake channel completed.
	15:03	Residual Heat Removal system (RHR) pump restarted.
5/3		
5/4		
5/5		
5/6		
5/7		
5/8		
5/9		
5/10		
5/11		
5/12		
5/13		
5/14		
5/15		
5/16		

(7) The spent fuel pool at the Fukushima Daiichi NPS

At the Fukushima Daiichi NPS, in addition to the spent fuel pools at Units 1 through 6, a common spent fuel pool is provided for all six reactors. Table IV-5-8 summarizes the capacity, the amount of fuel stored, and the decay heat of the spent fuel stored at these pools. In Unit 4, all fuel had been removed from the reactor because of the shroud replacement work, and the spent fuel pool was being used to store fuel from the core with a relatively high decay heat, so that pool had a higher decay heat than other pools. The condition of Unit 4’s spent fuel pool is shown in Figure IV-5-12. On the other hand, because nearly one year had passed since Unit 1’s last fuel removal, the decay heat had attenuated. Although the water in the spent fuel pool is usually cooled by releasing heat to the sea, which is the ultimate heat-sink, using FPC (the pool cooling and purification system), cooling failed due to the function loss of both the seawater pumps and the external power supply. In Units 1, 3 and 4, since the upper parts of their buildings were damaged, in order to tentatively secure the cooling function, efforts were made to maintain the proper water levels by external hosing, which was conducted using the Self-Defense Force’s helicopters, water cannon trucks, and the Fire Department's pumpers. Since Unit 4 had the greatest decay heat and the fastest decrease in water level due to evaporation, special attention was paid to it to maintain the proper water level. On the other hand, Unit 2’s building remained undamaged, and this was thought to suppress the decrease in water level to some extent as evaporated steam condensed on the building’s ceiling; efforts were made to recover the water supply line while maintaining the water level by hosing the opening of the building. On and after March 20, water injection began from the primary water supply line. In Units 5 and 6, the power supply was secured from Unit 6's emergency DG as mentioned above, and the cooling function was also secured using the temporary seawater pump, allowing the spent fuel pool and the reactor to be alternately cooled.

Nuclides from the water of the spent fuel pools of Units 2 through 4 were analyzed. The results of Unit 4 have already been shown in Table IV-5-4, and the analysis results of Units 2 and 3 are shown in Table IV-5-9.

It was confirmed that the common pool was almost full on March 18 and the water temperature was 55°C. On March 21, water was tentatively injected from fire engines and the power supply was restored on March 24, after which cooling was started using the common pool’s cooling pump. The major events that occurred are described in chronological order in Table IV-5-10.

Table IV-5-8 Capacity of the spent fuel pool, number of stored assemblies and decay heat.

	Stored assemblies (new fuel assemblies)	Storage capacity	Decay heat	
			At the time of the accident (March 11)	3 months after the accident (June 11)
Unit 1	392 (100)	900	0.18	0.16
Unit 2	615 (28)	1,240	0.62	0.52
Unit 3	566 (52)	1,220	0.54	0.46
Unit 4	1,535 (204)	1,590	2.26	1.58
Unit 5	994 (48)	1,590	1.00	0.76
Unit 6	940 (64)	1,770	0.87	0.73
Common pool	6,375	6,840	1.13	1.12

Table IV-5-9 Nuclide analysis of Unit 2 and 3 spent fuel pools

	Date of sampling	Major nuclides detected	Concentration (Bq/cm^3)
Unit 2	April 16	Cesium 134	160,000
		Cesium 137	150,000
		Iodine 131	4,100
Unit 3	April 28	Cesium 134	140,000
		Cesium 136	1,600
		Cesium 137	150,000
		Iodine 131	11,000

Table IV-5-10 Fukushima Daiichi NPS, Common Spent Fuel Pool – Main Chronology (Provisional)

* The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

	Fukushima Daiichi Nuclear Power Station	
	Common Spent Fuel Pool	
	Situation before the earthquake: stopped	
3/11		The water temperature in Common Spent Fuel Pool before the earthquake: approximately 30°C
3/12		
3/13		
3/14		
3/15		
3/16		
3/17		
3/18	0:00	The water temperature in the pool is 57°C
3/20		
3/21	10:37	Operation of water injection to Common Spent Fuel Pool by fire engines under way
3/22		
3/23		
3/24	15:37 18:05	Recovery of the temporary power supply of Common Spent Fuel Pool Cooling pump for the Spent Fuel Pool started up
3/25	15:20	The water temperature in the pool is 53°C
3/26		
3/27	8:00	The water temperature in the pool is 39°C
3/28		The water temperature in the pool is 53°C
3/29		
3/30		
3/31		
4/1		
4/2		
4/3		
4/4		
4/5		
4/6		
4/7		
4/8		
4/9		
4/10		
4/11		
4/12		
4/13		
4/14		
4/15		
4/16		Measures against the stagnant water in order to prevent inflow of groundwater into the building (April 16 to April 18)
4/17	14:36	Temporary power supply for Common Spent Fuel Pool stopped (14:36 to 17:30)
4/18		
4/19		
4/20		

4/21	
4/22	
4/23	
4/24	
4/25	
4/26	
4/27	
4/28	
4/29	
4/30	10:31 In order to reinforce the external power supply for Units 3 and 4 (Okuma 3 Line) from 6.6 KV to 66 KV, 480 V control panel of power source for Unit 4 and 480 V control panel of power source for Common Spent Fuel Pool stopped and recovered at 11:34 to terminate the power supply reinforcement work.
5/1	
5/2	
5/3	
5/4	
5/5	
5/6	
5/7	
5/8	
5/9	
5/10	
5/11	
5/12	
5/13	
5/14	
5/15	
5/16	

Fig. IV-5-12　Condition of the spent fuel pool (Unit 4)

(8) Status of accumulated water in the Fukushima Daiichi NPS

It is confirmed that water has accumulated in the basements of the turbine buildings of Unit 1 to 4, and such water hinders restoration work. In addition, highly concentrated radioactive material has been found existed in the stagnant water in Unit 2. Attention therefore must be paid with respect to the unintentional discharge of such radiation-tainted water into the environment.

It was decided that some of the stagnant water should be transferred to the condenser. In preparation for this, a plan to transfer the water in the condensed water storage tank to the suppression pool water surge tank and then transfer the water in the condenser to the condensed water storage tank was planned and carried out. A schematic diagram of this transfer work is shown in Figure IV-5-13. However, since the water level of the condenser is increasing in Units 1 and 3 and it is necessary to understand why this is happening, other measures are being planned. Specific details of the plan of future work are described in Section X. Measures to Bring the Accident Under Control. Cameras have been installed to monitor the water level in the turbine building basements and are remotely controlled for this objective.

It has also been confirmed that water has accumulated in the vertical shaft of the trench outside the turbine buildings. Work was carried out to transfer some of the accumulated water to the tanks in the buildings on March 31. At the same time cameras were installed in the shafts to remotely monitor water levels. The work to transfer the accumulated water in the trench in Unit 2 to the centralized waste treatment facility commenced on April 19. Prior to this work, both the low-concentration radioactive wastewater existed in the centralized waste treatment facility and the groundwater in the subdrain of Units 5 and 6 which contained radioactive materials were discharged into the sea in order to obtain some space in the treatment facility and prevent equipment important to safety of Units 5 and 6 from being submerged. Details of these operations are described in Section VI. Discharge of Radioactive Materials to the Environment.

Water samplings were carried out from the accumulated water to analyze the nuclides contained within it, and the results are shown in Table IV-5-11. The concentration detected for Unit 2 is some ten times higher than that for Unit 1 or 3. Since it is estimated that the water in the PCV that had been in contact with the damaged fuel has been directly discharged through a certain route, measures have been taken to start treatment of the accumulated water and intensively sample the groundwater and seawater to confirm the safety of environment. In addition, as water was found to be being released into the sea near the intake ports adjacent to the trenches of Unit 2 and Unit 3, the release was terminated on April 6 and on May 11. Details are described in Section VI. Discharge of Radioactive Materials to the Environment

Table IV-5-11 Nuclide analysis result of accumulated water (as of June 5)

Unit		Unit 1	Unit 2	Unit 3	Unit 4
Place of collection		Basement floor of the turbine building	Basement floor of the turbine building	Basement floor of the turbine building	Basement floor of the turbine building
Date of sample collection		2011/3/26	2011/3/27	2011/3/24 (2011/4/22)	2011/3/24 (2011/4/21)
Nuclide detected (half-life) Unit: Bq/cm^3	Molybdate-99 (about 66 hours)	Below detection limit	Below detection limit	Below detection limit (Below detection limit)	1.0×10^{0} (Below detection limit)
	Technetium-99m (about 6 hours)	Below detection limit	Below detection limit	2.0×10^{3} (Below detection limit)	6.5×10^{-1} (Below detection limit)
	Tellurium-129m (about 34 days)	Below detection limit	Below detection limit	Below detection limit (Below detection limit)	1.3×10^{1} (Below detection limit)
	Iodine-131 (about 8 days)	1.5×10^{5}	1.3×10^{7}	1.2×10^{6} (6.6×10^{5})	3.6×10^{2} (4.3×10^{3})
	Iodine-132 (about 2 hours)	Below detection limit	Below detection limit	Below detection limit (Below detection limit)	1.3×10^{1} (Below detection limit)
	Tellurium-132 (about 3 days)	Below detection limit	Below detection limit	Below detection limit (Below detection limit)	1.4×10^{1} (Below detection limit)
	Cesium-134 (about 2 years)	1.2×10^{5}	3.1×10^{6}	1.8×10^{5} (1.5×10^{6})	3.1×10^{1} (7.8×10^{3})
	Cesium-136 (about 13 days)	1.1×10^{4}	3.2×10^{5}	2.3×10^{4} (4.4×10^{4})	3.7×10^{0} (2.4×10^{2})
	Cesium-137 (about 30 years)	1.3×10^{5}	3.0×10^{6}	1.8×10^{5} (1.6×10^{6})	3.2×10^{1} (8.1×10^{3})
	Barium-140 (about 13 days)	Below detection limit	6.8×10^{5}	5.2×10^{4} (9.6×10^{4})	Below detection limit (6.0×10^{2})
	Lanthanum-140 (about 2 days)	Below detection limit	3.4×10^{5}	9.1×10^{3} (9.3×10^{4})	4.1×10^{-1} (4.8×10^{2})

(2) Transfer from condensers to condensate storage tanks		
Unit	Transfer date	Changes in the water level of condensate storage tanks
No. 1	Apr. 3 to 10	5% → 56%
No. 2	Apr. 2 to 9	4% → 88%
No. 3	Mar. 28 to 31	58.2% → 1.2%

(1) Transfer from condensate storage tanks to suppression pool water surge tanks		
Unit	Transfer date	Changes in the water level of condensate storage tanks
No. 1	Mar. 31 to Apr. 2	33% → 5%
No. 2	Mar. 29 to Apr. 1	28% → 4%

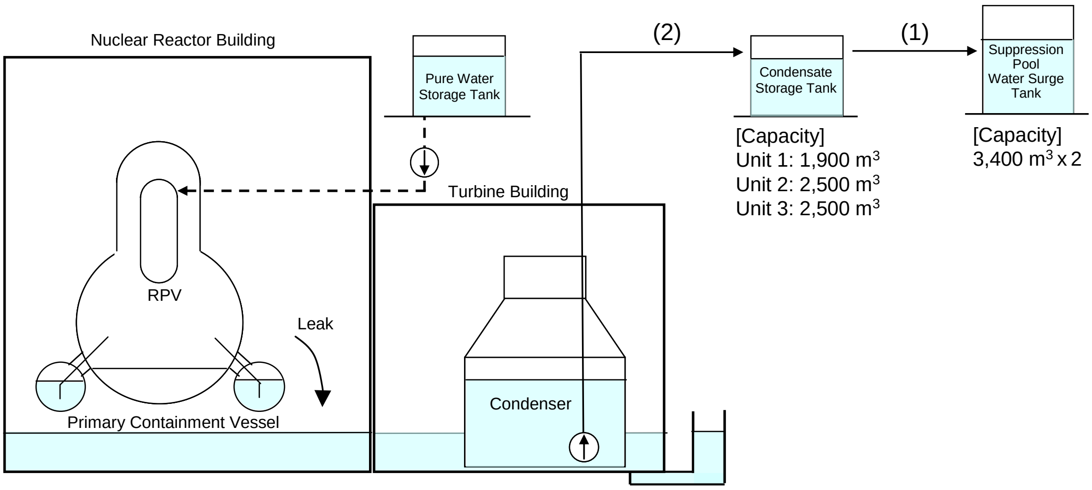


Fig. IV-5-13 Transfer of accumulated water

(9) Fukushima Daini NPS

No significant changes were recorded in the plant data of the Fukushima Daini NPS for Units 1 through 4, prior to the occurrence of the earthquake, and constant rated thermal power operations were being conducted. The live external power sources before the earthquake comprised lines 1 and 2 of the 500 kV Tomioka line and the No. 2 of 66 kV Iwaido line, making three lines in total.

The four nuclear reactors, Units 1 to 4, underwent an automatic shutdown (SCRAM) due to the great seismic acceleration at 14:48 on March 11, and control rods were inserted to the reactors to make them subcritical. The No. 2 of 500 kV Tomioka line stopped supplying power because of the failure and subsequent repair process of the substation equipment, and additionally, the No. 2 of 66 kV Iwaido line stopped supplying power approximately one hour after the earthquake.. So the supply of power to Units 1 to 4 was maintained through the No. 1 of Tomioka line. The No. 2 of 66 kV Iwaido line was recovered from repair at 13:38 on the next day, and the power supply with two lines resumed.

At around 15:34, the tsunami attacked the site of the Daini NPS. This rendered all reactor coolant systems (excluding the RCIC system) including the RHR system for Unit 1 and 2 and all reactor cooling systems (excluding the HPCS system and the RCIC system) including the RHR system for Unit 4 out of operation. The nuclear operator therefore judged that an event defined in Article 10 of the NEPA, “The loss of reactor heat removal,” occurred at 18:33.

1) Unit 1

The reactor was being cooled and the sufficient water level of the reactor core was maintained by the RCIC system and the condensate water supply system. However, as final heat removal could not be realized and the temperature of the SC water exceeded 100°C, the nuclear operator notified the NISA and related departments that the event was judged to correspond to an event defined in Article 1 of the NEPA “Loss of reactor pressure control,” at 05:22 on March 12, and the cooling of the reactor with a drywell spray was started at 07:10 on March 12.

The motors of the RHR system cooling water pump (D) and emergency component cooling water pump (B) necessary for the RHR system (B) operation were replaced with new ones in order to maintain a means of heat removal by the RHR. In relation to the motors of the seawater pump of the cooling system (B) of the RHR system, the cooling water pump (D) of the RHR system, and the emergency component cooling water pump (B), since the power supply panels connected to those motors were rendered inoperable, the power was supplied to those motors from other available power supply panels with provisional cables. As a result, the operation of the RHR system (B) started to cool the suppression chamber at 01:24 on March 14. This continuation of cooling decreased the temperature of the suppression chamber to below 100˚C at 10:15 on March 14, and the reactor itself came into a status of cold shutdown at 17:00 of the same day.

2) Unit 2

The cooling was being cooled, and the sufficient water level of the reactor core was maintained by the RCIC system and the condensate water supply system. However, as final heat removal could not be realized and the temperature of the suppression chamber water exceeded 100°C, TEPCO notified the NISA and related departments that the event was judged to correspond to an event defined in Article 1 of the NEPA “Loss of reactor pressure control,” at 05:32 on March 12.,

As regards the motors of the seawater pump (B) of the cooling system of the RHR system, the cooling water pump (B) of the RHR system, and the emergency component cooling water pump (B), since the power supply panels connected to those motors were rendered inoperable, the power was supplied to those motors from other available power supply panels with provisional cables in order to maintain a means of heat removal by RHR. As a result, the operation of the RHR system (B) started to cool the suppression chamber at 07:13 on March 14.

Cooling continued, and the SC temperature decreased to below 100˚C at 15:52 on March 14, and the reactor itself achieved cold shutdown at 18:00 of the same day.

3) Unit 3

Although the RHR system (A) and the LPCS system of Unit 3 failed because of the tsunami damage, the RHR system (B) was not damaged and was able to continue its operation. Thus cooling by this system continued and put the reactor into a status of cold shutdown at 12:15 on March 12.

4) Unit 4

The reactor was being cooled, and the sufficient water level was maintained by the RCIC system and the condensate water supply system. However, as final heat removal could not be realized and the temperature of the SC water exceeded 100°C, the nuclear operator concluded that an event corresponding to an emergency situation defined in Paragraph 1, Article 1 of the NEPA (loss of reactor pressure control) had occurred and notified the Prime Minister at 06:07 on March 12. Following this, the cooling of the reactor with a drywell spray was started at 07:35 on March 12.

In order to secure a means of heat removal by RHR, the motors of the RHR cooling water pump (B) necessary for RHR (B) were replaced. Since the power supply panels connected to the motors of the seawater pump (D) of the cooling system of the RHR system, the cooling water pump (B) of the RHR system, and the emergency component cooling water pump (B) were rendered inoperable, the power was supplied to these motors from other available power supply panels with provisional cables. As a result, the operation of the RHR system (B) started to cool the suppression chamber at 15:42 on March 14.

As cooling then continued, it decreased the SC temperature to below 100˚C and put the reactor into cold shutdown at 07:15 on March 15.

The time series of major events are shown in Table IV-5-12.

Table IV-5-12 Fukushima Daini NPS, Main Chronology (Provisional)

* The information included in the table is subject to modifications following later verification. The table was established based on the information provided by TEPCO, but it may include unreliable information due to tangled process of collecting information amid the emergency response. As for the view of the Government of Japan, it is expressed in the main body of the report.

	Overall	Unit 1	Unit 2	Unit 3	Unit 4
		Status before earthquake: Under operation	Status before earthquake: Under operation	Status before earthquake: Under operation	Status before earthquake: Under operation
3/11	14:46 Great East Japan Earthquake strikes				
		14:48 All control rods inserted (subcriticality confirmed) Automatic reactor shutdowr Automatic turbine shutdowr External power being supplie Main steam isolation valve; closed	14:48 All control rods inserted (subcriticality confirmed) Automatic reactor shutdowr Automatic turbine shutdowr External power being supplie Main steam isolation valve; closed	14:48 All control rods inserted (subcriticality confirmed) Automatic reactor shutdowr Turbine automatic shutdowr External power being supplie Main steam isolation valve; closed	14:48 All control rods inserted (subcriticality confirmed) Automatic reactor shutdowr Automatic turbine shutdowr External power being supplie Main steam isolation valve; closed
	17:35 Unit 1: Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (leakage of reactor coolant) has occurred.	17:35 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (leakage of reactor coolant) has occurred (the operator judges that there is no leakage of reactor coolant as of 19:30			
	18:33 Units 1, 2 4: Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (loss of reactor heat removal function) has occurred.	18:33 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (loss of reactor heat removal function) has occurred.	18:33 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (loss of reactor heat removal function) has occurred.		18:33 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (loss of reactor heat removal function) has occurred.
		Emergency Core Cooling System (ECCS) high pressure system: not operating ECCS low pressure system: manually shut down after actuation (at 20:00)	Emergency Core Cooling System (ECCS) high pressure system: manually shut down after actuatior ECCS low pressure system: manually shut down after actuation (at 20:00)	Emergency Core Cooling System (ECCS) high pressure system: prevention of actuation beforehan ECCS low pressure system: prevention of actuation beforehand Emergency diesel generator (D/G) (B), (H) operating with no load Residual Heat Removal (RHR) system normal	Emergency Core Cooling System (ECCS) high pressure system: prevention of actuation beforehan ECCS low pressure system: prevention of actuation beforehand Emergency D/G (H) operating with no load. (at 20:00)
3/12	5:22 Unit 1: Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.	5:22 Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.			
	5:32 Unit 2: Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.		5:32 Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.		
	6:07 Unit 4: Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.				6:07 Operator judges that an Event falling under Article 15 of the NEPA (loss of reactor pressure suppression function) has occurred.Operator judges that an
		7:10 Dry well (D/W) spraying started			
			7:11 Dry well (D/W) spraying started		
		8:19 Control rod (DR) 10-51 drift alarm sounded			
				9:36 RHR (B) shutdown cooling mode	
		9:43 Containment Vessel (PCV) preparation started			
			10:33 Containment Vessel (PCV) preparation started		
		10:43 Control rod (DR) 10-51 drift alarm cleared			
			10:58 PCV vent preparation completed		
					11:17 HPCS system activatec
					11:44 Containment Vessel (PCV) preparation started
					11:52 PCV vent preparation complete
				12:08 Containment Vessel (PCV) preparation started	
	12:15 Unit 3: Reactor cold shutdown			12:13 PCV vent preparation complete	
				12:15 Reactor cold shutdown	
		18:30 PCV vent preparation complete			
3/13		2:03 Control rod (DR) 10-51 drift alarm Control rod (DR) 10-51 drift alarm cleared (as of 12:00)			12:43 Control rod (DR) 10-19 drift alarm sounded
3/14	1:24 Unit 1: Cooling started using Residual Heat Removal system (RHR) (B)	1:24 Cooling started using Residual Heat Removal system (RHR) (B)			
	7:13 Unit 2: Cooling started using RHR (B)		7:13 Cooling started using Residual Heat Removal system (RHR) (B)		
			7:50 Suppression Chamber (S/C) spraying (using RHR (B)) started		
	15:42 Unit 4: Cooling started using RHR (B)				15:42 Cooling started using Residual Heat Removal system (RHR) (B)
	17:00 Unit 1: Reactor cold shutdown	17:00 Reactor cold shutdown			
	18:00 Unit 2: Reactor cold shutdown		18:00 Reactor cold shutdown		
	22:07 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (increase in radiation within site limits) has occurred. (Is assumed to be the effects of Fukushima Daiichi NPS)				
3/15	0:12 Operator judges that a Specific Initial Event falling under Article 10 of the NEPA (increase in radiation within site limits) has occurred. (Is assumed to be the effects of Fukushima Daiichi NPS)				
	7:15 Unit 4: Reactor cold shutdown				7:15 Reactor cold shutdown
3/16					
3/17				9:55 Restored to normal status from PCV vent preparation completed status	
					11:24 Restored to normal status from PCV vent preparation completed status
			17:19 Restored to normal status from PCV vent preparation completed status		
		17:22 Restored to normal status from PCV vent preparation completed status			
3/18					
3/19		15:28 RHR (B) shut down (for inspection of RHRC system pump)			
		22:14 RHR pump (B) start-up			
3/20				14:36 RHR (B) shut down (to switch to Suppression Chamber (S/C) cooling)	
				15:05 RHR pump (B) start-up S/C cooling started	

	Overall	Unit 1	Unit 2	Unit 3	Unit 4
		Status before earthquake: Under operation	Status before earthquake: Under operation	Status before earthquake: Under operation	Status before earthquake: Under operation
3/21					
3/22					
3/23					
3/24					
3/25					
3/26					
3/27				10:50 RHR (B) shut down Currently switching RHR operation mode	
3/28					
3/29					10:52 RHR pump (B) shut down (for inspection of intake)
					14:00 RHR pump (B) start-up
3/30			10:25 RHR (B) shut down (for installation of temporary power system)		
		10:34 RHR (B) shut down (for installation of temporary power system)			
			14:04 RHR (B) start-up		
		14:30 Acquisition of RHR (B) back-up power (emergency power) RHR (B) start-up			
		17:56 Detection of smoke occurrence from power board located in 1F of turbine			
		18:13 After shutdown of power supply, disappearance of smoke was confirmed			
		19:15 It was concluded that smoke occurrence was caused by abnormal condition of power board and therefore not by the fire			
3/31					14:35 RHR (B) shut down (reactor shutdown cooling mode (SHC) + Suppression Chamber cooling mode (S/C)→ SHC + S/C + Fuel Pool Cooling mode (FPC)
4/1					15:36 RHR (B) activated
		13:43 RHR pump (B) shut down (for inspection of intake)			
		15:07 RHR pump (B) start-up			
4/2					
4/3					
4/4					
4/5					
4/6					
4/7					
4/8					
4/9					
4/10					
4/11					
4/12					
4/13					
4/14					
4/15					
4/16					
4/17					
4/18					
4/19					
4/20					
4/21					
4/22					
4/23					
4/24					
4/25					
4/26					
4/27					10:20 RHR (B) shut down (for switching of power system)
					17:41 RHR (B) activated
4/28					
4/29					
4/30		9:10 RHR (B) shut down (for inspection of intake waterway)			
		12:54 RHR (B) activated			
5/1					
5/2					
5/3					
5/4					
5/5					
5/6					
5/7					
5/8					
5/9				9:51 RHR (B) shut down (for inspection of intake waterway)	
				14:46 RHR (B) activated	
5/10					
5/11					
5/12			9:36 RHR (B) shut down (for inspection of intake waterway		
			12:13 RHR (B) activated		
5/13					
5/14					
5/15					
5/16					