(2) Conditions of the Fukushima Dai-ichi NPS

This part overviews the current conditions of the Fukushima Dai-ichi NPS. Specifically, it introduces the current conditions of cooling the reactor and the SFP, the status of discharge of radioactive materials, contamination over on-site of the NPS, and the seismic safety in each Unit of the Fukushima Dai-ichi NPS.

The conditions of reactor buildings at Units 1 to 4 are shown in Figure II-2-26.

1) Conditions of cooling reactor and spent fuel pool, etc.

a. Unit 1

Water injection for Unit 1 by using fire engines, since stability of cooling function in terms of the necessity, etc. of supplying petrol as well as radiation exposure in conjunction with its operation, was considered problematic, so that, in accordance with progress in restoration of the fresh water supply system and restoration of power supply, a reactor water injection pump was installed and water injection for the reactor has been carried out via a reactor water injection system intended to add redundancy in each facility, as shown in Figure II-2-27.

For Unit 1, as of August 31, water injection has been carried out with the amount of water about 3.6m³/h, which exceeds the amount of water injection equivalent to decay heat.

Temperature of the bottom of the RPV has not shown behavior of continuous increase of temperature over the last one month and stayed under 100°C, and the reactor has been enabled to be cooled sufficiently by means of a reactor water injection system (Figure II-2-28).

In Unit 1, on April 7, the injection of nitrogen into the PCV was sta rted (Figure II-2-29), and it is still ongoing as of August 31.

Furthermore, following the calibration of the water level gauge conducted in May, the reference leg side of the reactor water level gauge (fuel range A system) has been filled with water. A temporary pressure gauge was installed, and it has started monitoring the reactor water level as well as reactor pressure from reading pressure values and hydraulic head. Monitoring has been continuously carried out to date (Figure II-2-30).

b. Unit 2

Water injection for Unit 2 by using fire engines, since stability of cooling function in terms of the necessity, etc. of feeding petrol as well as radiation exposure in conjunction with its operation, was considered as problems so that, in accordance with progress in restoration of fresh water supply system and restoration of power supply, etc., reactor water injection pump, etc. was installed and water injection for reactor has been carried out by reactor water injection system intended to add redundancy in each facility as shown in Figure II-2-27, .

For Unit 2, as of August 31, water injection has been carried out with the amount of water about 3.8m³/h which exceeds the amount of water injection equivalent to decay heat

Temperature of the bottom of the RPV has not shown behavior of continuous increase of temperature over the last one month and stayed under 130°C, and the reactor has been enabled to be cooled sufficiently by reactor water injection system (Figure II-2-31).

In Unit 2, on June 28, the injection of nitrogen into the PCV was s tarted (Figure II-2-32), and it is still ongoing as of August 31.

Furthermore, with regard to the measures carried out after June, a temporary pressure gauge was installed as the same configuration of Unit 1 on June 22. It was estimated that reactor water level was - 5m or less from the TAF, the same estimation as that of Unit 1, but TEPCO recognizes that it is not possible to correctly measure it at this point.

c. Unit 3

Water injection for Unit 3 by using fire engines, since stability of cooling function in terms of the necessity, etc. of feeding petrol as well as radiation exposure in conjunction with its operation, was considered as problems so that, in accordance with progress in restoration of fresh water supply system and restoration of power supply, etc., reactor water injection pump, etc. was installed and water injection for reactor has been carried out by reactor water injection system intended to add redundancy in each facility as shown in Figure II-2-27, .

For Unit 3, as of August 31, water injection has been carried out with the amount of water about 7.0m³/h which exceeds the amount of water injection equivalent to decay heat

Temperature of the bottom of the RPV has not shown behavior of continuous increase of temperature over the last one month and stayed under 120°C, and the reactor has been enabled to be cooled sufficiently by reactor water injection system (Figure II-2-33).

In Unit 3, on July 14, the injection of nitrogen into the PCV was s tarted (Figure II-2-34), and it is still ongoing as of August 31.

d. Unit 4

Unit 4 was undergoing periodic inspection at the time of the earthquake, and its condition was that all fuel assemblies had been transferred to the SFP from the reactor.

A large sound was confirmed and damage to the reactor building of Unit 4 was ascertained around 6:00 on March 15 (Figure II-2-26). Regarding the cause of this, in the June Report, the possibility was indicated that due to PCV venting in Unit 3, the current of air in the PCV venting including hydrogen gas flowed through the ventilation stack (Figure II-2-35 and Figure II-2-36).

After that, in order to verify the related facts, measurements of the radioactive dose of SGTS filter-train in Unit 4 were conducted on August 25, and it was confirmed that a radioactive dose on the outlet side of the filter-train was high but decreasing by closing to the inlet side (Figure II-2-37). This can be considered as a result showing the possibility that PCV venting flowed into Unit 4 through the SGTS piping.

e. Unit 5

Unit 5 has been in cold shutdown since March 20. Regarding major restoration status of the facilities after June, the existing auxiliary seawater pump (C) was restored on June 24, and constant operation of SFP cooling and RPV cooling by using the Reactor Building Cooling Water System (RCW) pump and the FPC pump became possible. Moreover, the results of the test operation of the emergency DG (A) and (B) were that there were no abnormal conditions confirmed (on June 27 and 28), and these have been shifted to stand-by status. On July 15, the RHR (B) pump was restored and the RHR (B) system was started.

f. Unit 6

Unit 6 has been in cold shutdown since March 20. Regarding major restoration status of the facilities since June, on August 9, in order to enhance the means of connection of alternative cooling temporary pump of the residual heat removal seawater system (RHRS), connection work of the said temporary pump to RHR(A) was carried out. Also, SFP cooling by using the FPC pump is being prepared.

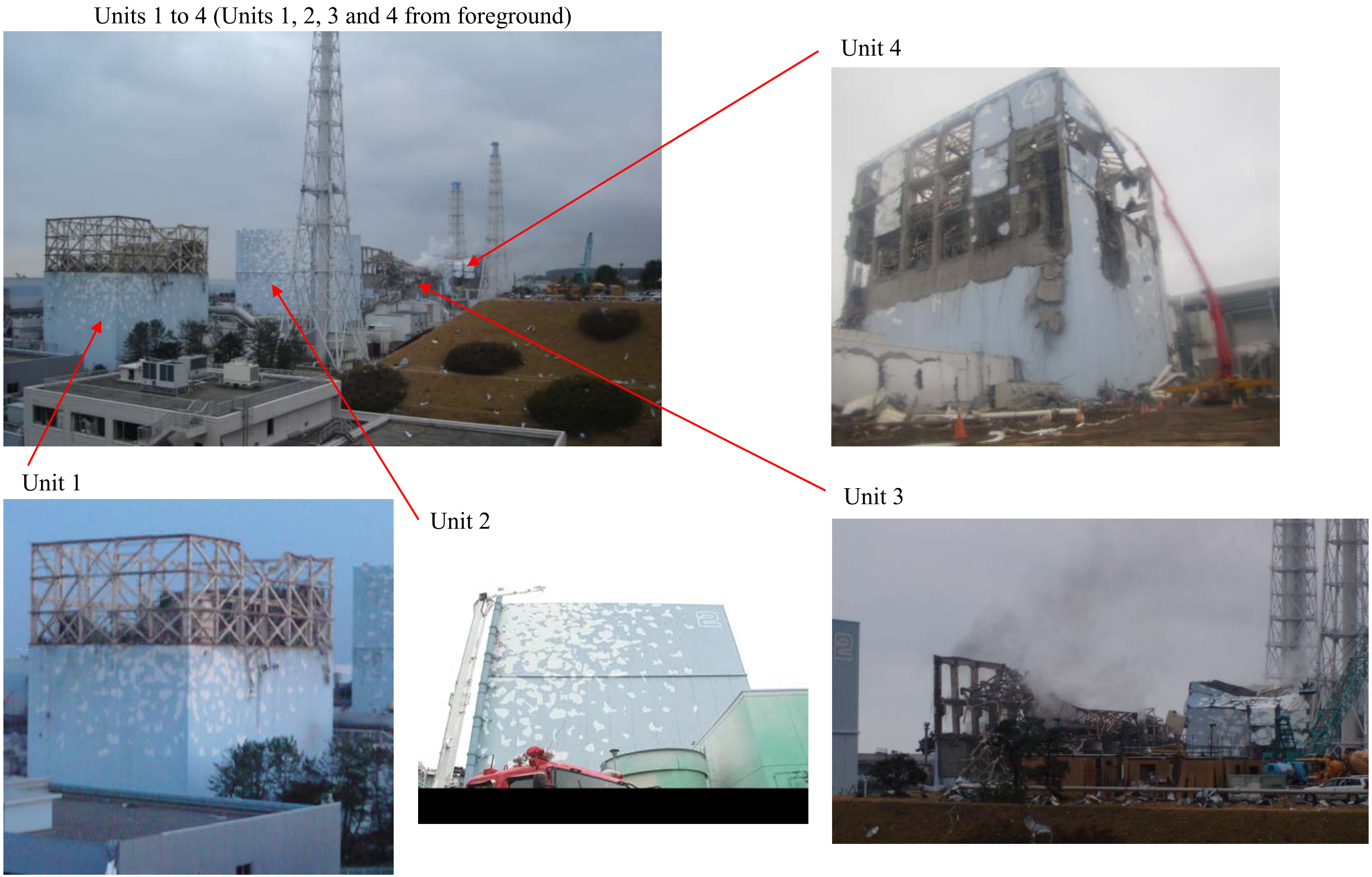


Figure II-2-26 Condition of Reactor Buildings, Units 1 to 4, Fukushima Dai-ichi NPS

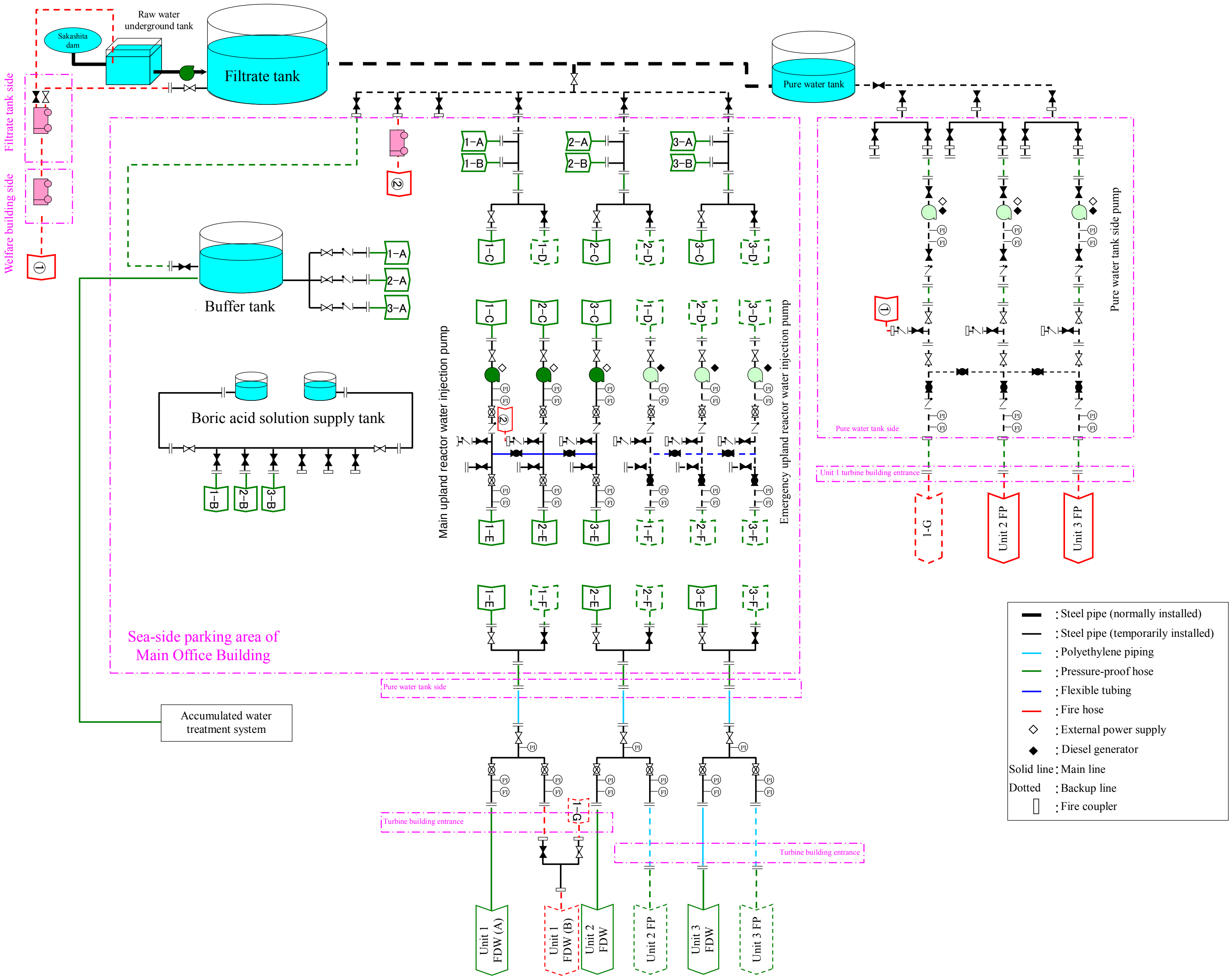


Figure II-2-27 Schematic System Diagram of Reactor Water Injection System

Temperature Parameter (Typical Point), Unit 1, Fukushima Dai-ichi NPS

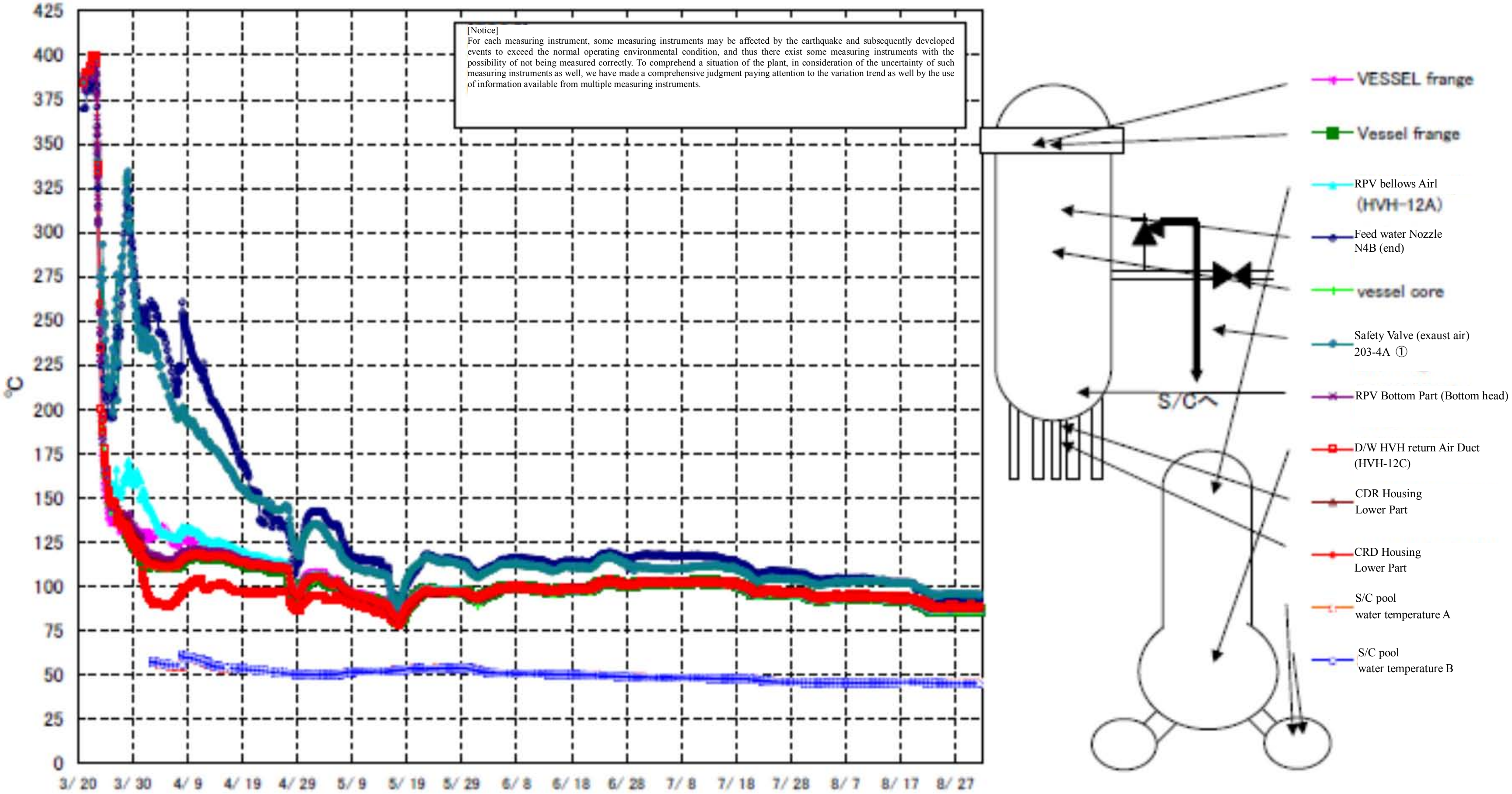


Figure II-2-28 Temperature Parameter, Unit 1, Fukushima Dai-ichi NPS

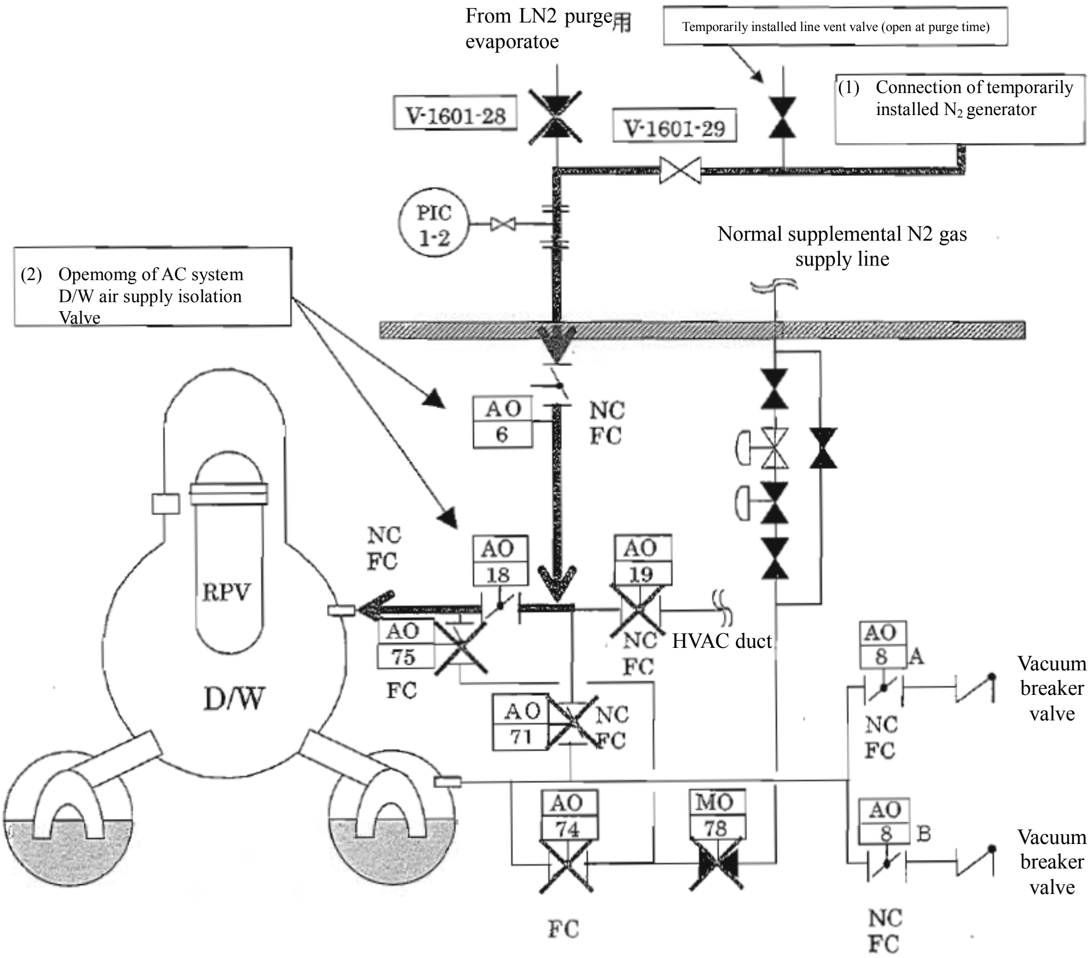


Figure II-2-29 Nitrogen Injection Line to Primary Containment Vessel, Unit 1, Fukushima Dai-ichi NPS

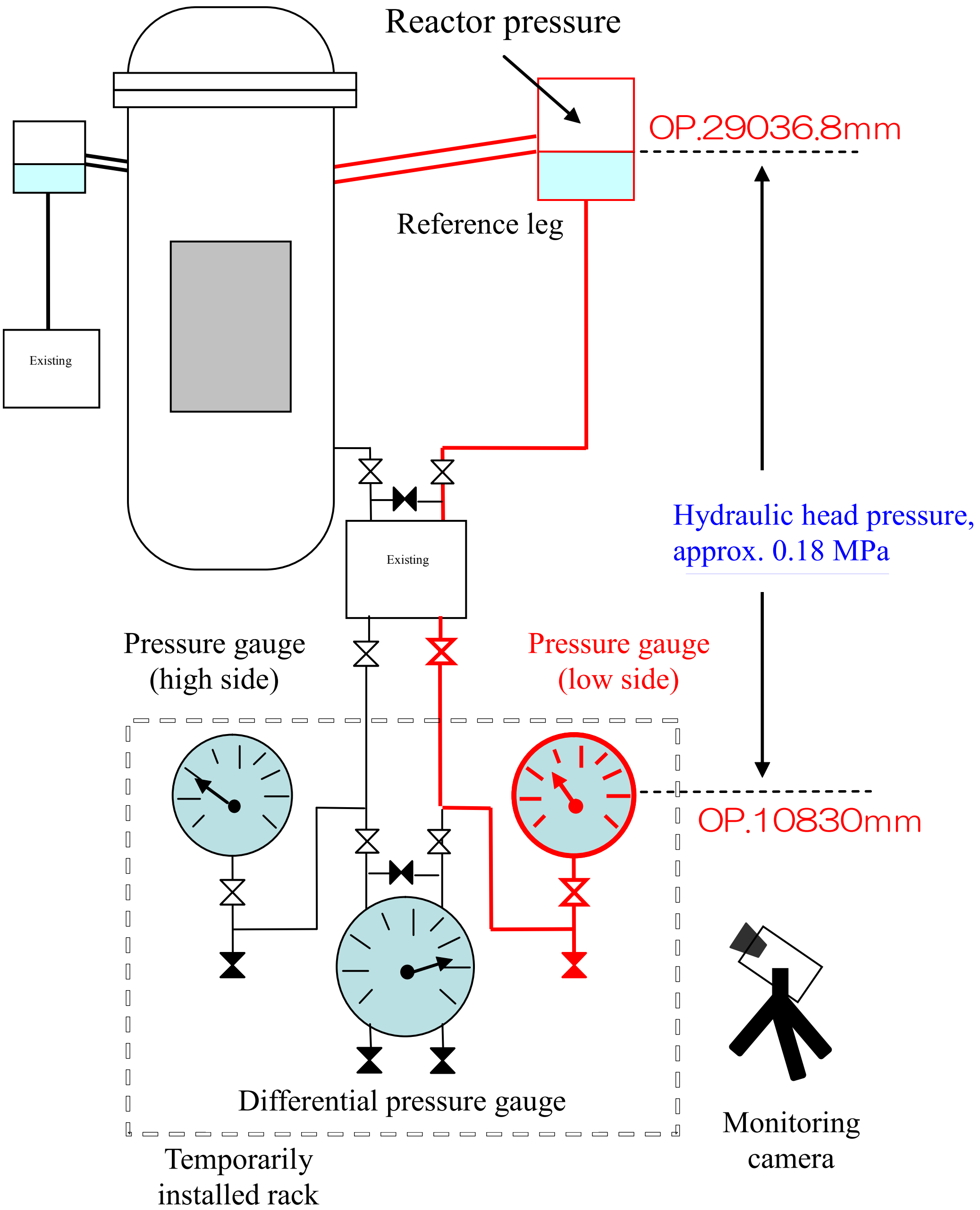


Figure II-2-30 Concept Diagram for Installation of Temporarily Installed Reactor Pressure Gauge, Unit 1, Fukushima Dai-ichi NPS

Temperature Parameter (Typical Point), Unit 2, Fukushima Dai-ichi NPS

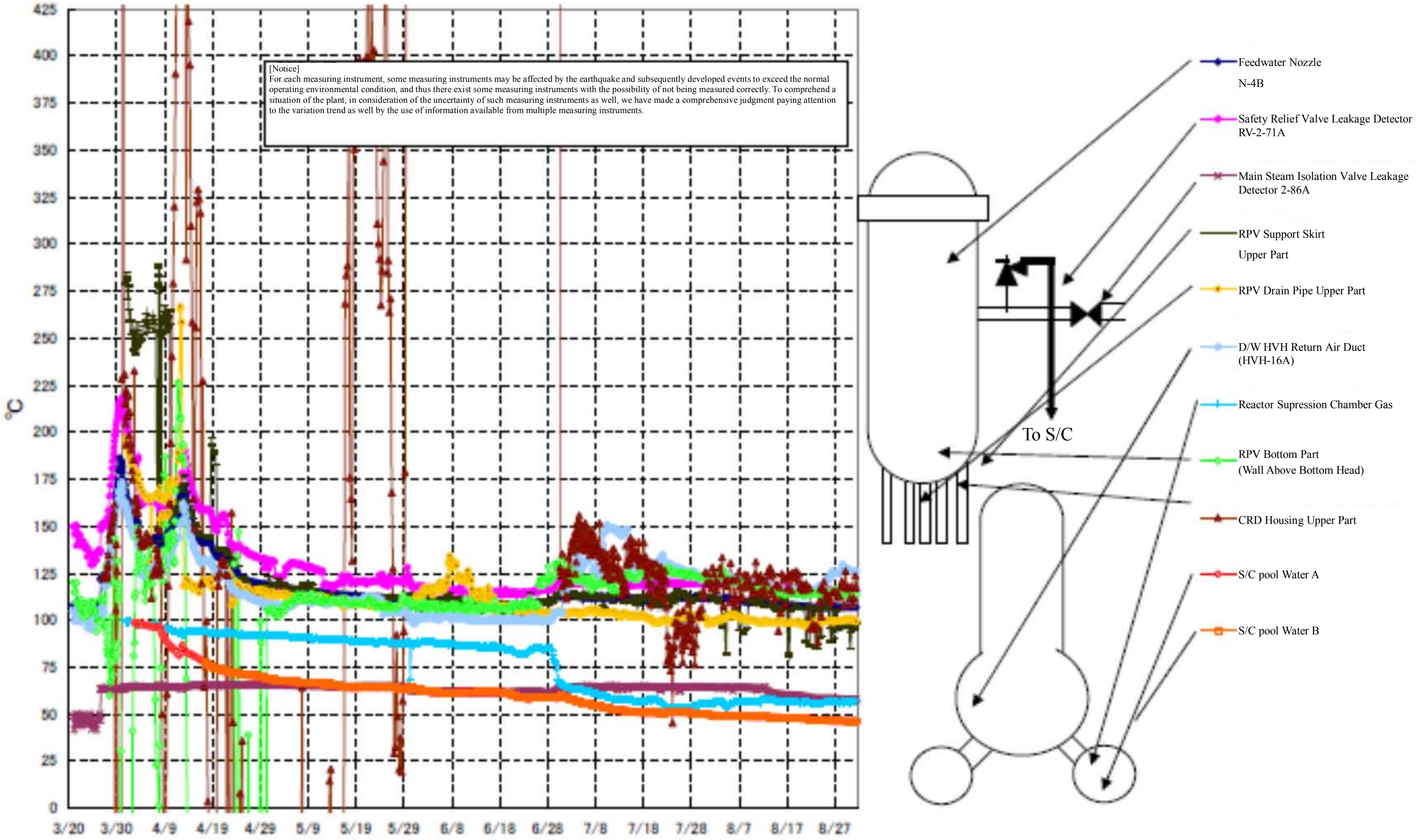


Figure II-2-31 Temperature Parameter, Unit 2, Fukushima Dai-ichi NPS

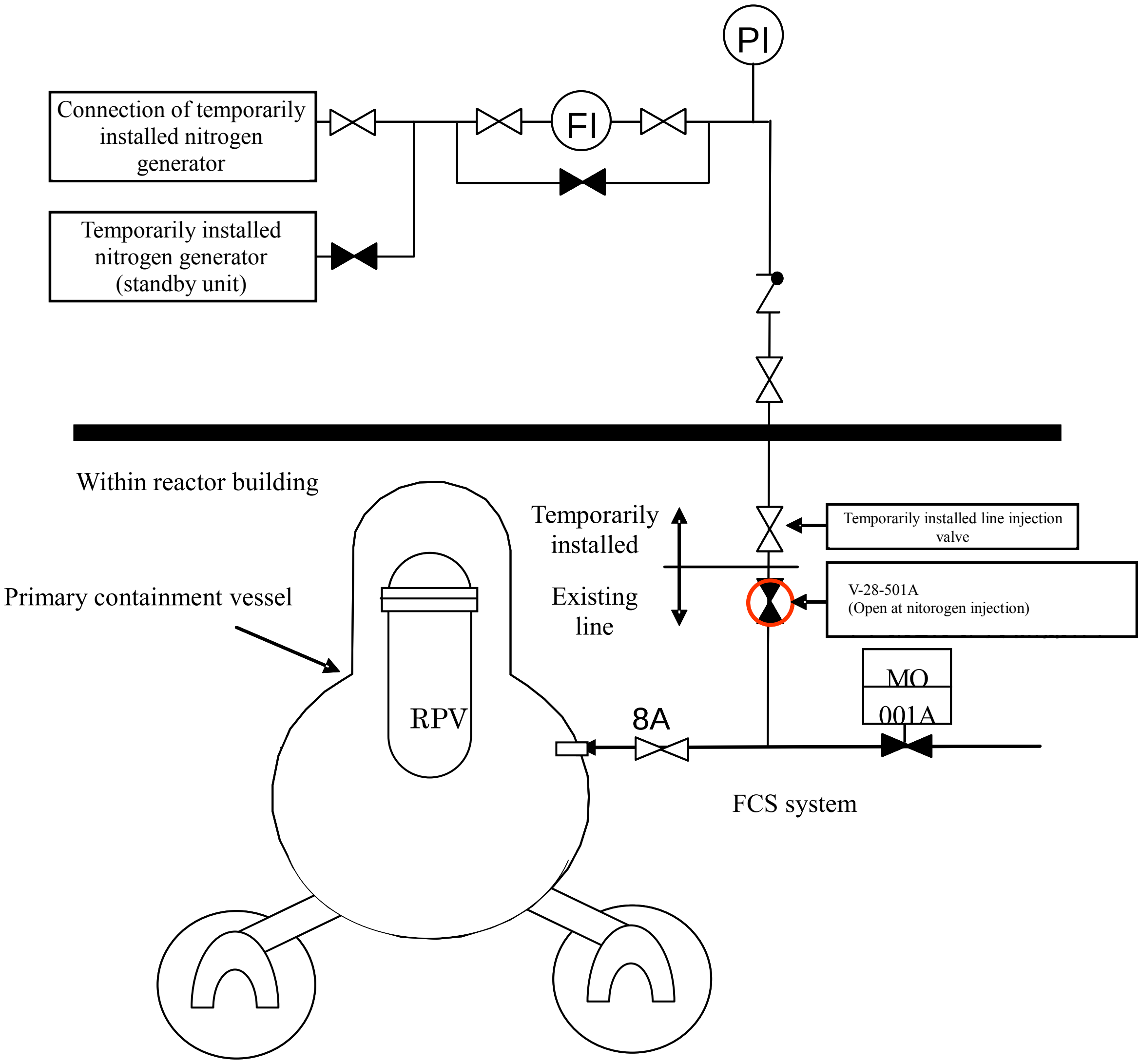
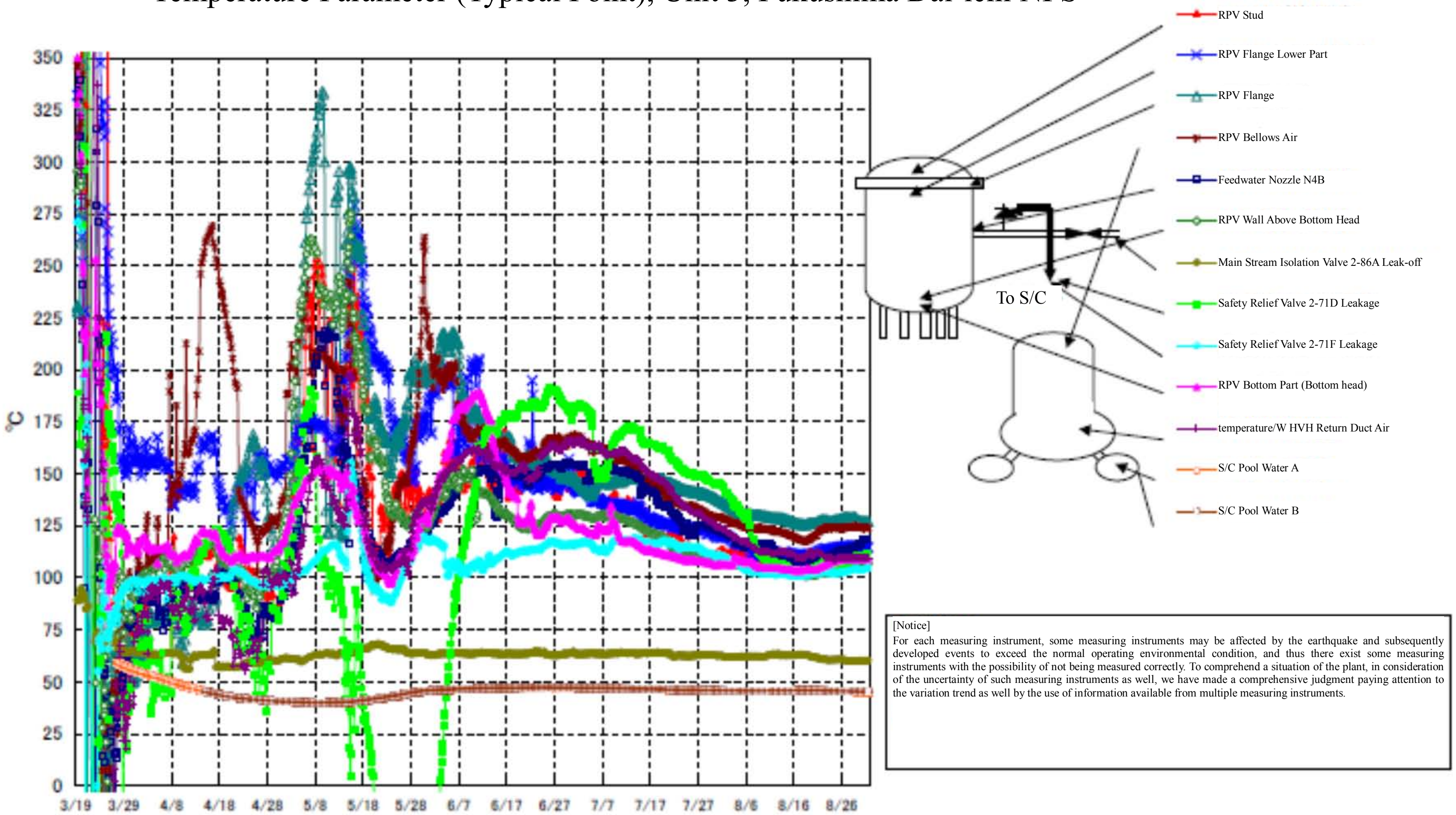


Figure II-2-32 Nitrogen Injection Line to Primary Containment Vessel, Unit 2, Fukushima Dai-ichi NPS

Temperature Parameter (Typical Point), Unit 3, Fukushima Dai-ichi NPS



[Notice]
For each measuring instrument, some measuring instruments may be affected by the earthquake and subsequently developed events to exceed the normal operating environmental condition, and thus there exist some measuring instruments with the possibility of not being measured correctly. To comprehend a situation of the plant, in consideration of the uncertainty of such measuring instruments as well, we have made a comprehensive judgment paying attention to the variation trend as well by the use of information available from multiple measuring instruments.

Figure II-2-33 Temperature Parameter, Unit 3, Fukushima Dai-ichi NPS

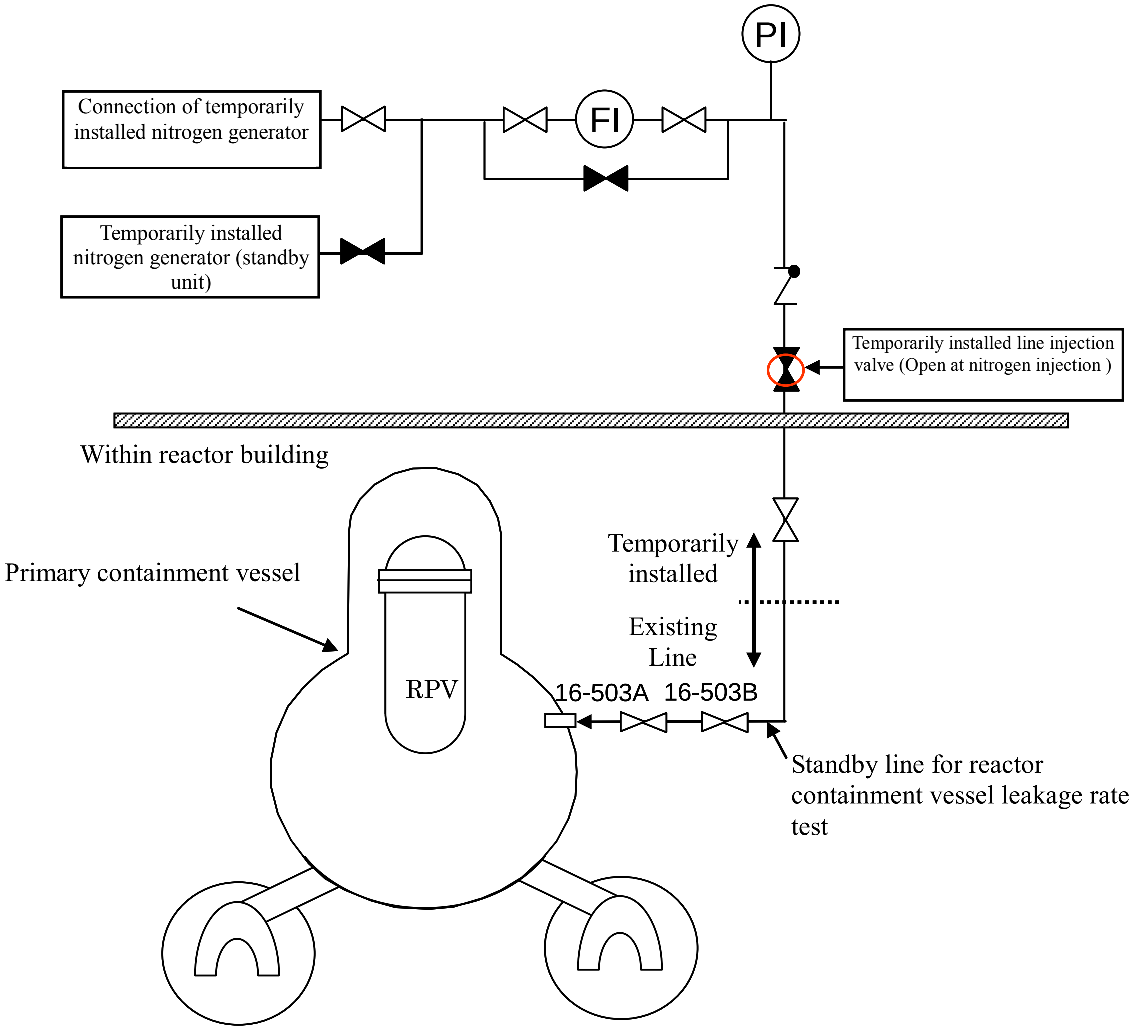


Figure II-2-34 Nitrogen Injection Line to Primary Containment Vessel, Unit 3, Fukushima Dai-ichi NPS

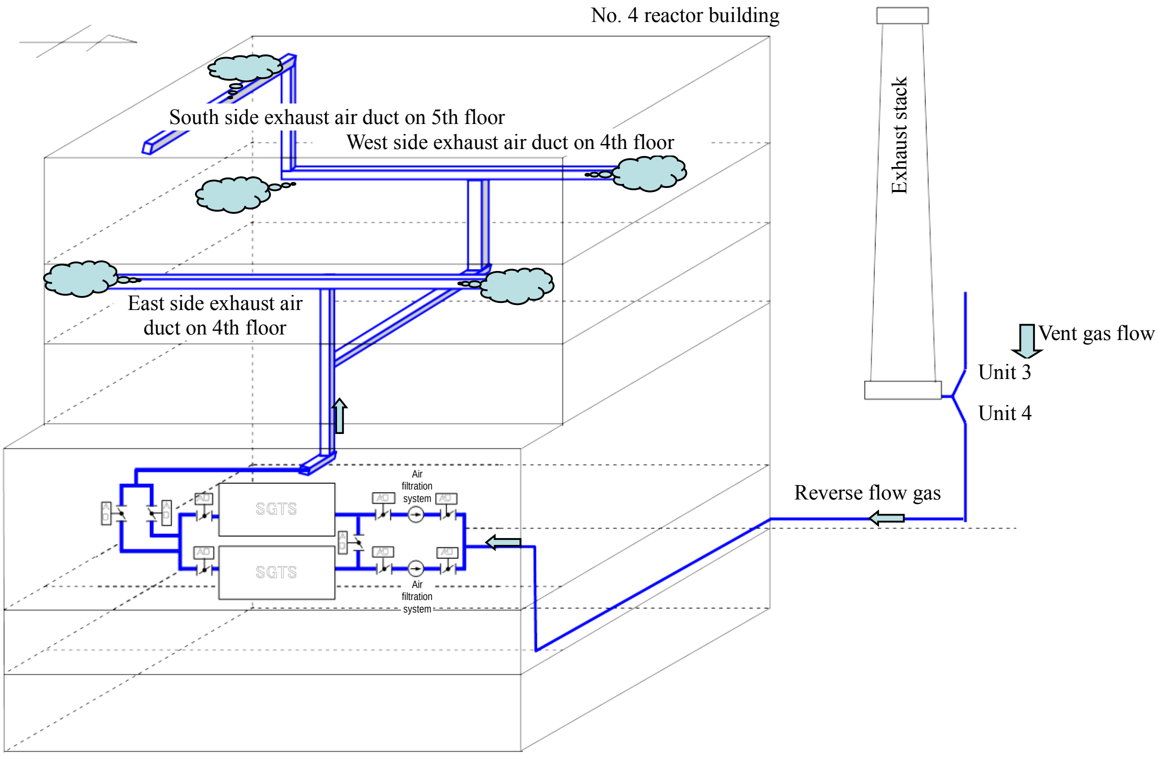


Figure II-2-35 Inflow Path of PCV Vent Flow from Unit 3 to Unit 4

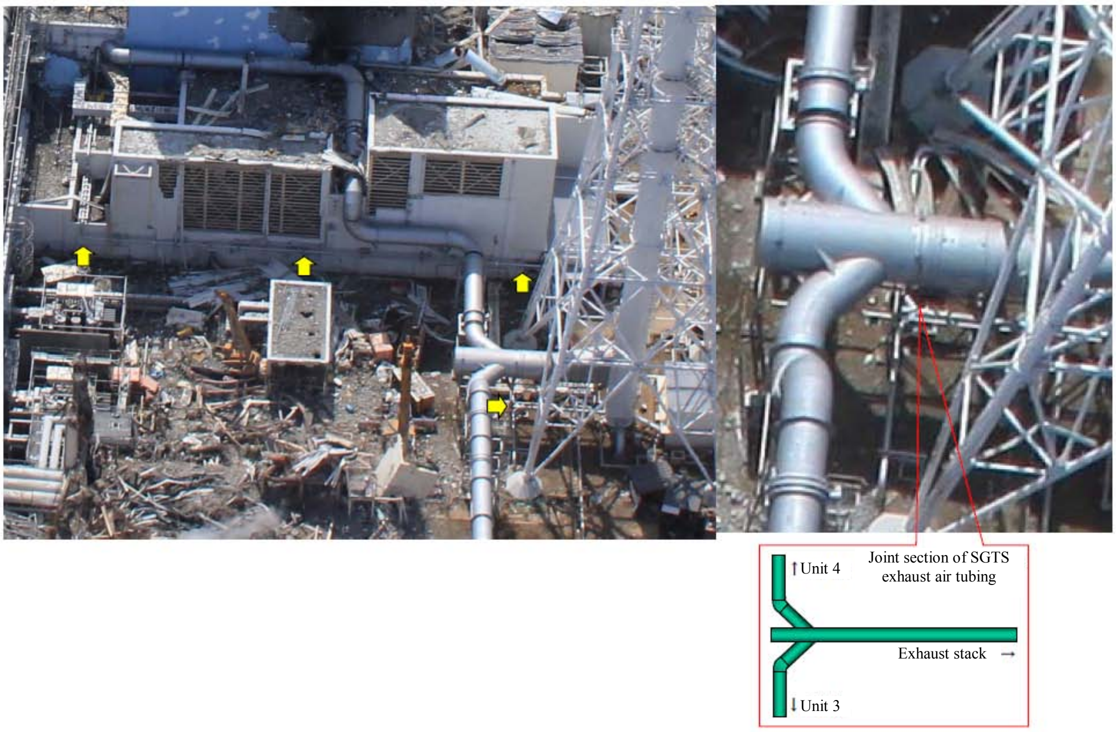


Figure II-2-36 SGTS Exhaust Air Piping

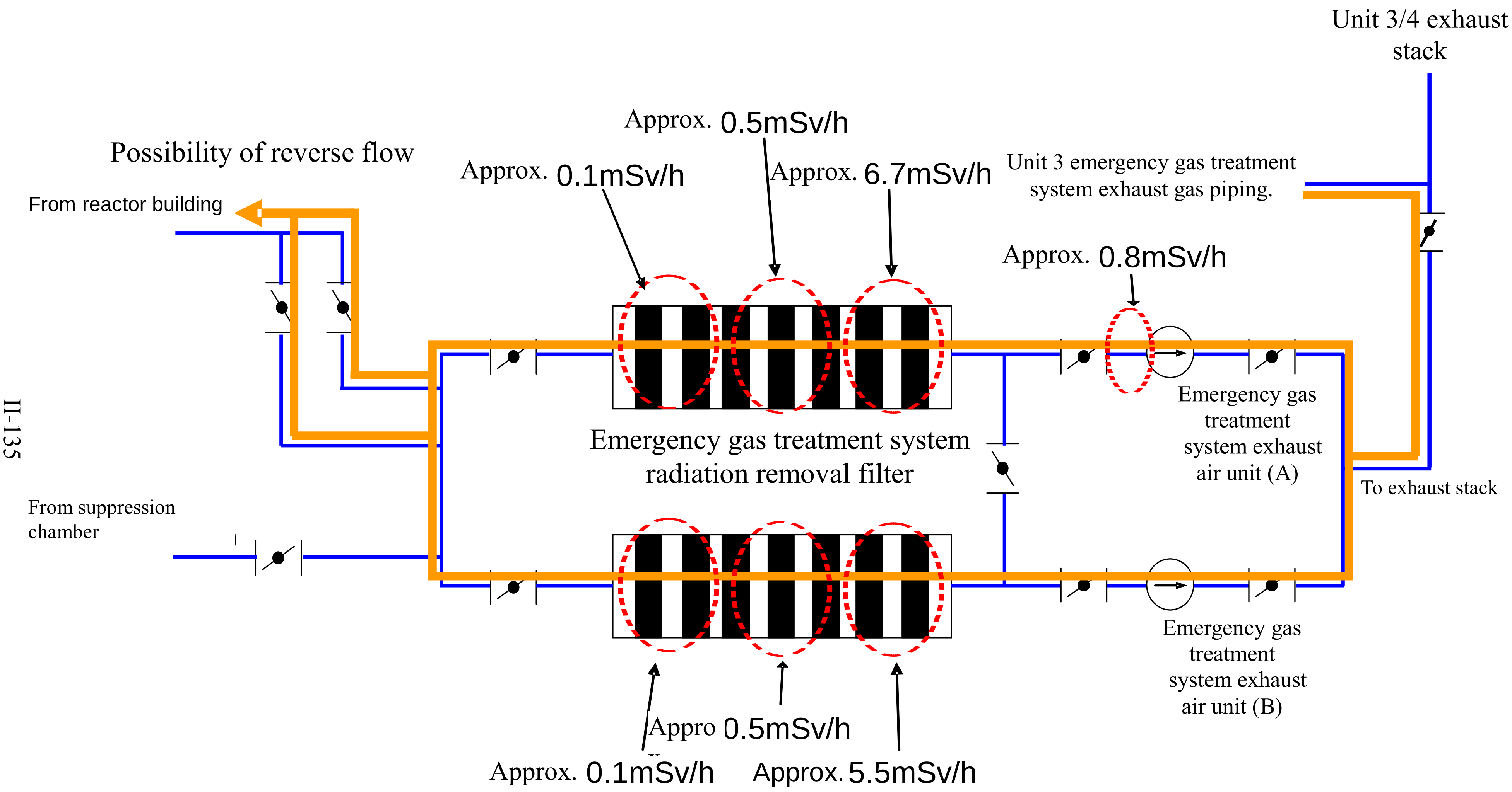


Figure II-2-37 Measurement Result of Unit 4 SGTS Radiation Dose (Measured in August 25, 2011)

g. Fuel pool

○ Unit 1

As of March 11, 292 assemblies of spent fuel and 100 assemblies of fresh fuel were stored in the SFP of Unit 1. Also, decay heat was calculated 0.18MW as of March 11, and at 0.16MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, all AC power and consequently seawater pump function were lost, and subsequently the cooling and makeup water functions of the SFP were lost. At 15:36 on March 12, the reactor buildings were damaged by an explosion assumed to be a hydrogen gas explosion, and ceiling parts fell on the upper side of the pool. However, these ceiling parts didn’t fall entirely to the operating floor, as some were instead hanging on the upper side of the operating floor, appearing as if they were located above the overhead crane.

Water spraying had been conducted by Concrete Pump Truck since March 31 till May 22, total amount was 240t (fresh water). However, it was uncertain that conclusive water injection had made or not by the spraying of Concrete Pump Truck.

Test injection was made by FPC piping with fresh water source on May 28, when full-scale injection was conducted next day, full capacity of water was confirmed by verification of rising of Skimmer Surge Tank Level (2,050mm→4,550mm) which is considered to be overflow of pool water. Total amount of water injected till full capacity was 413t, since whole amount of water wasn’t seemed to be reached, total amount of lost water since the occurrence of accident was considered less than this. Amount of water for the pool with normal water level is around 1,000t and depth of the pool is about 3 times of the fuel active length. Considering these facts, water level of SFP at Unit 1 was seemed to have been kept and exposure of fuel was highly unlikely.

Pool water cooling by alternative cooling system (Figure II-2-38) was started on August 10. When the cooling was started, water temperature was 47ºC (FPC pump inlet temperature), reached to steady condition approximately on August 27, water temperature has been stabilized around 30ºC since then. Results of water injection to SFP are shown in Table II-2-15.

Outflow water from SFP to Skimmer Surge Tank at Unit 1 which was sampled by pump drain piping of FPC on June 22 and August 19 and nuclide analysis of radioactive materials was conducted. (Analysis and sampling were done on the same date.) The results of analysis are shown in Table II-2-16.

Unit 1 shut down for refueling outage on March 25, 2010 and even the fuel with shortest cooling period had been cooled for around 1 year, therefore, detected short half-life nuclides Iodine 131 (half-life: about 8 days) wasn't considered to be emitted from the stored fuel in SFP, there is higher possibility to be from nuclear reactor. However, due to the fact that rubbles had fallen on the pool, possibility of damages on parts of spent fuel cannot be denied.

○ Unit 2

As of March 11, 587 assemblies of spent fuel and 28 assemblies of fresh fuel were stored at SFP of Unit 2. Also, decay heat was calculated 0.62MW as of March 11, and 0.52MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, all AC power and consequently seawater pump function were lost, and then cooling function and makeup water function of SFP were lost. At 15:36 on March 12, reactor buildings of Unit 1 were damaged by an explosion assumed to be a hydrogen gas explosion and the Blow-out Panel of reactor buildings at Unit 2 was opened with the influence of that explosion. White smoky vapor release from Blow-out Panel was confirmed, but starting time of release was uncertain.

Water injection by using existing FPC piping with seawater source was conducted on March 20. When the injection was conducted again on March 22, full capacity of water was confirmed by verification of rising of Skimmer Surge Tank Level (6,350mm→6,500mm) which is considered to be overflow of pool water. Total amount of water injected till full capacity was 58t, this amount was considered to be the same amount of water which was lost at the time of occurrence of the accident till reached to full capacity, and when it was compared with the amount about 1,400t which is normal water level of the pool, it was considerably small. In addition, measuring of water temperature by existing thermometer became available on March 20. Measured temperature continued to show the behavior of rising when water was full capacity and the behavior of declining when the exposure to gas-phase appeared by lowering water level. From the information of water level, water level of SFP at Unit 2 was seemed to have been kept and exposure of fuel was highly unlikely. Because fresh water could be used as a water source since March 29, the total amount of seawater injected was 88t. Since then, 1,082t of water had been injected at almost regular interval until full-scale operation of alternative cooling system started.

At 17:21, May 31, pool water cooling by alternative cooling system (Figure II-2-39) was started. When the cooling was started, water temperature was 70ºC (SFP thermometer reading), reached to steady condition approximately on June 5, water temperature has been stabilized at around 30ºC since then. Results of water injection to SFP are shown in Table II-2-17.

Outflow water from SFP to Skimmer Surge Tank at Unit 2 was sampled by sampling piping of FPC on April 16 and August 19, 2011 and nuclide analysis of radioactive materials was conducted (date of analysis: April 17 and August 19). The results of analysis are shown in Table II-2-18. Unit 2 shut down for refueling outage on September 16, 2010 and even the fuel with shortest cooling period had been cooled for around 7 months, therefore, detected short half-life nuclides Iodine 131 (half-life: about 8 days) wasn't considered to be emitted by the stored fuel in SFP, and there is higher possibility to be from by nuclear reactor.

○ Unit 3

As of March 11, 514 assemblies of spent fuel and 52 assemblies of fresh fuel were stored at SFP of Unit 3. Also, decay heat was calculated 0.54MW as of March 11, and 0.46MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, all AC power and consequently seawater pump function were lost, and then cooling function and makeup water function of SFP were lost. At 11:01 on March 14, whole upper side exterior wall of operating floor was damaged by explosion assumed to be a hydrogen gas explosion, a large amount of rubbles fell down on SFP. From the bared operating floor caused by the damage of reactor buildings, a large amount of water vapor release was identified.

At around 09:48, March 17, seawater spraying to the upper side of reactor buildings by helicopter of Self-Defense Force was started. It was confirmed that steam came up after spraying. At 19:05, March 17, water spraying was started to SFP by water spraying trucks of police. Since then till March 25, water spraying had been conducted to SFP by water spraying trucks and water spraying trucks with bending arms of fire department (except for some cases, most of the spraying were done by seawater).

About 815t of water spraying was conducted by concrete pump trucks from March 27 to April 22. (Fresh water was sprayed after March 29.) Concrete pump truck were switched to the one equipped with camera on April 12. Graphic images by camera enabled spraying with recognition of water level up-rise, so full water capacity of SFP at Unit 3 was confirmed for the first time. The results of water injection to SFP are shown in Table II-2-19. When full capacity was confirmed, amount of water (about 35t) injected was smaller than estimated amount (about 80t : results on April 10) which was considered leakage of makeup water; therefore, water-level-decline more than amount of water which was lost by decay heat couldn't be considered. Also, according to the results of water injection, evaporated amount per day was estimated around 10-20t, therefore, amount of water which was lost by evaporation until full capacity was calculated around 320-640t. Even if there's no injection to SFP till full capacity, amount of water of SFP is about 1,400t and depth of SFP is about 3 times of the fuel active length, so it can be calculated that more than half of the water level can be remained. Additionally, even if water level would decline by sloshing and explosion of reactor buildings besides evaporation, it still allows more than 2m till exposure. Therefore, water level of SFP at Unit 3 would have been kept and exposure of fuel is highly unlikely.

On April 26, full-scale injection had been conducted by using existing FPC piping, around 824.5t injection with existing FPC piping had been made till June 29.

From the results of sampling, alkaline was detected from the pool water because of the elution of fallen rubbles' alkali metal (calcium etc.), alkaline corrosion of aluminum fuel racks was concerned. So, boric acid was injected to neutralize alkaline. By this, while pH11.2 (measured on May 8) of strong alkaline was shown before injection, pH9.0 (measured on July 7) of weak alkaline was shown after the injection. That's how water quality was improved.

On June 30, SFP cooling by alternative cooling system (Figure II-2-40) was started. Water temperature was around 62ºC when the cooling was started (temperature at the inlet of alternative cooling system). It reached to steady condition on around July 7, and water temperature has been stabilized at around 30ºC.

At Unit 3, pool water was sampled by using Concrete Pump Truck on May 8, and outflow water from SFP to Skimmer Surge Tank was sampled by sampling piping of FPC on July 7 and August 19, and nuclide analysis of radioactive materials was conducted (date of analysis: May 9, July 7 and August 19). The results of analysis are shown in Table II-2-20. Unit 3 shut down for refueling outage on June 19, 2010 and even the fuel with shortest cooling period had been cooled for more than 10 months, therefore, detected short half-life nuclides Iodine 131 wasn't considered to be emitted by the stored fuel in SFP, and there was higher possibility to be from nuclear reactor. Also, based on the fact that results of analysis of accumulated water at underground of turbine of Unit 3 and ratio of each nuclide was similar in extent, possibility of reactor-generated influence seemed higher. However, due to the fact that rubbles had fallen on the pool, possibility of damages on parts of spent fuel cannot be denied.

When pool water sampling was conducted on May 8, filming by video camera was done at the same time. Picture is shown in Figure II-2-41. Because a large amount of rubbles fell inside of pool water, conditions of fuel etc. stored in pool couldn't be confirmed.

○ Unit 4

As of March 11, 1,331 assemblies of spent fuel and 204 assemblies of fresh fuel were stored at SFP of Unit 4. Also, decay heat was calculated 2.26MW as of March 11, and 1.58MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, all AC power and consequently seawater pump function were lost, and then cooling function and makeup water function of SFP were lost. On March 15, upper-side etc. wall of operating floor was damaged by explosion assumed to be a hydrogen gas explosion.

On March 16, when measurement of dose rate was conducted for the purpose of water spraying by helicopter on Unit 3, helicopter flew close to the operating floor of Unit 4. On this occasion, water surface of Unit 4 was visually observed, and reported there was no fuel exposure observed.

On March 20, fresh water spraying by water spraying truck of Self-Defence

Force was started. About 250t of water sprayed from ground had been conducted till March 21.

On March 22, seawater spraying by Concrete Pump Truck was made. Approximately 5,700t of water spraying (fresh water spraying after March 30) had been conducted until June 14.

On April 12, SFP water sampling and preceding water level measurement were done by using Concrete Pump Truck. On that occasion, measured water level was TAF+2.1m. On April 22, water level verification was done by Concrete Pump Truck again, and water level was even lower and measured TAF+1.7m. Water level of SFP were within expectation when yield ratio of injected water and evaporated amount by decay heat were considered, so water spraying by Concrete Pump Truck toward full capacity of SFP were conducted with measuring water level. On April 27, by observing wide range of rise of Skimmer Surge Tank Level (4,300mm→6,050mm) considered to be caused by overflow of SFP, full capacity was confirmed. Possibility of leakage from the SFP of Unit 4 was pointed out, but consequent relation between water injection and water level turned out to be within the decreasing-level by expected evaporation from decay heat. So it was assumed that there’s no large amount of leakage from SFP.

On April 27, measurement of water level on reactor well side was conducted for the first time since the accident. Water level was TAF+1.8m. Loss of large amount of water was not seemed to be caused by evaporation because there was no source of heat generation and there was full capacity before the earthquake. Therefore, water of reactor well side was presumed to flow to SFP side through pool gate along with lowering water level of SFP and minimum water level of SFP was considered to be the same level. (Approximately TAF+1.8m)

On April 29, it was confirmed that a large amount of drain water wasn’t present at drain system of SFP inside of reactor buildings, and this could be another evidence of non-leakage of a large amount of water from SFP.

On June 16, water injection by a temporary SFP injection facility was conducted. Amount of 280t of water had been injected by the temporary SFP injection facility until July 31.

On June 19, water injection from In Core Monitor (ICM)piping to reactor well and Dryer and Separator (DS) Pit was conducted for the purpose of suppressing radiation dose which came from the in-core structure stored inside of DS Pit.

After reaching to full capacity at reactor well, decline of water level at reactor well side was observed, and increase of Skimmer Surge Tank Level at the time of reactor well injection was confirmed. So, water was considered to be poured into SFP side. Water injection only from reactor ICM piping has been conducted since July 1.

On June 31, pool water cooling by alternative cooling system (Figure II-2-42) was started. Water temperature was around 75ºC when the cooling was started (temperature at the inlet of alternative cooling system). It reached to steady condition on around August 3, and water temperature has been stabilized at around 40ºC. Results of water injection to SFP are shown in Figure II-2-21.

At Unit 4, pool water was sampled by using Concrete Pump Truck on April 12, April 28 and May 7, and outflow water from SFP to Skimmer Surge Tank was sampled by pump drain piping of FPC on August 20, and nuclide analysis of radioactive materials was conducted (date of each analysis: April 13, April 29, May 8 and August 20). The results of analysis are shown in Table II-2-22. From these results, most of the fuel inside SFP is in sound condition, it is presumed that systematic mass damage didn't occur. However, due to the fact that reactor buildings at Unit 4 were damaged and rubbles had fallen on the pool, possibility of damages on parts of the fuel cannot be denied. Unit 4 shut down for refueling outage on November 30, 2010 and even the fuel with shortest cooling period had been cooled for more than 4 months; therefore, detected short half-life nuclide Iodine 131 (half-life: about 8 days) wasn't considered to be emitted by the stored fuel in SFP, there is higher possibility to be from nuclear reactors of Units 1 to 3.

Due to the periodic inspection at Unit 4, water was filled at both of reactor well and DS Pit and pool was separated by a pool-gate. As shown in Figure II-2-43, connecting part of SFP and reactor well is being shut from SFP side by pool gates and its water tightness is being kept by water pressure from SFP. Because there is no water in the reactor well side during operation, pool gate receives major water pressure. On the other hand, Unit 4 was under periodic inspection and water was retained in the reactor well side. Therefore, retained water in SFP side was being evaporated after the cooling function of FPC was lost, and water level on reactor well side is considered to become high and water level of SFP side is considered to become low. In that case, as shown in the Figures II-2-44 and II-2-45, pool gate will turn out to receive water pressure from opposite side to normal and water-tightness of pool-gate will be lost structurally, then water will pour in till reaching to the same water level as reactor well side. In addition, pool-gate is installed to be hooked on a hook-like structure at SFP to avoid being fallen over by a pressure from reactor well side, so water running from reactor well side flows through a small gap between SFP and pool-gate.

When pool water sampling was conducted on May 7, filming by video camera was done at the same time. Pictures are shown in Figure II-2-46 to Figure II-2-49. Even though small and large rubbles fell down into pool water, it was observed that fuel stored in SFP had kept a condition of being stored in rack.

Moreover, Tokyo Electric Power Co. Inc. installed supporting structures at the bottom of SFP to improve safety margin. Load-reduction effect started to be expected after steel brace installation was completed on June 20. Furthermore, concrete and grout were filled to strengthen functions and installation of supporting structures was completed on July 30 (Figure II-2-50).

○ Evaluation of SFP water level at Units 1 to 4.

Situations of SFP at Units 1 to 4 have been indicated so far, and regarding the Units whose cooling function and makeup water function of SFP were lost for a long period of time, it was recognized to be important for fuel assemblies to be kept flooded until cooling function gets recovered.

The following is the results of evaluation by Tokyo Electric Power Co. Inc. on SFP water level since March 11 at Units 1 to 4. With this evaluation, energy balancing is modeled between the energy generated as decay heat and the energy spent for water temperature rising in pool water, cooling by water injection from outside and heat removal energy by water evaporation and heat release. By inputting calculated time series of data of decay heat based on the stored fuel at each Unit and actual injection results for each Unit, stored water level is evaluated as follows: Also, based on the possibility of losing pool water by sloshing at the time of earthquake and explosion, evaluation was conducted under the assumption of losing a large amount of water for the sake of conservative evaluation for keeping water level above TAF level. Also, with this evaluation, it was presumed that generated energy by decay heat at the initial stage was consumed for water temperature rising, and didn’t contribute to evaporation. It was also presumed that after reaching steady temperature (evaporation starting temperature), water temperature rising would not be counted and energy was presumed to be consumed for evaporation.

Results of evaluation of SFP at Unit 1 are shown in Figure II-2-51. With this evaluation results, water level is presumed to be diminished once (by 1.5m) by March 13 due to the influence of sloshing by earthquake and explosion, and then water level is presumed to be maintained until reaching to 70ºC, evaporation starting temperature of water, and after that water level is presumed to be lowered by evaporation. Water level was recovered by water injection on March 31 and also by injection from FPC piping in late May, and full capacity of water was observed by rising of Skimmer Surge Tank Level on May 29 and June 5. Also, because the amount of decay heat of SFP at Unit 1 was smaller than that of other Units in comparison, the amount of decrease in water level was small even though water injection had not been conducted for more than one month, and water level as of late June was evaluated as around 6m level above the top of fuel rack.

Results of evaluation of SFP at Unit 2 are shown in Figure II-2-52 along with reading results. With this evaluation results, water level is presumed to be diminished (by 0.5m) due to the influence of sloshing by earthquake. And after reaching to 70ºC, evaporation starting temperature of water, water level went lower by evaporation but water level recovered by injection each time. Water level continued to appear declined by evaporation and recovered by injection, looked like a saw-tooth edge. Water level control has been done at around full capacity level in general.

Water injection by existing FPC can be done because there is no major damage on reactor building at Unit 2, and water injection by using appropriate line has been conducted periodically. When SFP reached to full capacity, overflow water pours into Skimmer Surge Tank and measure of water level at Skimmer Surge Tank goes up. By utilizing this basis, water level of SFP at

Unit 2 is being confirmed. That is to say, the time when water level of Skimmer Surge Tank is rising means that full capacity of SFP has been reached. Those points are shown as water level readings in Figure II-2-52.

According to Figure II-2-52, evaluation readings of water level are accorded with measurement readings generally. Reason why evaluation readings from mid-March to late March were lower than measurement readings (full capacity), to be assumed that there was an effect of bigger estimate of initial sloshing influence for the safety reason. Also, an existing water temperature meter of FPC can be used and measurements are taken periodically. As the results of measurement show, once level went up to nearly 70ºC right after injection and then down to around 50ºC after a couple of days, and this inclination of fluctuation has been continued. This has been caused by exposure of thermometer from water by lowered water level of SFP and after exposure, atmospheric temperature has been shown instead of water temperature.

At 17:21, on May 31, after full scale operation of alternative cooling system, water cooling of SFP was conducted and water temperature has been at around 30ºC (34ºC as of 14:00, July 7).

Results of evaluation of SFP water level at Unit 3 are shown in Figure II-2-53 along with reading results. With this evaluation results, water level is presumed to be diminished (by 1.5m) by March 14, due to the influence of sloshing by earthquake and explosion. After March 17, intensive water spraying had been conducted and water level was recovered. Periodic water injection has been conducted since then and water level has been controlled at around full capacity level. (Water injection could not be done in late April to early May due to a trouble of pump truck.) In addition, considering different ratio of actual amount of water poured into each pool at an earlier stage by water spraying from truck, by water injection from Concrete Pump Truck and by water injection from FPC piping, yield ratio has been set for each case.

Water level measurement has been conducted since mid-April through observed images taken by a camera installed at concrete pump truck. Measurement readings and evaluation readings match in general. Water level of SFP has continued to be fluctuated, lowered by evaporation and recovered by injection, so that it seems to be controlled at around full capacity level in general.

Regarding water temperature measurement, only one result showed around 60ºC, but because this measurement was taken from the water sampling result which was collected on the surface of the pool, this temperature seemed to be lower than the average pool water temperature. Water temperature at the time of evaporation on evaluation basis has been set at 70ºC, based on the result of SFP at Unit 2 having a similar decay heat.

At 19:47, on June 30, after full scale operation of alternative cooling system, water cooling of SFP was conducted and water temperature has reached to around 30ºC (30.8ºC as of 11:00, July 7, temperature at the inlet of heat exchanger).

Results of evaluation of SFP water level at Unit 4 are shown in Figure II-2-54 along with reading results. With this evaluation results, water level is presumed to be diminished (by 1.5m), due to the influence of sloshing by earthquake and explosion. After reaching to 90ºC (evaporation starting temperature), water level went lower by evaporation. Water level recovery has been made by water injection since March 20. Evaporation amount had been above injection amount until around on April 20, and water level had been lowered to the level at +1.5m of the top of fuel rack. After intensive water injection from April 22 to April 27 had made water level recovered to full capacity, injection was stopped till May 5 to observe the tendency of decreasing level. After that, intensive water spraying had been conducted and water level was recovered. Water level has continued to be fluctuated, lowered by evaporation and recovered by injection, and it seems to be controlled at around full capacity level generally. In addition, considering different ratio of actual amount of water poured into each SFP at an earlier stage by water spraying from truck, by water injection from Concrete Pump Truck and by water injection from temporary SFP water injection facility, yield ratio has been set for each case, assuming from the results etc. of water level measurement.

Thermocouple has been hanged at Concrete Pump Truck since mid-April and water level measurement has been frequently conducted. Measurement readings and evaluation readings match in general.

Regarding water level evaluation before April 22 when a declining trend of pool water level had been generally seen, water in SFP and water in reactor well were regarded as one, and after intensive injection to pool had been conducted, water of SFP and reactor well were regarded as independent ones. Regarding water level of reactor well, results of measurement, which indicated stabilized level at around 2m above of fuel rack, have been obtained since early May, and they match well with results of evaluation in general.

Measurement of water temperature has been conducted by using a thermocouple hanged at Concrete Pump Truck, along with the water level measurement. Most of the measurement results show around 90ºC and their temperatures look high compared with the results at Unit 2 which show 70ºC. This is because of high fuel decay heat of SFP at Unit 4, and temperature at quasi-steady condition is high. Some measurement results show below 70ºC as shown in Figure II-2-54, and this is due to water sampling, etc. taken from the surface of the pool.

Based on these facts, it was determined that, since the occurrence of earthquake to date, such damage as having effect on preservation of water level at SFP has not been identified, water level has been kept and the exposure of fuel has not occurred.

○ Unit 5

As of March 11, 946 assemblies of spent fuel and 48 assemblies of fresh fuel were stored in SFP of Unit 5. Decay heat was calculated 1.01MW as of March 11, and 0.76 MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, station blackout occurred and consequently seawater pump function was lost, and cooling function and makeup water function of SFP were lost.

Water temperature of SFP kept increasing; however a temporary cooling facility started its operation in full-scale at 5:00 on March 19. Increase in the water temperature was 68.8°C at the highest, and it became possible to maintain a stable cooling status. In this regard, since the temporary cooling facility was decided to use for cooling reactor fuel and was operated by switching lines, the water temperature of the pool was increased when switching cooling system, and fluctuated between 30°C and 50°C.

Because transition to the SHC mode was carried out on May 6 and isolated operation became possible on June 25, it became possible to maintain more stable cooling condition, and water temperature has been stable at around 30°C.

○ Unit 6

As of March 11, 876 assemblies of spent fuel and 64 assemblies of fresh fuel were stored in SFP of Unit 6. Decay heat was calculated 0.87 MW as of March 11, and 0.73 MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, the seawater pump for cooling FPC lost its function (but emergency DG (6B) kept its function), and cooling function and makeup water function of SFP were lost.

The water temperature of SFP kept increasing; however, a temporary cooling facility started its operation in full-scale at 22:00 on March 19. Increase in the water temperature was 67.5°C at the highest, and it became possible to maintain a stable cooling status. In this regard, since the temporary cooling facility was decided to use for cooling reactor fuel and was operated by switching lines, water temperature of the pool was increased when switching cooling system, and fluctuated between 20°C and 40°C.

Transition to the SHC mode was carried out on May 6, and because of the effect of an increase in air temperature, the water temperature has been stable between 30°C and 50°C.

○ Common pool

As of March 11, 6,375 assemblies of spent fuel were stored in the common pool of the Fukushima Dai-ichi NPS. Decay heat was calculated 1.13 MW as of March 11, and 1.12 MW as of June 11.

By the tsunami caused by Tohoku District – Off the Pacific Ocean Earthquake at 14:46 on March 11, station blackout occurred, and then cooling function (air cooling) and makeup water function of the common pool were lost.

On March 18, the common pool was inspected, and it was confirmed that the water level was secured

The water temperature of the common pool kept increasing, but since a temporary cooling facility started its operation in full-scale at 18:00 on March 24, an increase in water temperature was 73°C at the highest, and it became possible to maintain a stable cooling condition.

Since then, it has kept the stable condition at the temperature between 30 to 40°C.

Table II-2-15 Status of Water Injection into Unit 1 Spent Fuel Pool

As of 09:00 August 12, 2011

		Total quantity of injection	Approx. 578 (t)
Date and time	Means	Water type	Quantity of injection (t)
March 31, from 13:03 till 16:04	TEPCO concrete pump tracks (62 m class)	Fresh water	90
April 2, from 17:16 till 17:19	TEPCO concrete pump tracks (62 m class)	Fresh water	(Confirmation of water spraying position)
May 14, from 15:07 till 15:18 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	- (Water spraying was canceled due to high wind.)
May 20, from 15:06 till 16:15 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	60 (Approx. 90t was planned, but water spraying was stopped due to high wind and the like.)
May 22, from 15:33 till 17:09 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	90
May 28, from 16:47 till 17:00 (water spraying)	FPC	Fresh water	5 (leak test)
May 29, from 11:10 till 15:35	FPC	Fresh water	168
June 5, from 10:16 till 10:48	FPC	Fresh water	15
July 5, from 15:10 to 17:30	FPC	Fresh water	75
August 5, from 15:20 till 17:51	FPC	Fresh water	75

Table II-2-16 Analysis Result of Unit 1 Skimmer Surge Tank Water

Detected nuclides	Half-life	Concentration (Bq/cm^3)			
		Sampled on June 22	Sampled on August 19	(Reference) Unit 1 spent fuel pool water (February 11)	(Reference) Accumulated water on basement floor at Unit 1 turbine building (March 26)
Cesium 134	Approx. 2 years	1.2×10^4	1.8×10^4	Less than detection limit	1.2×10^5
Cesium 137	Approx. 30 years	1.4×10^4	2.3×10^4	7.8×10^{-2}	1.3×10^5
Iodine 131	Approx. 8 days	68	Less than detection limit	Less than detection limit	1.5×10^5

Table II-2-17 Status of Water Injection into Unit 2 Spent Fuel Pool

As of 09:00 August 12, 2011

		Total quantity of injection	(Maximum) approx. 1122 (t)
Date and time	Means	Water type	Quantity of injection (t)
March 20, from 15:05 till 17:20	FPC	Sea water	40
March 22, from 16:07 till 17:01	FPC	Sea water	18
March 25, from 10:30 till 12:19	FPC	Sea water	30
March 29, from 16:30 till 18:25	FPC	Fresh water	15 to 30
March 30, from 19:05 till 23:50	FPC	Fresh water	less than 20
April 1, from 14:56 till 17:05	FPC	Fresh water	70
April 4, from 11:05 till 13:37	FPC	Fresh water	70
April 7, from 13:29 till 14:34	FPC	Fresh water	36
April 10, from 10:37 till 12:38	FPC	Fresh water	60
April 13, from 13:15 till 14:55	FPC	Fresh water	60
April 16, from 10:13 till 11:54	FPC	Fresh water	45
April 19, from 16:08 till 17:28	FPC	Fresh water	47
April 22, from 15:55 till 17:40	FPC	Fresh water	50
April 25, from 10:12 till 11:18	FPC	Fresh water	38
April 28, from 10:15 till 11:28	FPC	Fresh water	43
May 2, from 10:05 till 11:40	FPC	Fresh water	55
May 6, from 09:36 till 11:16	FPC	Fresh water	58
May 10, from 13:09 till 14:45	FPC	Fresh water	56
May 14, from 13:00 till 14:37	FPC	Fresh water	56
May 18, from 13:10 till 14:40	FPC	Fresh water	53
May 22, from 13:02 till 14:40	FPC	Fresh water	56
May 26, from 10:06 till 11:36	FPC	Fresh water	53
May 30, from 12:06 till 13:52	FPC	Fresh water	53

May 31, from 17:21 till start of operation of SFP circulating cooling system From 10:47 till 11:04 (primary system water filling) From 11:40 till 11:50 (L/T) From 17:21 (in-service after T/R)	SFP circulating cooling system	Fresh water	-
June 1, from 06:06 till 06:53 (Due to lowering of skimmer surge tank water level)	FPC	Fresh water	25

Table II-2-18 Analysis Result of Unit 2 Skimmer Surge Tank Water

Detected nuclides	Half-life	Concentration (Bq/cm^3)			
		Sampled on April 16	Sampled on August 19	(Reference) Unit 2 spent fuel pool water (February 10)	(Reference) Accumulated water on basement floor at Unit 2 turbine building (March 27)
Cesium 134	Approx. 2 years	1.6×10^5	1.1×10^5	Less than detection limit	3.1×10^6
Cesium 137	Approx. 30 years	1.5×10^5	1.1×10^5	0.28	3.0×10^6
Iodine 131	Approx. 8 days	4.1×10^3	Less than detection limit	Less than detection limit	1.3×10^7

Table II-2-19 Status of Water Injection into Unit 3 Spent Fuel Pool

As of 09:00 August 12, 2011

		Total quantity of injection	Approx. 6167.5 (t)
Date and time	Means	Water type	Quantity of injection (t)
March 17, from 09:48 till 10:01	Helicopters of the Self-Defense Force	Sea water	30
March 17, from 19:05 till 19:13*[1]	High-pressure water cannon vehicles of the Tokyo Metropolitan Police's mobile unit	Sea water	44
March 17, from 19:35 till 20:09	High-pressure water cannon vehicles of the Self-Defense Force	Real water	30*[2]
March 18, from around 14:00 till 14:38	High-pressure water cannon vehicles of the Self-Defense Force	Real water	40*[3]
March 18, from 14:42 to 14:45	High-pressure water cannon vehicles of U.S. military forces	Real water	2
March 19, from 0:30 till 01:10	Refractive water cannon tower vehicles and others of Tokyo Fire Department (Tokyo Fire Department)	Sea water	60
From 14:10 on March 19 till 03:40 on March 20	Refractive water cannon tower vehicles and others of Tokyo Fire Department (Tokyo Fire Department)	Sea water	2430
From around 21:36 on March 20 till 03:58 on March 21	Refractive water cannon tower vehicles and others of Tokyo Fire Department (Tokyo Fire Department, Osaka City Fire Department)	Sea water	1137
March 22, from 15:10 till 15:59	Refractive water cannon tower vehicles and others of Tokyo Fire Department (Tokyo Fire Department, Osaka City Fire Department)	Sea water	150
March 23, from 11:03 to 13:20	FPC	Sea water	35
March 24, from around 05:35 till around 16:05	FPC	Sea water	120
March 25, from 13:28 to 16:00	Refractive water cannon tower vehicles and others of Tokyo Fire Department (Kawasaki City Fire Department supported by Tokyo Fire Department))	Sea water	450
March 27, from 12:34 till 14:36	TEPCO concrete pump tracks (52 m class)	Sea water	100
March 29, from 14:17 till 18:18	TEPCO concrete pump tracks (52 m class)	Fresh water	100
March 31, from 16:30 till 19:33	TEPCO concrete pump tracks (52 m class)	Fresh water	105
April 2, from 09:52 till 12:54	TEPCO concrete pump tracks (52 m class)	Fresh water	75
April 4, from 17:03 till 19:19	TEPCO concrete pump tracks (52 m class)	Fresh water	70
April 7, from 06:53 till 08:53	TEPCO concrete pump tracks (52 m class)	Fresh water	70
April 8, from 17:06 till 20:00	TEPCO concrete pump tracks (52 m class)	Fresh water	75
April 10, from 17:15 till 19:15	TEPCO concrete pump tracks (52 m class)	Fresh water	80
April 12, from 16:26 till 17:16	TEPCO concrete pump tracks (62 m class)	Fresh water	35
April 14, from 15:56 till 16:32	TEPCO concrete pump tracks (62 m class)	Fresh water	25
April 18, from 14:17 till 15:02	TEPCO concrete pump tracks (62 m class)	Fresh water	30
April 22, from 14:19 till 15:40	TEPCO concrete pump tracks (62 m class)	Fresh water	50
April 26, from 12:00 till 12:02	TEPCO concrete pump tracks (62 m class)	Fresh water	(Confirmation of water level)
April 26, from 12:25 to 14:02	FPC	Fresh water	47.5

May 8, at 11:38 (water level measurement) From 12:10 till 14:10 (water injection) From 14:10 till 14:50 (water level measurement, sampling)	FPC	Fresh water	(Water level measurement, sampling) 60
May 9, from 12:14 till 15:00 (water injection) (water level measurement before and after water injection)	FPC	Fresh water	(Water level measurement) 80
May 16, from 15:00 till 18:32	FPC	Fresh water	106
May 24, from 10:15 till 13:35	FPC	Fresh water	100
May 28, from 13:28 till 15:08	FPC	Fresh water	50
June 1, from 14:34 till 15:54	FPC	Fresh water	40
June 5, from 13:08 till 15:14	FPC	Fresh water	60
June 9, from 13:42 till 15:31	FPC	Fresh water	55
June 13, from 10:09 till 11:48	FPC	Fresh water	42
June 17, from 10:19 till 11:57	FPC	Fresh water	49
June 26, from 09:56 till 11:23	FPC	Fresh water (containing boric acid)	45
June 27, from 15:00 to 17:18	FPC	Fresh water (containing boric acid)	60
June 29, from 14:45 till 15:53	FPC	Fresh water	30
June 30, from 09:45 till 10:43 (water filing and leakage confirmation) From 18:33 (operation confirmation) till 19:47 (start of alternative cooling system)	SFP circulating cooling system	Fresh water	-

*1 According to the records of National Police Agency, the durarion was from 19:05 till 19:15.
*2 According to the records of Ministry of Defense, the amount was 35 t.
*3 According to the records of Ministry of Defense, the amount was 49.5 t.

Table II-2-20 Analysis Result of Unit 3 Spent Fuel Pool Water

Detected nuclides	Half-life	Concentration (Bq/cm^3)				
		Unit 3 pool water				(Reference) Accumulated water on basement floor at Unit 3 turbine building (April 22)
		Sampled on May 8	Sampled on July 7	Sampled on August 19	(Reference) Sampled on March 2	
Cesium 134	Approx. 2 years	1.4×10^5	9.4×10^4	7.4×10^4	Less than detection limit	1.5×10^6
Cesium 137	Approx. 30 years	1.5×10^5	1.1×10^5	8.7×10^4	Less than detection limit	1.6×10^6
Iodine 131	Approx. 8 days	1.1×10^4	Less than detection limit	Less than detection limit	Less than detection limit	6.6×10^5

Table II-2-21 Status of Water Injection into Unit 4 Spent Fuel Pool

As of 09:00 August 12, 2011

		Total quantity of injection	Approx. 6242 (t)
Date and time	Means	Water type	Quantity of injection (t)
March 20, from 08:21 till 9:40 *4	High-pressure water cannon vehicles of the Self-Defense Force	Real water	80
March 20, from around 18:30 till 19:46 *5	High-pressure water cannon vehicles of the Self-Defense Force	Real water	80
March 21, from 06:37 till 08:41	High-pressure water cannon vehicles of the Self-Defense Force	Real water	90
March 21, from 08:38 till 08:41	High-pressure water cannon vehicles of U.S. military forces	Real water	2.2
March 22, from 17:17 till 20:32	TEPCO concrete pump tracks (58 m class)	Sea water	150
March 23, from 10:00 till 13:02	TEPCO concrete pump tracks (58 m class)	Sea water	125
March 24, from 14:36 till 17:30	TEPCO concrete pump tracks (58 m class)	Sea water	150
March 25, from 06:05 till 10:20	FPC	Sea water	21
March 25, from 19:05 *4 till 22:07	TEPCO concrete pump tracks (58 m class)	Sea water	150
March 27, from 16:55 till 19:25	TEPCO concrete pump tracks (58 m class)	Sea water	125
March 30, from 14:04 till 18:33	TEPCO concrete pump tracks (58 m class)	Fresh water	140
April 1, from 08:28 till 14:14	TEPCO concrete pump tracks (58 m class)	Fresh water	180
April 3, from 17:14 till 22:16	TEPCO concrete pump tracks (58 m class)	Fresh water	180
April 5, from 17:35 till 18:22	TEPCO concrete pump tracks (62 m class)	Fresh water	20
April 7, from 18:23 till 19:40	TEPCO concrete pump tracks (62 m class)	Fresh water	38
April 9, from 17:07 till 19:24	TEPCO concrete pump tracks (62 m class)	Fresh water	90
April 13, from 00:30 till 6:57	TEPCO concrete pump tracks (62 m class)	Fresh water	195
April 15, from 14:30 till 18:29	TEPCO concrete pump tracks (62 m class)	Fresh water	140
April 17, from 17:39 till 21:22	TEPCO concrete pump tracks (62 m class)	Fresh water	140
April 19, from 10:17 till 11:35	TEPCO concrete pump tracks (62 m class)	Fresh water	40
April 20, from 17:08 till 20:31	TEPCO concrete pump tracks (62 m class)	Fresh water	100
April 21, from 17:14 till 21:20	TEPCO concrete pump tracks (62 m class)	Fresh water	140
April 22, from 17:52 till 23:53	TEPCO concrete pump tracks (62 m class)	Fresh water	200
April 23, from 12:30 till 16:44	TEPCO concrete pump tracks (62 m class)	Fresh water	140
April 24, from 12:25 till 17:07	TEPCO concrete pump tracks (62 m class)	Fresh water	165
From 18:15 on April 25 till 00:26 on	TEPCO concrete pump tracks (62 m class)	Fresh water	210

April 26			
April 26, from 16:50 till 20:35	TEPCO concrete pump tracks (62 m class)	Fresh water	130
April 27, from 12:18 till *4 15:15	TEPCO concrete pump tracks (62 m class)	Fresh water	85
April 28, from 11:43 till 11:54	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement)
April 28, from 11:55 till 12:07	TEPCO concrete pump tracks (62 m class)	Fresh water	(Sampling)
April 29, at 10:29 (water level measurement), at 10:35 (temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
April 30, from 10:14 till 10:28 (water level measurement, temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
May 1, from 10:32 till 10:38 (water level measurement, temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
May 2, from 10:10 till 10:20 (water level measurement, temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
May 3, from 10:15 till 10:23 (water level measurement, temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
May 4, from 10:25 till 10:35 (water level measurement, temperature measurement)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement)
May 5, from 11:55 till 12:05 (water level measurement, temperature measurement) From 12:19 till 20:46 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement) 270
May 6, at 12:16 (water level measurement, temperature measurement) From 12:38 till 17:51 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, temperature measurement) 180
May 7, at 11:00 (water level measurement, underwater photography, sampling) From 14:05 till 17:30 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	(Water level measurement, underwater photography, sampling) 120
May 9, from 16:05 till 19:05 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	100
May 11, from 16:07 till 19:38 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	120
May 13, from 16:04 till 19:04 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	100
May 15, from 16:25 till 20:25 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	140
May 17, from 16:14 till 20:06 (water	TEPCO concrete pump tracks (62 m class)	Fresh water	120

spraying)			
May 19, from 16:30 till 19:30 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	100
May 21, from 16:00 till 19:56 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	130
May 23, from 16:00 till 19:09 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	100
May 25, from 16:36 till 20:04 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	121
May 27, from 17:05 till 20:00 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	100
May 28, from 17:56 till 19:45 (water spraying)	TEPCO concrete pump tracks (62 m class)	Fresh water	60
June 3, from 14:35 till 21:15 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	210
June 4, from 14:23 till 19:45 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	180
June 6, from 15:56 till 18:35 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	90
June 8, from 16:12 till 19:41 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	120
June 13, from 16:36 till 21:00 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	150
June 14, from 16:10 till 20:52 (water spraying)	TEPCO concrete pump tracks (58 m class)	Fresh water	150
June 16, from 13:14 till 15:44 (water spraying)	Temporary water spraying equipment	Fresh water	75
June 18, from16:05 till 19:23 (water spraying)	Temporary water spraying equipment	Fresh water	99
June 22, from 14:31 till 16:38 (water spraying)	Temporary water spraying equipment	Fresh water	56
June 29, from 11:47 till 12:01 (water spraying)	Temporary water spraying equipment	Fresh water	7 (leakage check)
June 30, from 11:30 till 11:55 (water spraying)	Temporary water spraying equipment	Fresh water	13
July 31, from 8:47 till 9:38 (fresh water)	Temporary water spraying equipment	Fresh water	25

*4 According to the records of Ministry of Defense, the duration was from 08:22 till 09:44.
*5 According to the records of Ministry of Defense, the duration was from 18:22 till 19:34.

Table II-2-22 Analysis Result of Unit 4 Spent Fuel Pool Water

Detected nuclides	Half-life	Concentration (Bq/cm^3)					
		Unit 4 pool water					(Reference) Accumulated water on basement floor at Unit 4 turbine building (March 24)
		Sampled on April 12	Sampled on April 28	Sampled on May 7	Sampled on August 20	(Reference) Sampled on March 4	
Cesium 134	Approx. 2 years	88	49	56	44	Less than detection limit	31
Cesium 137	Approx. 30 years	93	55	67	61	0.13	32
Iodine 131	Approx. 8 days	220	27	16	Less than detection limit	Less than detection limit	360

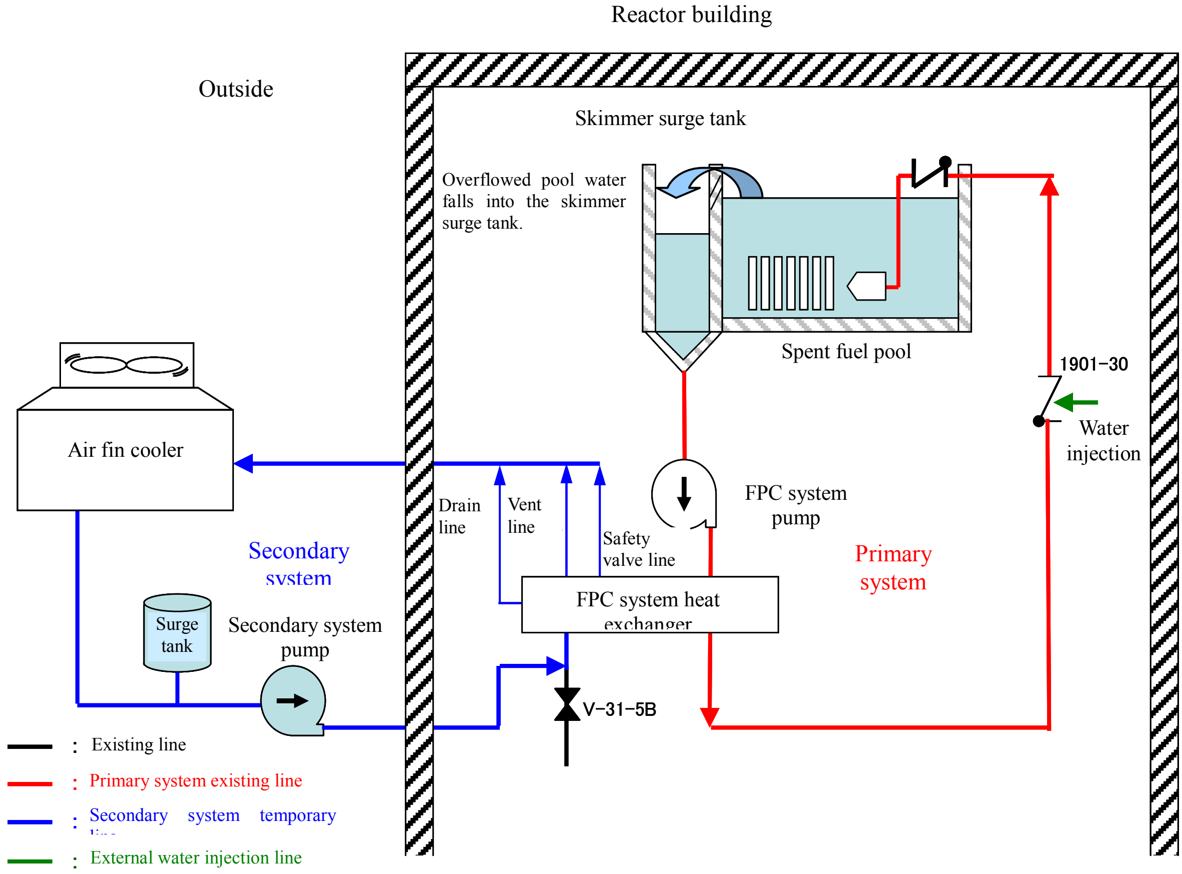


Figure II-2-38 Schematic Diagram of Alternative Cooling System

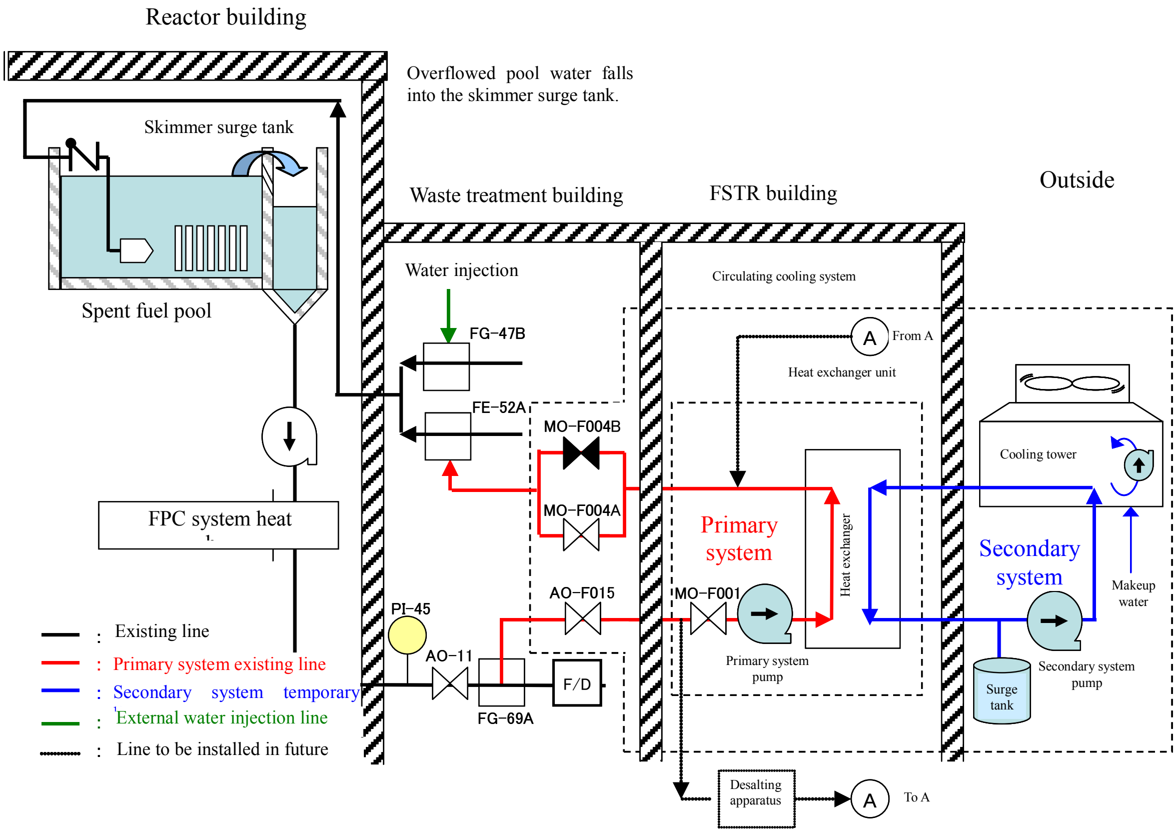


Figure II-2-39 Schematic Diagram of Alternative Cooling System

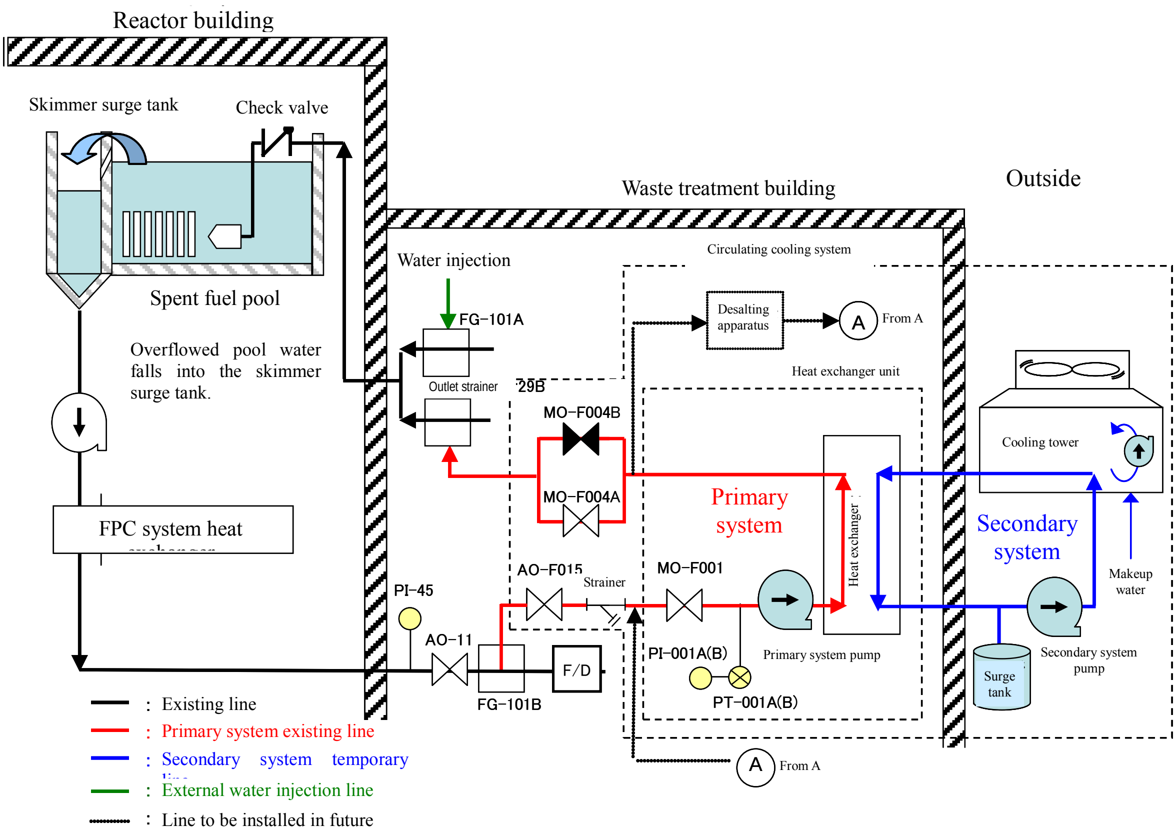


Figure II-2-40 Schematic Diagram of Alternative Cooling System

Figure II-2-41 Unit 3 Spent Fuel Pool Viewed from Underwater

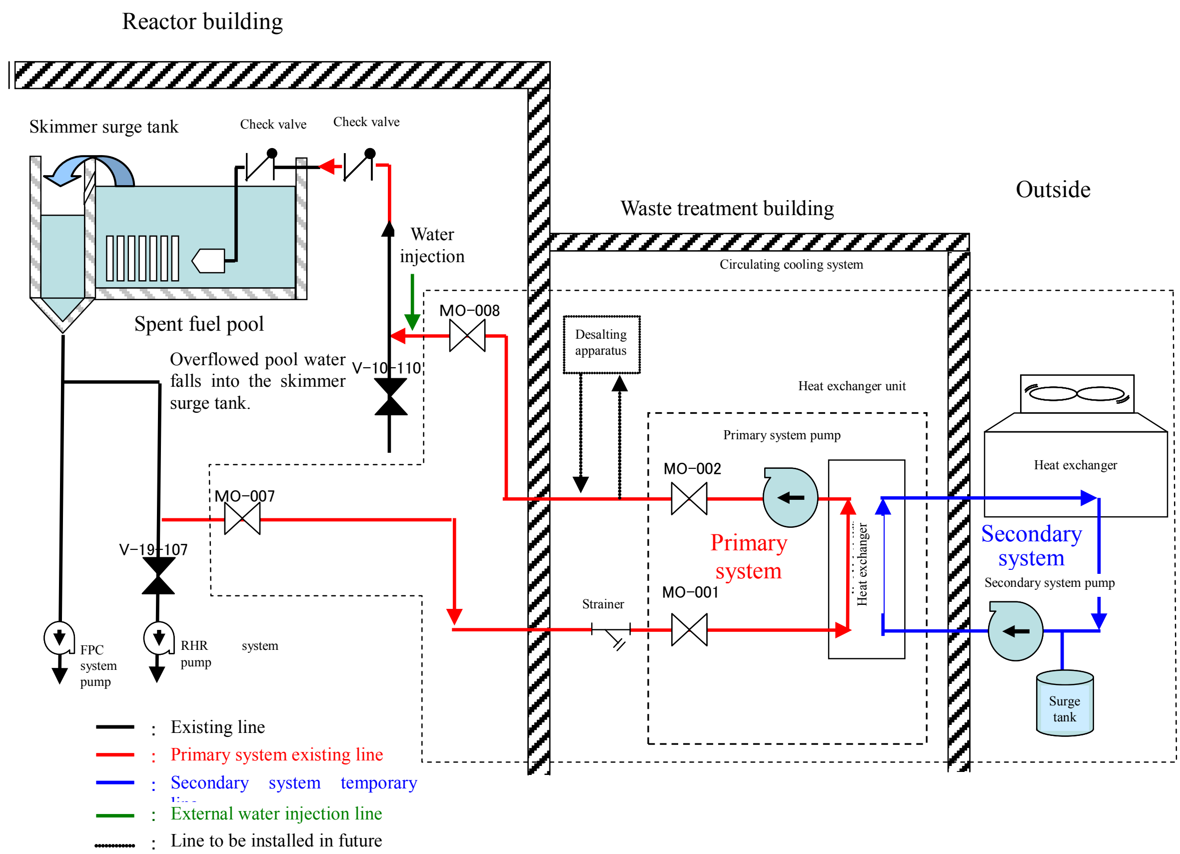


Figure II-2-42 Schematic Diagram of Alternative Cooling System

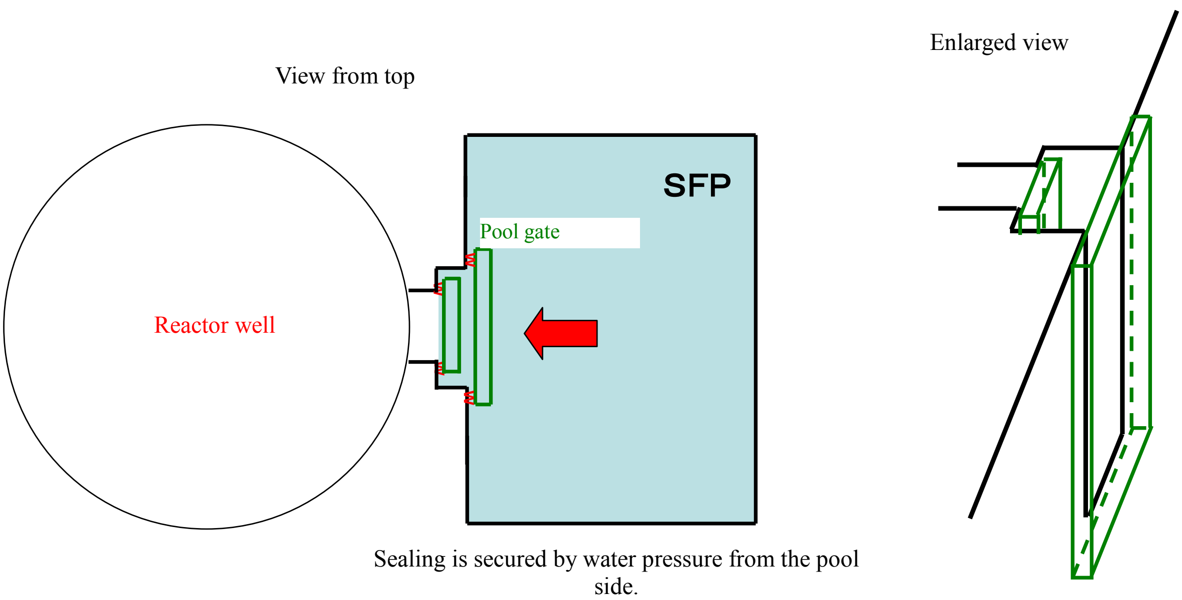


Figure II-2-43 Structure of Pool Gate

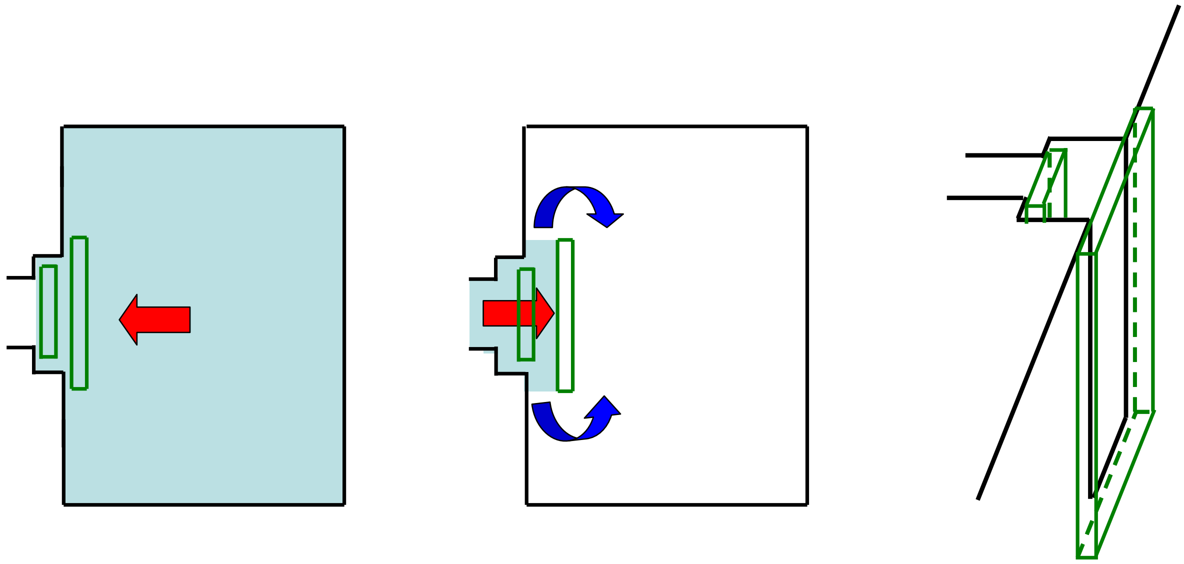


Figure II-2-44 Water inflow Mechanism through pool gate

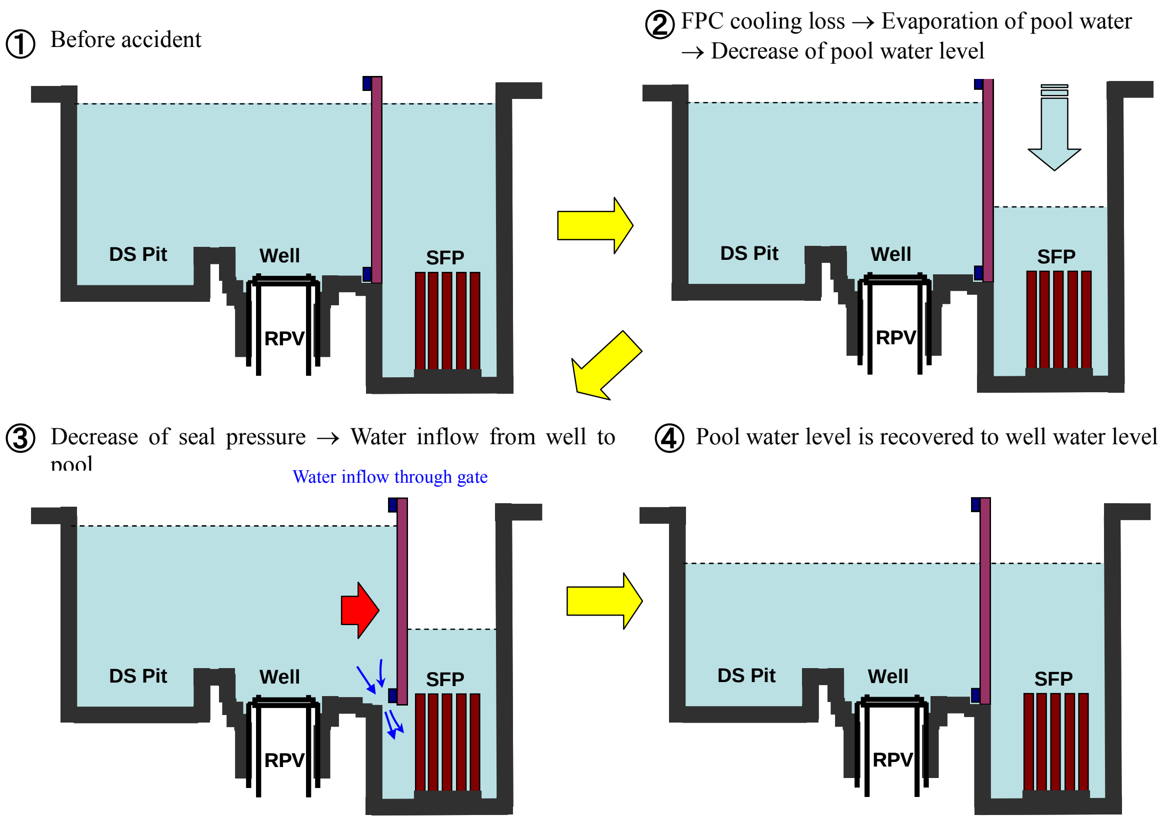


Figure II-2-45 Water inflow Mechanism through pool gate

Figure II-2-46 Unit 4 Pool Viewed from Underwater (No. 1)

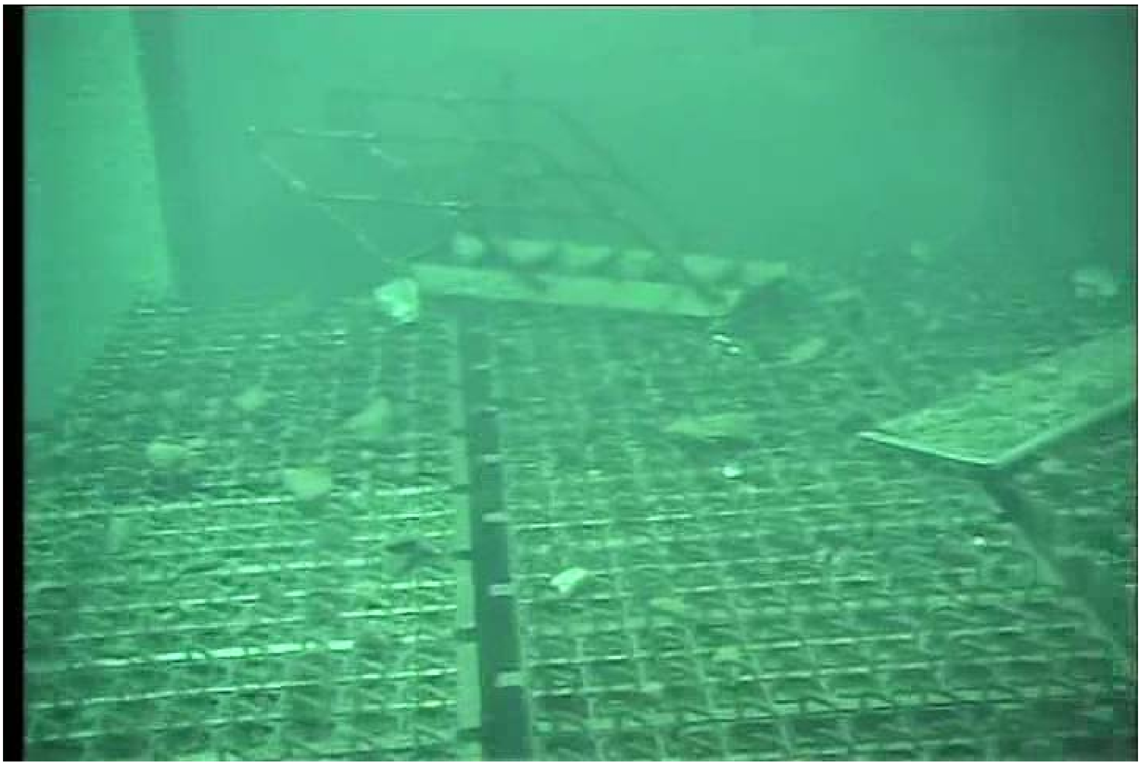


Figure II-2-47 Unit 4 Pool Viewed from Underwater (No. 2)

Figure II-2-48 Unit 4 Pool Viewed from Underwater (No. 3)

Figure II-2-49 Unit 4 Pool Viewed from Underwater (No. 4)

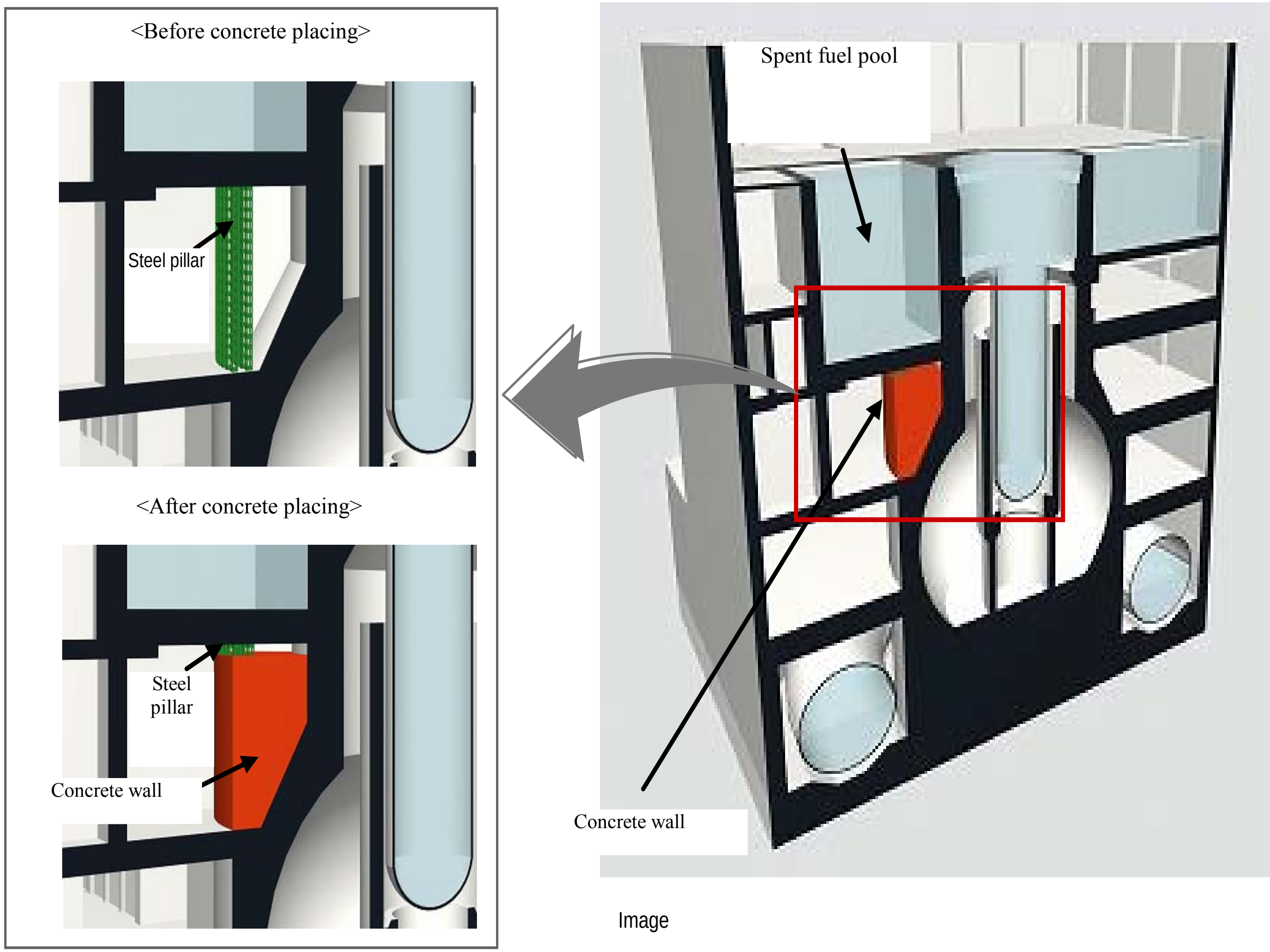


Figure II-2-50 Installation of Support Structure at Bottom of Spent Fuel Pool of Reactor Building of Fukushima Dai-ichi Unit 4

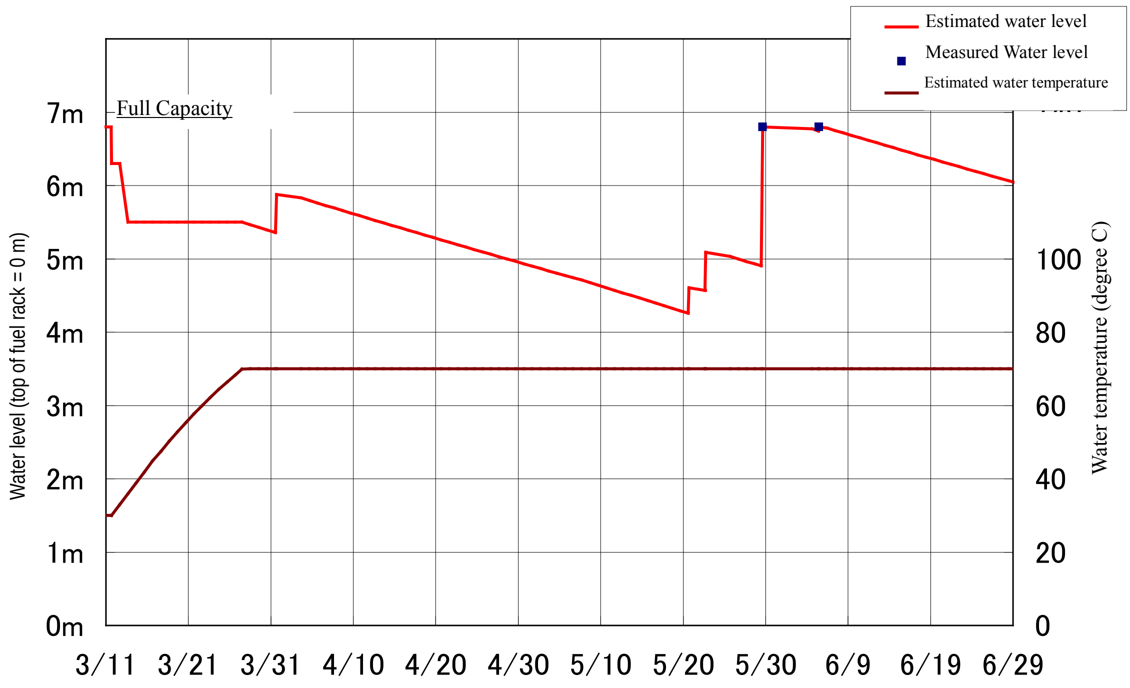


Figure II-2-51 Evaluation Result of Unit 1 SFP

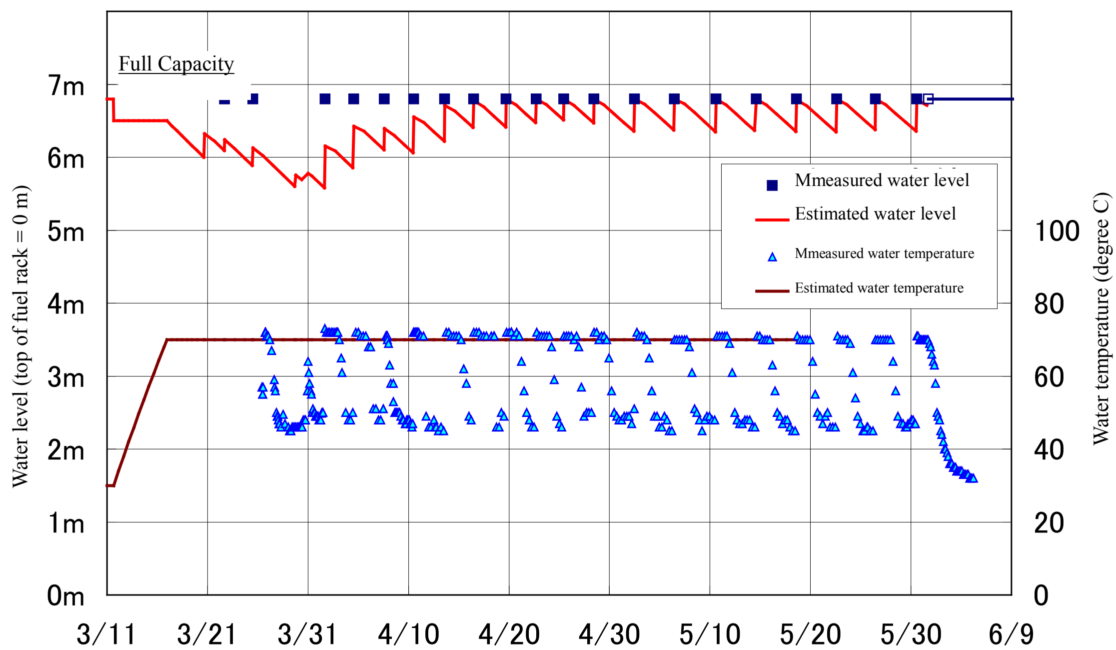


Figure II-2-52 Evaluation Result of Unit 2 SFP

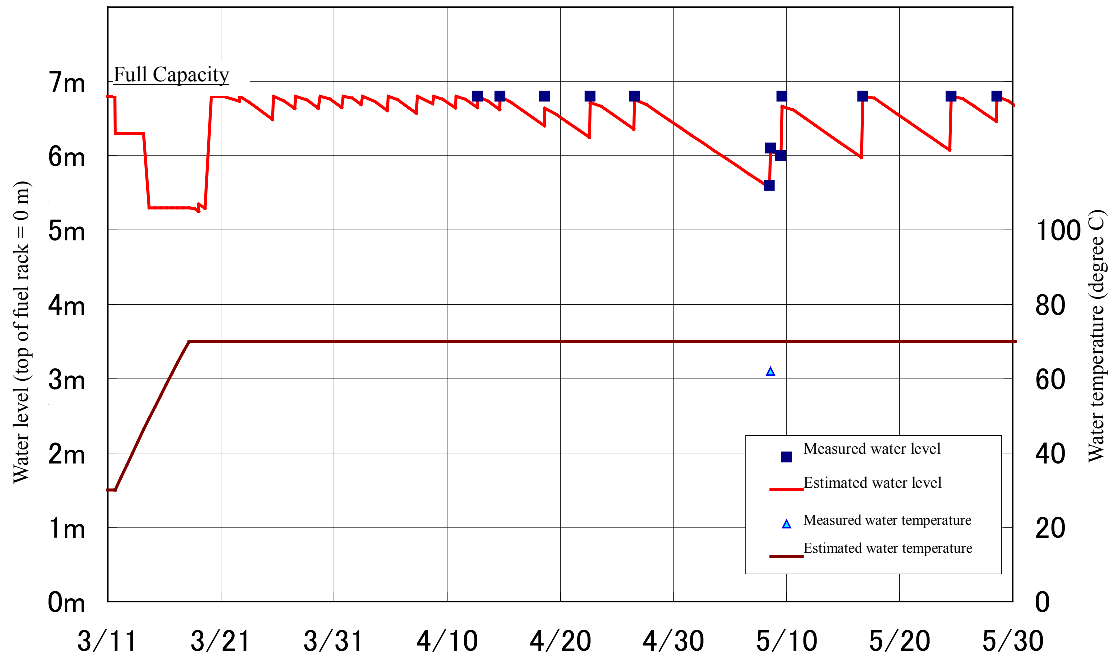


Figure II-2-53 Evaluation Result of Unit 3 Spent Fuel Pool

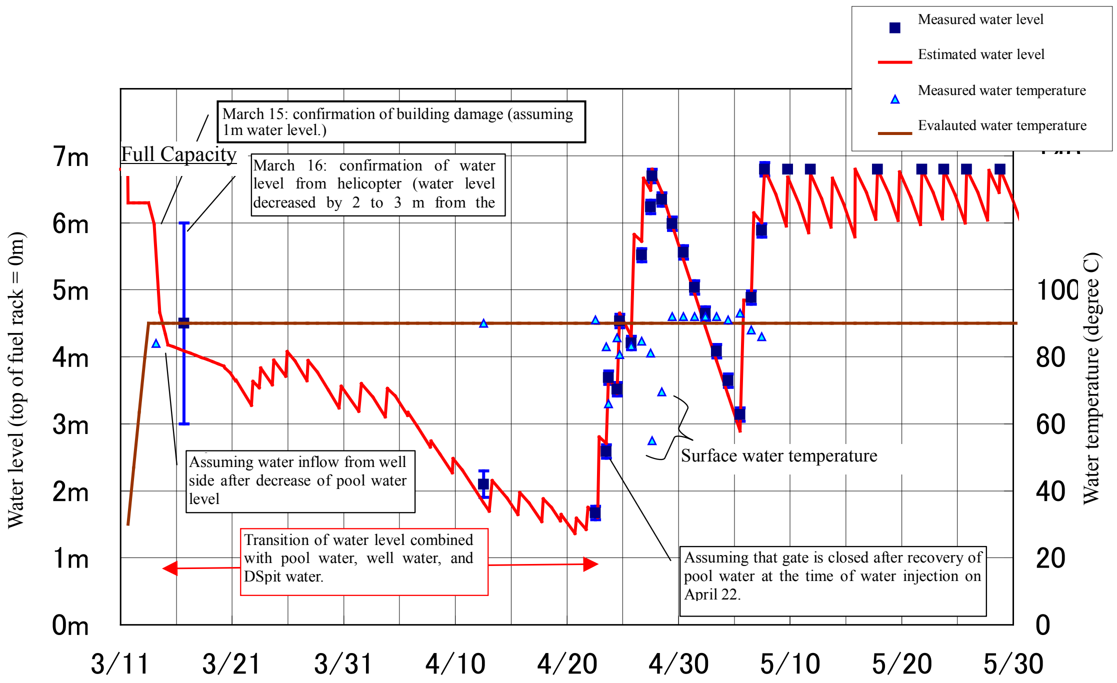


Figure II-2-54 Evaluation Result of Unit 4 Spent Fuel Pool

h. Other

○ Dry cask storage building

Dry cask storage is a storage method in which spent fuel is accommodated in a dry storage cask, as shown in Figure II-2-55, and stored in a cask storage building. The dry cask storage building ("cask building") is located between Units No.1-4 and No.5-6, went into operation in August, 1995.

As of March 11, there were a total of 408 spent fuel assemblies stored in the cask building, consisting of 5 large-sized casks that can each contain 52 fuel assemblies and 4 medium-sized casks that can each contain 37 assemblies.

As the cask building was located at a relatively low altitude, large amounts of sea water, sand and rubble gushed in when it was hit by the tsunami triggered by Tohoku District – Off the Pacific Ocean Earthquake that occurred at 14:46, March 11. Despite the loss of all AC power (cause yet unidentified), the cask cooling function was not lost as the casks are designed to be cooled by natural air convection.

Tokyo Electric Power Company has carried out multiple investigations inside the cask building since March 17. In the cask building, the cask storage area was inundated up to floor-level, with louvers and doors also destroyed. However, the airflow expected from the natural convection of air was not hampered, and it was confirmed that no problems occurred regarding cooling.

Except that they are covered with the rubbles that was washed into the building by the tsunami, the casks remained bolted in their original positions, and so far, no issues on their integrity have been identified from appearance. The dose level within the cask building (up to few tens of μSv/h) is not abnormally high compared to background radiation. Dry storage casks have high seal performance ensured by a double sealing structure through primary and secondary covers, but at the moment, the integrity of their sealing performance has not yet been verified directly through leakage tests. Figure II-2-56 is a photo showing the conditions inside the cask building.

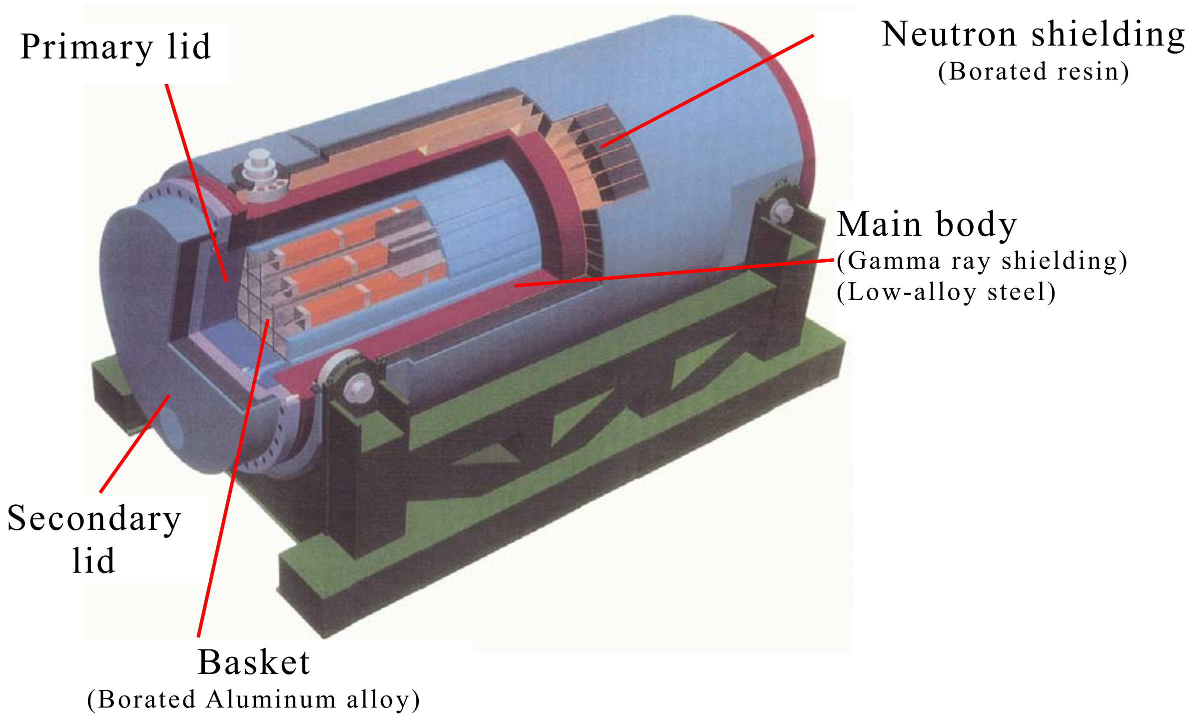


Figure II-2-55 Structure of Dry Storage Cask

Figure II-2-56 Situation in Dry Storage Cask Facility

2) Situation of the release of radioactive materials

TEPCO, to assess situation of the release of radioactive materials by the site of the Fukushima Dai-ichi NPS, conducts atmospheric sampling and nuclide analysis. Also, at the monitoring posts (MP), TEPCO measures dose rate around the NPS site (Figure II-2-57). Situation of the release of radioactive materials at Units 1 to 4 of the Fukushima Dai-ichi NPS is reported below.

a Situation of radioactive materials in the atmosphere

At the site of the Fukushima Dai-ichi NPS, nuclide analysis of radioactive materials in the atmosphere is periodically conducted. Previously, sampling was conducted near the site boundary of the NPS (West Gate) everyday, and from July periodical sampling started at 12 points as well: the site of the NPS and 12 points in the surrounding area as well.

Radioactive concentration of gamma-ray nuclides at the West Gate has been decreasing since the accident, and is lower than the concentration limit required by the law, often lower than the detection limit (Figure II-2-58). Analysis of plutonium (Pu-238, Pu-239, Pu-240) and strontium (Sr-89, Sr-90) in the atmosphere at the West Gate is also periodically conducted and the results to date showed lower values than the detection limit.

Radiation dose rate around the NPS site are measured continuously at the MPs and from June remain generally flat and no significant change is observed (Figure II-2-59).

b Status of each Unit

○Unit 1

TEPCO on July 29 conducted sampling of the air in the PCV from the detection line of the PCV oxygen analysis rack in the reactor building and measured concentration of the radioactive materials inside aiming at the measurement of the concentration of representative radioactive materials contained in gases in the PCV from the perspective of decreasing the release of radioactive materials. The measurement results are shown in Table II-2-23.

Also, to assess situation of the release of radioactive materials to surrounding environment, TEPCO conducted sampling of the radioactive materials in the atmosphere over the top of the reactor building, and the results are summarized in Tables II-2-24 to II-2-26.

Table II-2-23 Result of Sampling from the Inside of Unit 1 Reactor Containment Vessel

Time and date of sampling	July 29, 2011, 13:10
Nuclide	Radioactive material concentration (Bq/cm^3)
Cs-137	2.0×10^1
Cs-134	1.7×10^1
I-131	Below the detection limit
Kr-85	-
Xe-131m	-

Table II-2-24 Result of Sampling above Unit 1 Reactor Building (No. 1)

Point of sampling	Above the reactor building	Above the reactor building	East side of the reactor building (Approx. 5 m outward from the external wall)*1, 2
Date and time of sampling	May 22, 2011, 13:15 to 13:35	June 22, 2011, 12:49 to 13:09	July 24, 2011, 4:28 to 5:57
Nuclide	Sample concentration (Bq/cm^3)		
I-131	7.6×10^{-5}	Below the detection limit	Below the detection limit
Cs-134	3.6×10^{-4}	2.4×10^{-4}	Below the detection limit
Cs-137	4.2×10^{-4}	2.4×10^{-4}	Below the detection limit

*1 Approx. 10 m above the top of the steel frames of the reactor building
*2 Samples taken by T-Hawk

Table II-2-25 Result of Sampling above Unit 1 Reactor Building (No. 2)

Point of sampling	Above the reactor building (1) (Northwest side above the reactor)	Above the reactor building (2) (Northeast side above the reactor)	Above the reactor building (3) (Southwest side above the reactor)	Above the reactor building (4) (Southeast side above the reactor)
Date and time of sampling	August 28, 2011, 9:40 to 10:10	August 28, 2011, 10:15 to 10:45	August 28, 2011, 12:05 to 12:35	August 28, 2011, 12:45 to 13:15
Nuclide	Sample concentration (Bq/cm^3)			
I-131	Below the detection limit	Below the detection limit	Below the detection limit	Below the detection limit
Cs-134	7.0×10^{-6}	5.7×10^{-6}	7.4×10^{-6}	5.6×10^{-6}
Cs-137	7.4×10^{-6}	5.3×10^{-6}	1.1×10^{-5}	5.3×10^{-6}

Table II-2-26 Result of Sampling above Unit 1 Reactor Building (No. 3)

Point of sampling	Lateral side above the reactor building (1) (West side below the equipment hatch)	Lateral side above the reactor building (2) (West side above the equipment hatch)
Date and time of sampling	August 28, 2011, 8:10 to 8:40	August 28, 2011, 8: 45 to 9:15
Nuclide	Sample concentration (Bq/cm^3)	
I-131	Below the detection limit	Below the detection limit
Cs-134	3.8×10^{-5}	2.6×10^{-4}
Cs-137	4.6×10^{-5}	3.3×10^{-4}

In relation to the recovery works, etc. conducted by TEPCO to date, the dose rate in the reactor building, etc. has become available (As there are many high-dose areas in the reactor building, TEPCO conducts dose measurement together with other necessary work and by using robot, etc.)

On July 31, when TEPCO conducted confirmation work of the dose after the disposal of rubbles implemented to that date by using gamma-ray camera, source of high dose was observed near the connection of the standby gas treatment system (hereinafter referred to as SGTS) pipe at the bottom of main exhaust stack of Units 1 and 2. On August 1, higher than 10Sv/h dose was observed at that source (Figure II-2-60). Also, on August 2, by implementing dose measurement with robot in the SGTS train room on the second floor of Unit 1-turbine building, higher than 5Sv/h dose was observed at that area (Figure II-2-61). Additionally, on August 4, 3.6Sv/h dose was observed at the bottom of stack drain pipe of main exhaust stack of Units 1 and 2 (Figure II-2-62). Accordingly the same parts of Units 3 and 4 were examined and no extremely high dose was observed. The cause of the high dose at main exhaust stack of Units 1 and 2 and in the SGTS train room of Unit 1 is now being examined.

○Unit 2

On August 9, TEPCO conducted sampling of the air in the PCV from the detection line pipe of the PCV oxygen analysis rack in the reactor building and measured concentration of the radioactive materials inside, aiming at the measurement of the concentration of representative radioactive materials contained in gases in the PCV from the perspective of decreasing the release of radioactive materials. The measurement results are shown in Table II-2-27.

Also, to assess situation of the release of radioactive materials to surrounding environment, TEPCO conducted sampling of the radioactive materials in the atmosphere near the opening of the reactor building and the results are summarized in Table II-2-28.

Table II-2-27 Result of Sampling from the Inside of Unit 2 Reactor Containment Vessel

Time and date of sampling	August 9, 2011, 10:39 to 11:13		
Nuclide	Radioactive material concentration (Bq/cm^3)		
	1st	2nd	3rd
Cs-137	5.4×10^{-1}	2.4×10^{-1}	2.5×10^{-1}
Cs-134	5.1×10^{-1}	2.3×10^{-1}	2.4×10^{-1}
I-131	Below the detection limit	Below the detection limit	Below the detection limit
Kr-85	Below the detection limit	7.4×10^{1}	7.5×10^{1}
Xe-131m	3.8×10^{1}	4.7×10^{1}	4.0×10^{1}

Table II-2-28 Result of Sampling at Aperture Points of Unit 2 Reactor Building

Point of sampling	East side of the reactor building (Approx. 5 m outward from the external wall)*1,2	Above the reactor building (1) (Below the aperture of blowout panel)	Above the reactor building (2) (Center of the aperture of blowout panel)
Date and time of sampling	July 22, 2011, 5:06 to 6:02	August 29, 2011, 10:35 to 11:35	August 29, 2011, 12:20 to 13:20
Nuclide	Sample concentration (Bq/cm^3)		
I-131	Below the detection limit	Below the detection limit	Below the detection limit
Cs-134	2.2×10^{-4}	9.6×10^{-4}	1.5×10^{-3}
Cs-137	2.7×10^{-4}	1.0×10^{-3}	1.6×10^{-3}

*1 Approx. 10 m above the top of the roof of the reactor building
*2 Samples taken by T-Hawk

In relation to the recovery works, etc. conducted by TEPCO to date, the dose rate in the reactor building, etc. has become available (As there are many high-dose areas in the reactor building, TEPCO conducts dose measurement together with other necessary work and by using robot, etc.)

Measurement results of the dose rate in the reactor building at the time of entering into the reactor building on June 21 for installing temporary water level gauge and pressure level gauge for reactor of Unit 2 are shown in Figures II-2-63 and II-2-64. As a result, high atmospheric dose at the ground floor and the second floor in the reactor building was observed.

Additionally, for dust sampling, measurement of dose rate conducted by using the robot (Quince) at the upper floors of the Unit-2 reactor building on July 8 showed high atmospheric dose at the stairs and the second floor (Table II-2-65).

○Unit 3

TEPCO, to assess situation of the release of radioactive materials to surrounding environment, conducts sampling of the radioactive materials in the atmosphere near the opening of the reactor building and the results are summarized in Figures II-2-29 and II-2-30.

In relation to the recovery works, etc. conducted by TEPCO to date, the dose rate in the reactor building, etc. has become available (As there are many high-dose areas in the reactor building, TEPCO conducts dose measurement together with other necessary work and by using robot, etc.)

Measurement results of the dose rate in the reactor building at the time of entering in the building on July 6 for preparatory works for nitrogen injection into Unit 3 are shown in Figure II-2-66. As a result, high atmospheric dose near the candidate places for nitrogen injection at the ground floor in the reactor building was identified.

Additionally, in order to identify where to inject water effectively to the reactor, dose rate was measured at the time of entering in the Unit-3 reactor building on July 26 and 27 as well and high atmospheric dose at the stairs and the second floor was also found (Figures II-2-67 and II-2-68).

Table II-2-29 Result of Sampling above Unit 3 Reactor Building (No. 1)

Point of sampling	Above the reactor building	Above the reactor building	Above the reactor building	Above the reactor building	Above the reactor building	West side of the reactor building *
Date and time of sampling	June 13, 2011, 15:33 to 15:53	July 12, 2011, 11:30 to 12:00	July 12, 2011, 15:00 to 15:30	July 13, 2011, 6:46 to 7:16	July 13, 2011, 11:00 to 11:30	July 23, 2011, 4:37 to 6:08
Nuclide	Sample concentration (Bq/cm^3)					
I-131	3.0×10^{-4}	4.6×10^{-6}	2.8×10^{-6}	2.3×10^{-6}	2.5×10^{-6}	Below the detection limit
Cs-134	5.6×10^{-4}	1.8×10^{-5}	1.1×10^{-5}	Below the detection limit	6.4×10^{-6}	Below the detection limit
Cs-137	5.4×10^{-4}	8.9×10^{-6}	1.5×10^{-5}	1.1×10^{-5}	1.3×10^{-5}	Below the detection limit

* Approx. 10 m above the top of the steel frames of the reactor building

(Samples taken by T-Hawk)

Table II-2-30 Result of Sampling above Unit 3 Reactor Building (No. 2)

Point of sampling	Above the reactor building (West side above the reactor)	Above the reactor building (East side above the reactor)	Above the reactor building (North side above the reactor)	Above the reactor building (South side above the reactor)
Date and time of sampling	August 24, 2011, 9:00 to 9:30	August 24, 2011, 9:35 to 10:05	August 24, 2011, 11:30 to 12:00	August 24, 2011, 12:05 to 12:35
Nuclide	Sample concentration (Bq/cm^3)			
I-131	2.8×10^{-6}	Below the detection limit	Below the detection limit	Below the detection limit
Cs-134	1.0×10^{-3}	6.6×10^{-6}	1.6×10^{-4}	5.0×10^{-5}
Cs-137	1.2×10^{-3}	5.4×10^{-6}	1.7×10^{-4}	5.2×10^{-5}

○Unit 4

TEPCO, to assess situation of the release of radioactive materials to surrounding environment, conducted sampling for radioactive materials in the atmosphere over the top of the reactor building and the results are summarized in Figure II-2-31.

In relation to the recovery works, etc. conducted by TEPCO to date, the dose rate in the reactor building, etc. has become available (As there are many high-dose areas in the reactor building, TEPCO implements dose measurement together with other necessary work.)

TEPCO, for the investigation of the circulating cooling line of spent fuel pool (SFP) at Unit 4, implemented on-site survey at the fifth floor of the reactor building on June 29. As a result, it was found that the dose rate around SFP was relatively low (Figures II-2-69).

Table II-2-31 Result of Sampling above Unit 4 Reactor Building

Place of sampling	Above the reactor building	Above the reactor building	Above the reactor building	5th floor of the reactor building	
				Above the spent fuel cask pit	Southwest side of spent fuel pool
Time and date of sampling	May 23, 2011, 14:17 to 14:37	June 18, 2011, 12:23 to 12:43	June 18, 2011, 14:38 to 14:58	June 30, 2011, 17:00 to 17:05	
Nuclide	Density of Sample (Bq/cm^3)				
I-131	1.4×10^{-5}	Below the detection limit	Below the detection limit	Below the detection limit	Below the detection limit
Cs-134	1.5×10^{-4}	8.4×10^{-5}	1.2×10^{-4}	1.1×10^{-3}	4.0×10^{-4}
Cs-137	1.5×10^{-4}	1.0×10^{-4}	1.1×10^{-4}	1.1×10^{-3}	4.1×10^{-4}

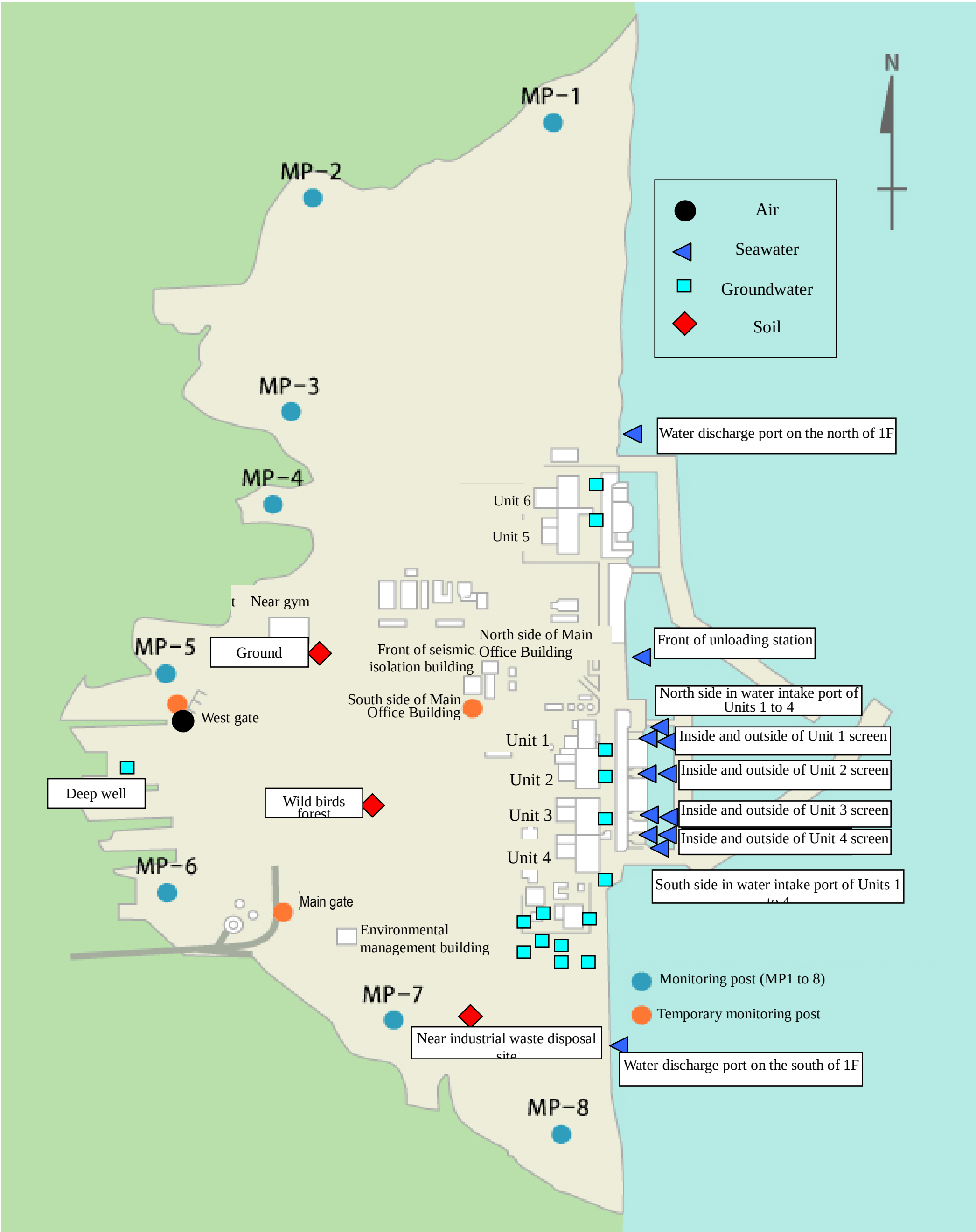


Figure II-2-57 Monitoring Points in Fukushima Dai-ichi NPS

Analysis result of nuclide of dust collected at the west gate of Fukushima Dai-ichi NPS
(Bq/cm³)

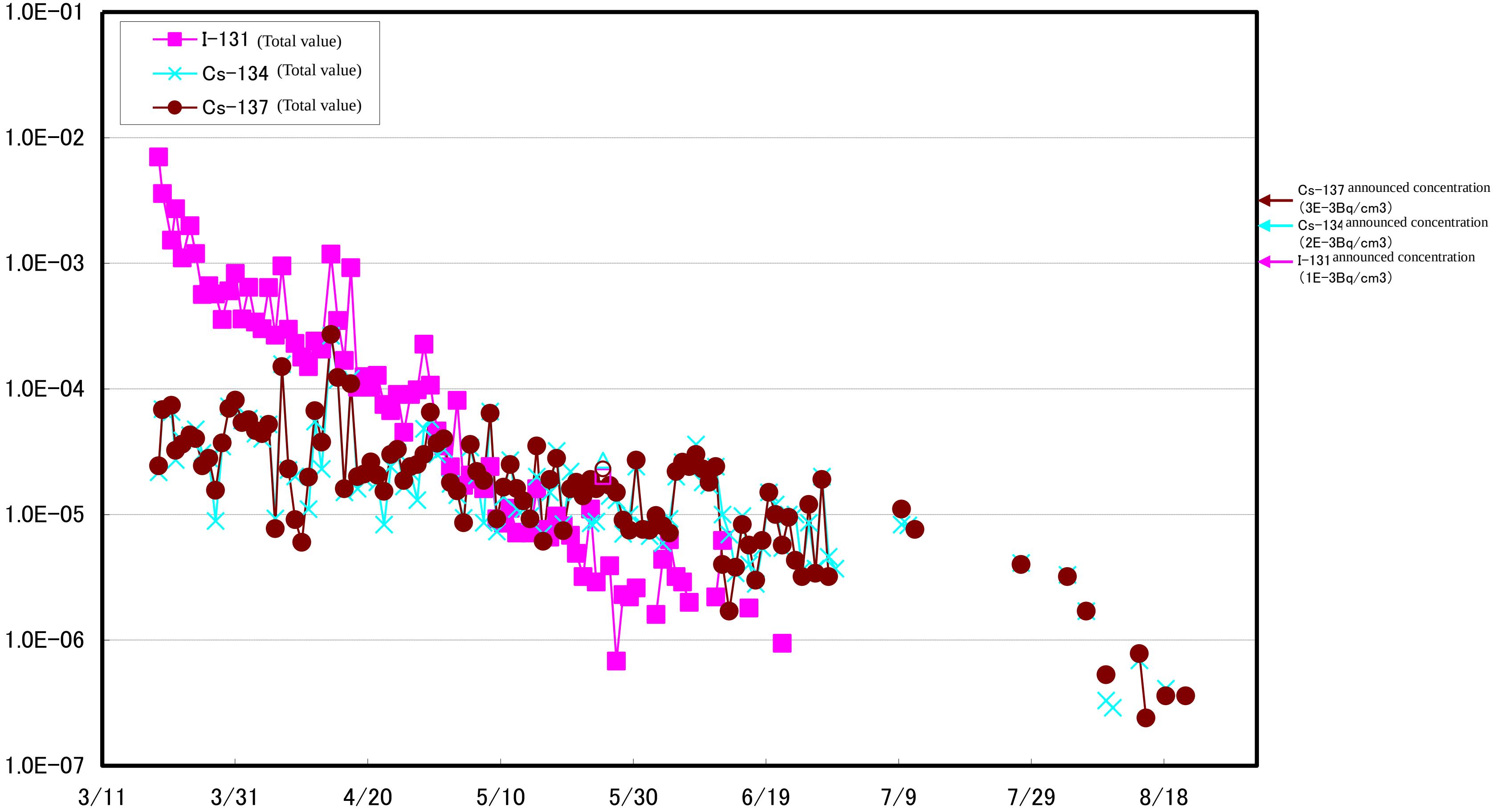


Figure II-2-58 Analysis Result of Nuclide of Dust Collected at the West Gate of Fukushima Dai-ichi NPS

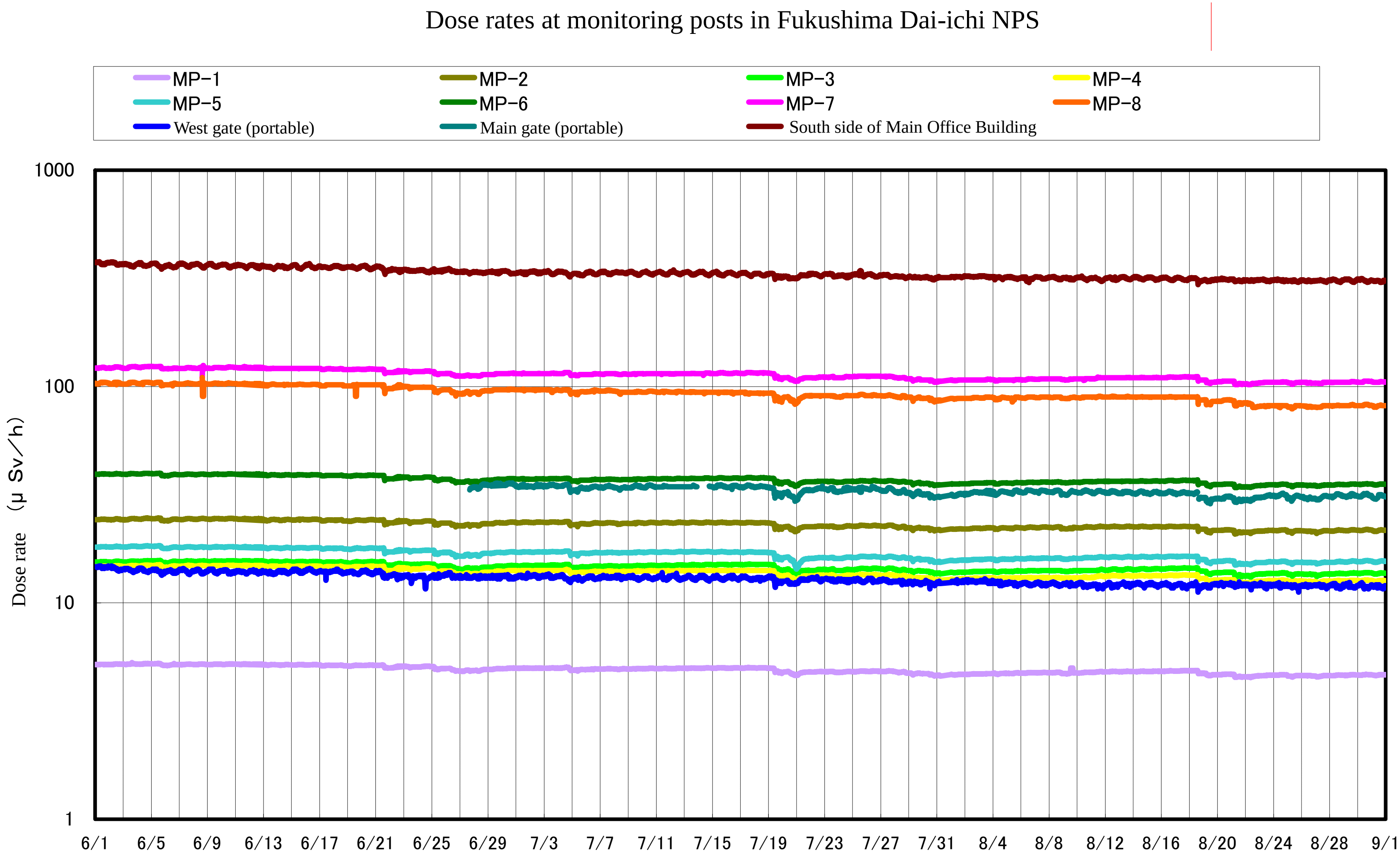
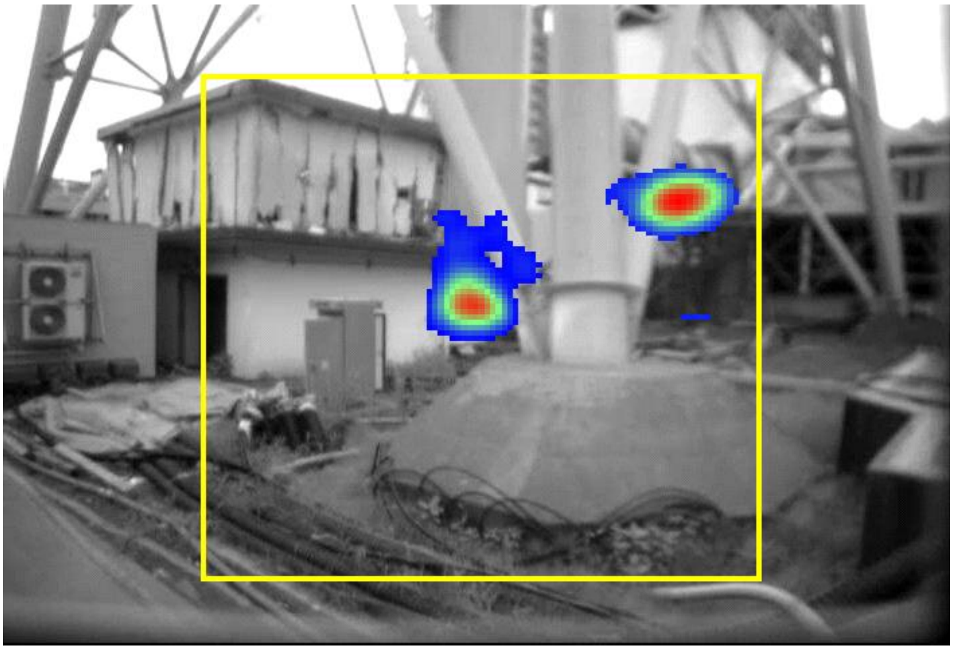


Figure II-2-59 Dose Rates at Monitoring Posts in Fukushima Dai-ichi NPS

August 2, 2011
TEPCO

Location: Near the standby gas treatment system pipe joint at the bottom of the main exhaust stack of Units 1 and 2
Time: August 1, 2011, around 14:30
Photographed by: TEPCO

August 2, 2011
TEPCO



Location: Near the main exhaust stack of Units 1 and 2
Time: July 31, 2011, around 16:00
Photographed by: TEPCO

Figure II-2-60 Near the Main Exhaust Stack of Units 1 and 2 in Fukushima Dai-ichi NPS

August 3, 2011
TEPCO

High-dose detected area on the 2nd floor of Unit 1 turbine building in Fukushima Dai-ichi NPS

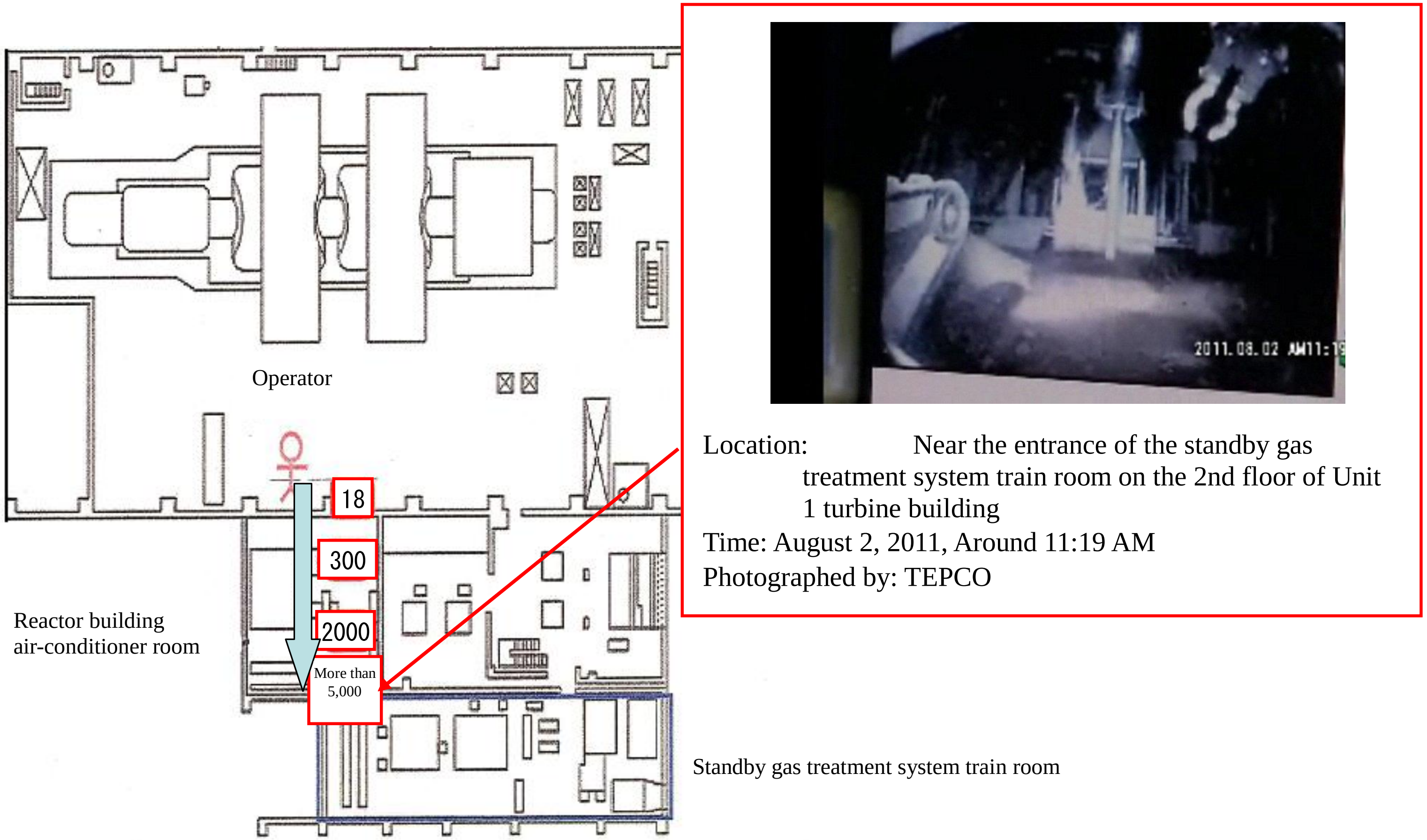
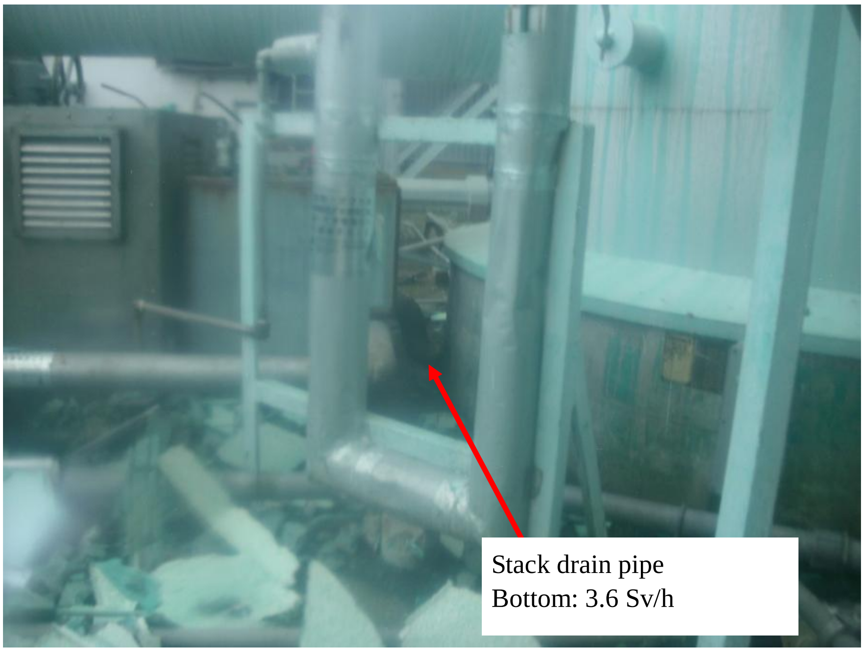


Figure II-2-61 High-dose Detected Area on the 2nd Floor of Unit 1 Turbine Building in Fukushima Dai-ichi NPS

August 5, 2001
TEPCO

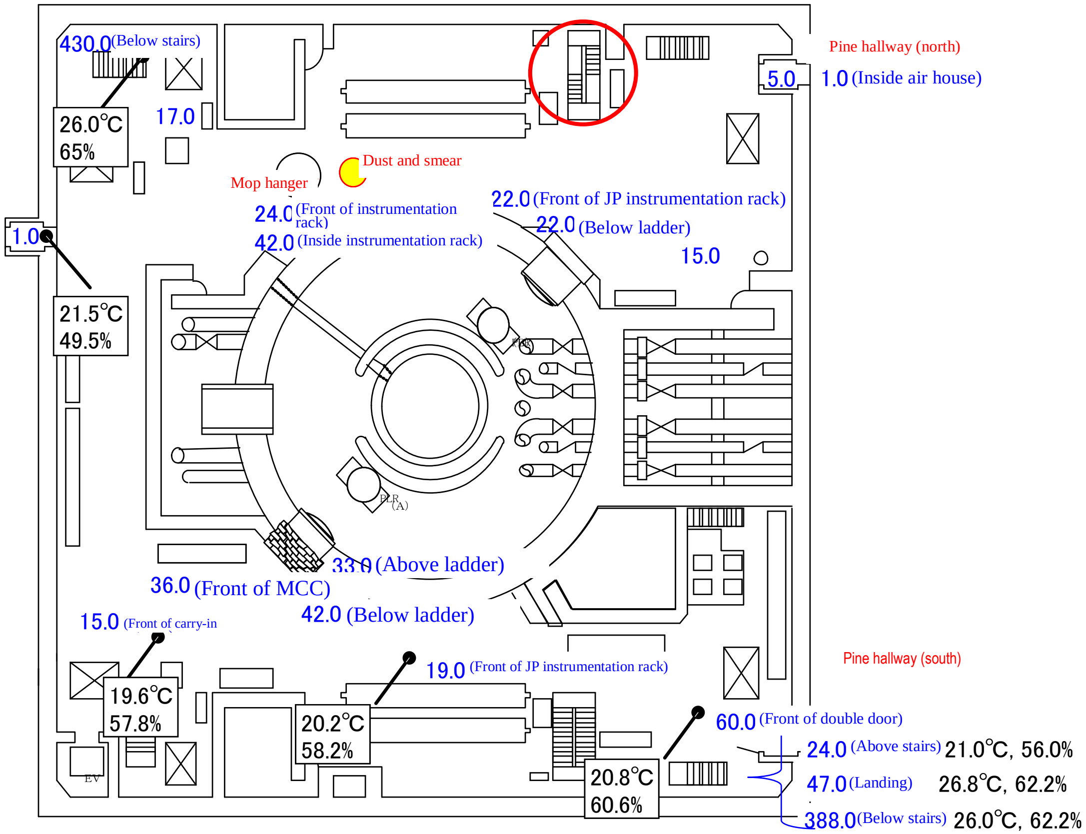
Location: Stack drain pipe at the main exhaust stack of Units 1 and 2 (view from the east side)
Time: August 4, 2011, around 15:30
Photographed by: TEPCO

August 5, 2001
TEPCO



Location: Stack drain pipe at the main exhaust stack of Units 1 and 2 (view from the west side)
Time: August 4, 2011, around 15:30
Photographed by: TEPCO

Figure II-2-62 Stack Drain Pipe of the Main Exhaust Stack of Units 1 and 2 in Fukushima Dai-ichi NPS

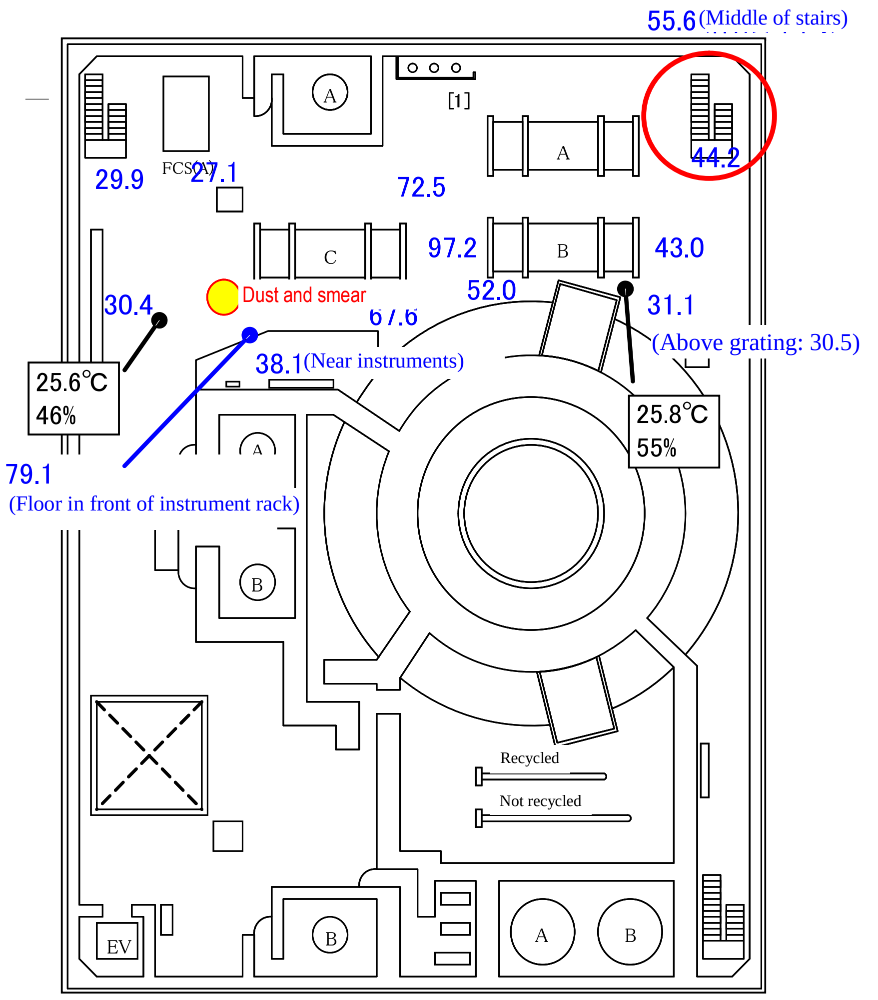


1st floor of reactor building

Northwest stairs (half basement)

Southeast stairs (half basement)

Figure II-2-63 Result of Investigation inside Unit 2 Reactor Building in Fukushima Dai-ichi NPS (No. 1)

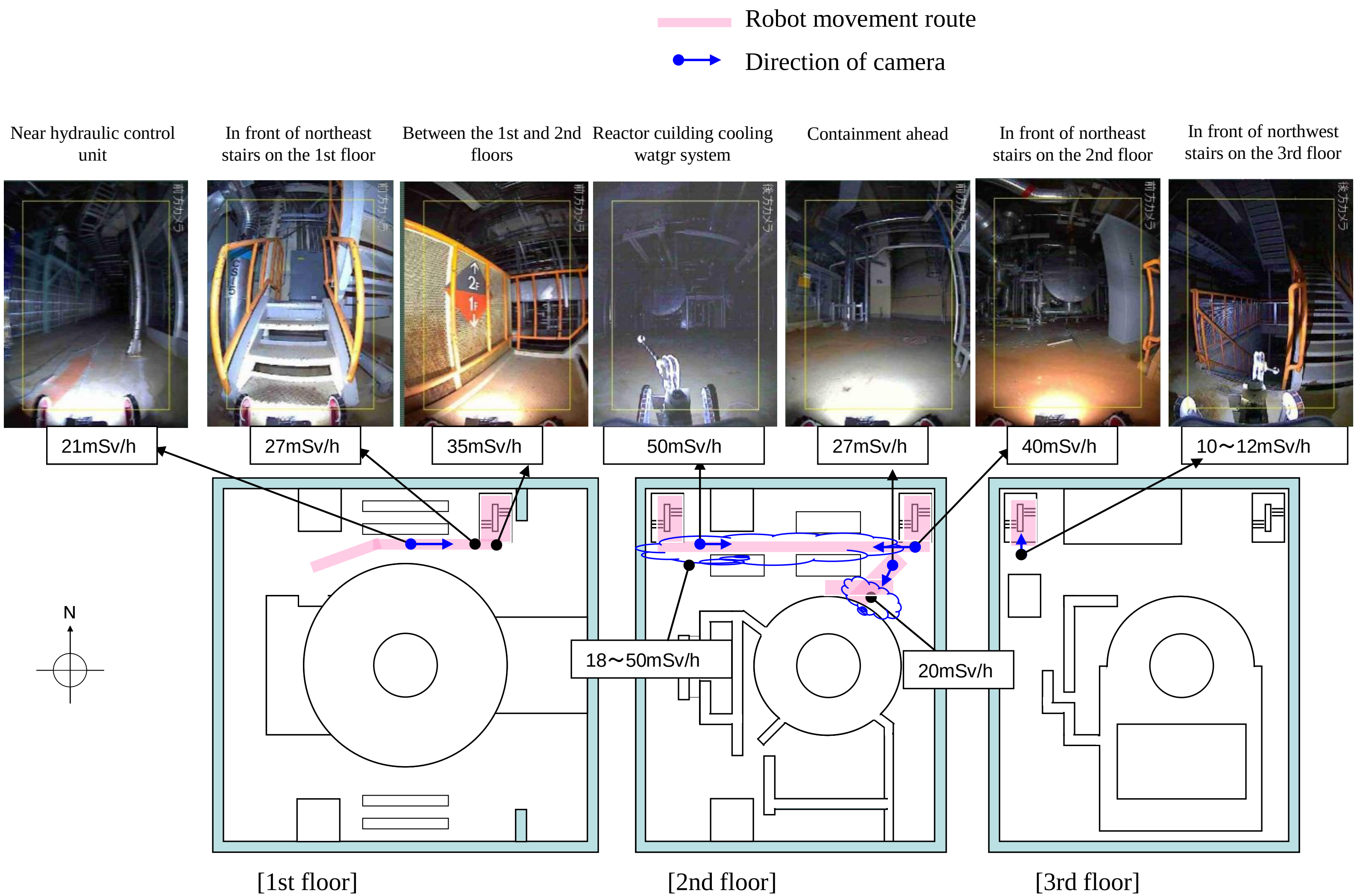


2nd floor of reactor building

Reactor instrumentation rack

Floor in front of reactor instrumentation rack

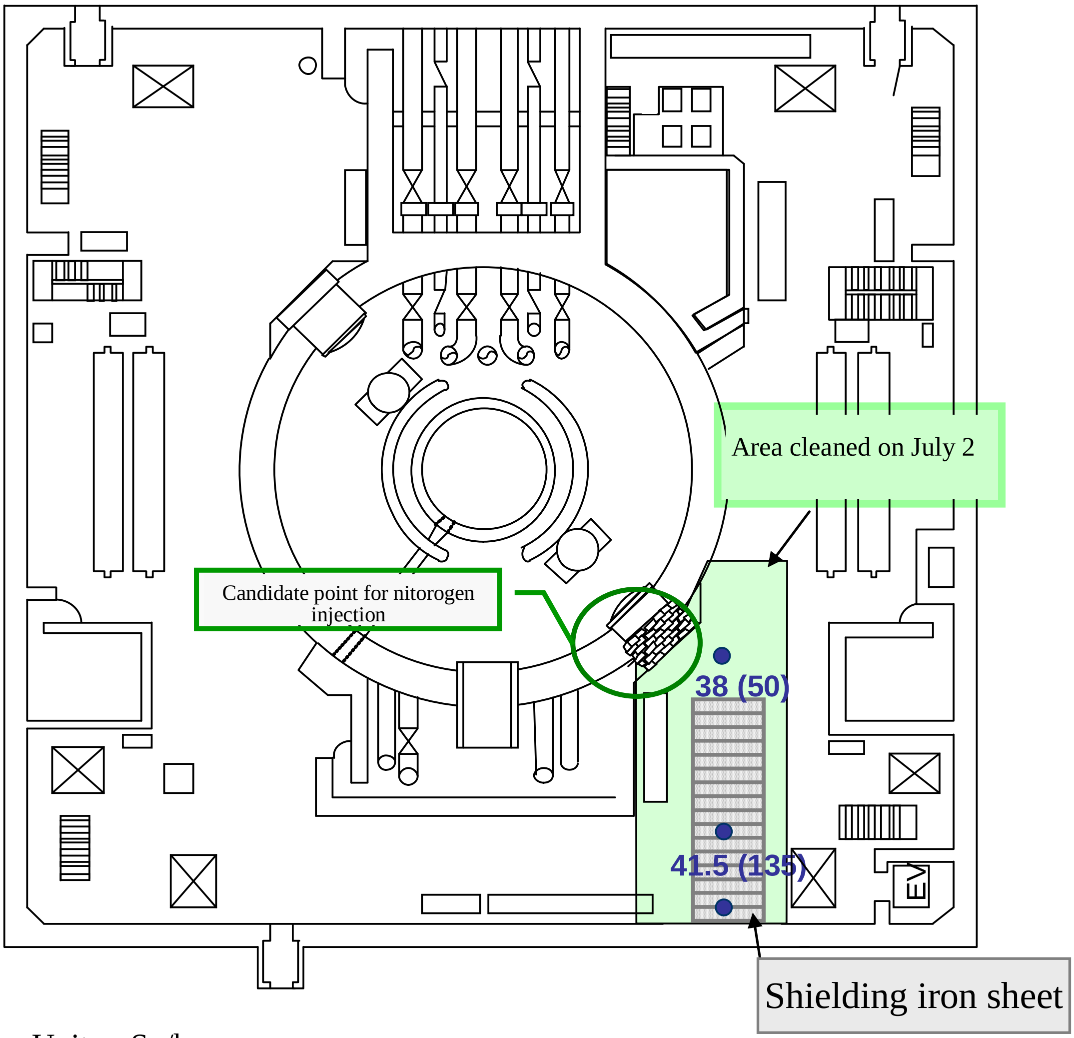
Figure II-2-64 Result of Investigation inside Unit 2 Reactor Building in Fukushima Dai-ichi NPS (No. 2)



Building layout is image (scale and layout are not accurate)

Figure II-2-65 Result of Investigation inside the Roof of Unit 2 Reactor Building in Fukushima Dai-ichi NPS

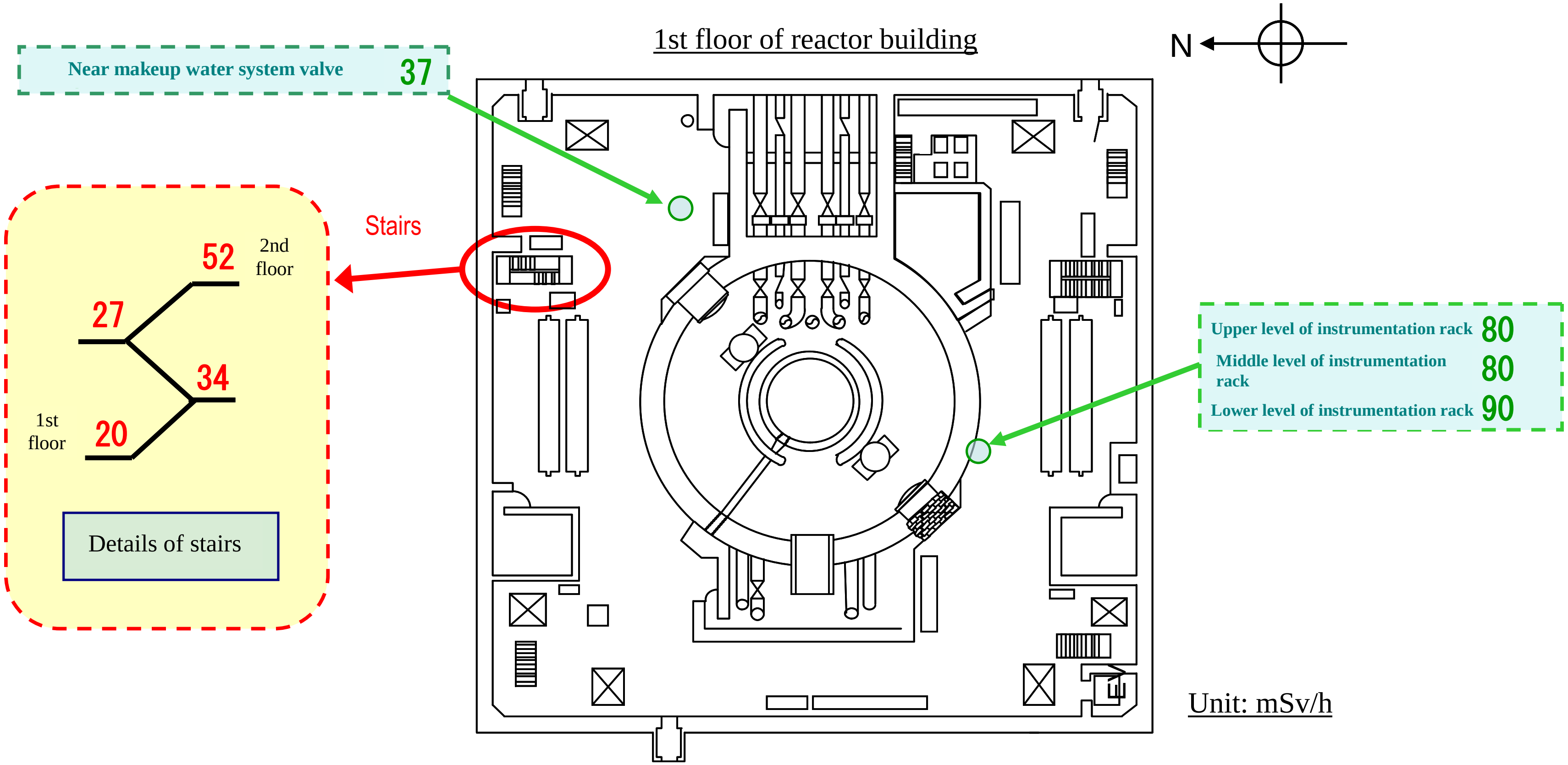
1st floor of reactor building



Unit: mSv/h

Note: Data measured on July 2 are indicated in the parentheses.

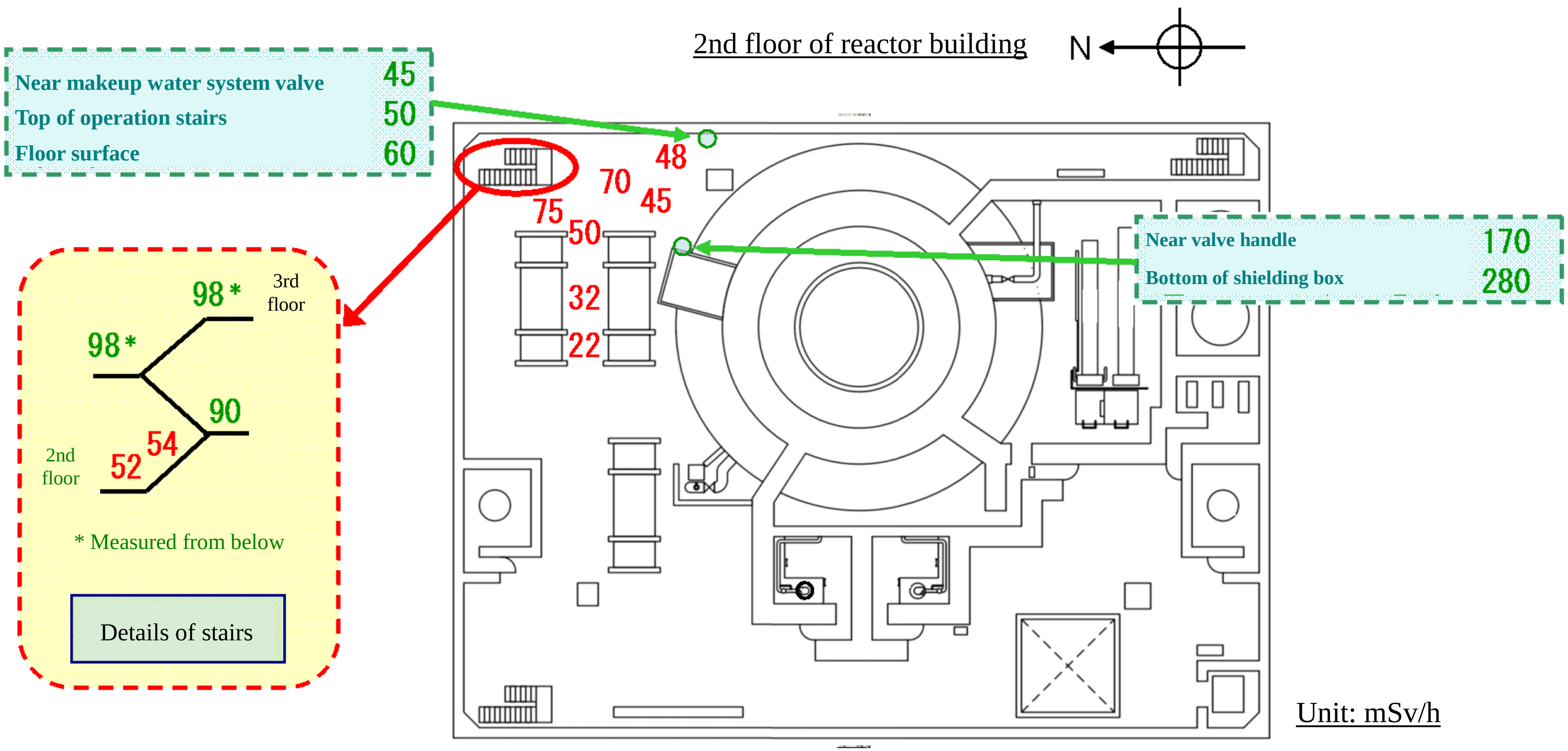
Figure II-2-66 Investigation Result of Dose in Unit 3 Reactor Building in Fukushima Dai-ichi NPS



Red: On-the-spot investigation conducted by Quince on July 26
Green: On-the-spot investigation conducted by workers on July 27

* Building layout is image (scale and layout are not accurate)

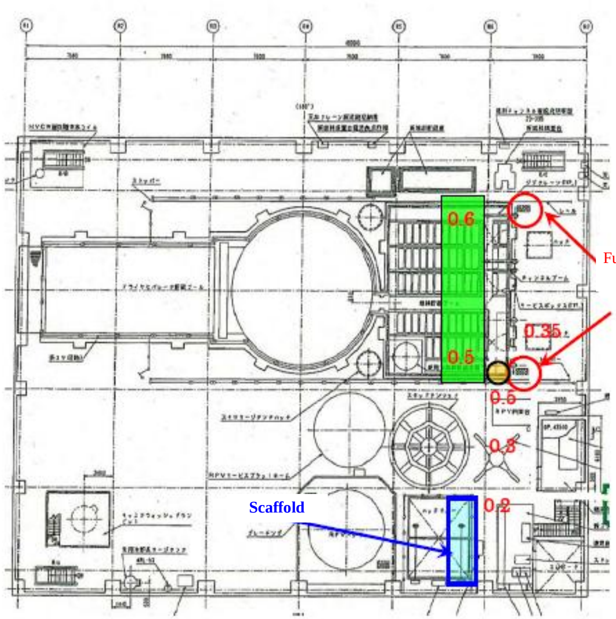
Figure II-2-67 Result of Investigation inside Unit 3 Reactor Building in Fukushima Dai-ichi NPS (No. 1)

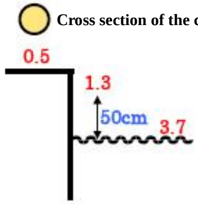


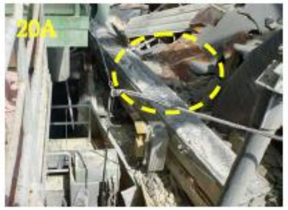
Red: On-the-spot investigation conducted by Quince on July 26
Green: On-the-spot investigation conducted by workers on July 27

* Building layout is image (scale and layout are not accurate)

Figure II-2-68 Result of Investigation inside Unit 3 Reactor Building in Fukushima Dai-ichi NPS (No. 2)







Fuel pool cooling and clean-up system valve

Equipment storage pool viewed from refueling

Reactor well

Spent fuel pool gate

Figure II-2-69 Result of On-the-spot Investigation of the 5th Floor of Unit 4 Reactor Building in Fukushima Dai-ichi NPS

3) Situation of the contamination at the NPS

For monitoring to figure out the impact on surrounding environment, in the site of the Fukushima Dai-chi NPS, now, sampling and nuclide analysis of sea water at the NPS site (intake channel, water discharge canal), subsurface water (Sub-Drain), the soil, etc. have been implemented as follows. Also, measurement of dose rate in the NPS site is implemented (Figure II-2-57).

a　Sea water (water discharge canal)

Near the water discharge canal of Units 1 to 4 and water discharge canal of Units 5 and 6 of the Fukushima Dai-ichi NPS, nuclide analysis of radioactive materials in the sea water is periodically conducted.

Radioactive concentration of gamma-ray nuclides is measured everyday, but has decreased after the accident occurred, and is at the similar level of the concentration limit defined by the law and in many cases below the detectable limit (Figure II-2-70).

Additionally, analysis of plutonium (Pu-238, Pu-239, Pu-240) and strontium (Sr-89, Sr-90) is also conducted periodically. The results to date are that plutonium has been below the detectable limit, while strontium is detected.

b　Sea water (intake channel)

As high level of contaminated water flowed out from the concrete pits near the intake channels of Units 2 and 3, the measurement started, and now nuclide analysis of radioactive materials in the sea water near the intake channels of Units 1 to 4 and inside of the harbor is periodically conducted.

Radioactive concentration of gamma-ray is nuclides measured everyday, and has decreased near the intake channel of Units 2 and 3 where the leakage took place, and is, although varied to some extent, now almost similar as the concentration of the other measurement points (Figure II-2-71).

Additionally, analysis of plutonium (Pu-238, Pu-239, Pu-240) and strontium (Sr-89, Sr-90) on the north of the intake channels of Units 1 to 4 is also conducted periodically. The results to date are that plutonium is below the detection limit, while that strontium has is detected.

c Sub-drain

For the accumulated water in the basements of the turbine buildings and in the Radioactive Waste Treatment Facilities, to check its leak into the underground of the outside of the buildings, now, samples are taken three times a week in surrounding areas of the turbine building and every day in surrounding areas of the Radioactive Waste Treatment Facilities, and the nuclide analysis is periodically implemented.

Radioactive concentration of gamma-ray nuclides, although varied to some extent due to the effect of precipitation, etc., tends to decrease and no significant rise is observed (Figure II-2-72). Also, no significant change at sub-drain in surrounding areas of the Radioactive Water Treatment Facilities is identified.

Additionally, analysis of plutonium (Pu-238, Pu-239, Pu-240) and strontium (Sr-89, Sr-90) at sub-drain near the turbine buildings of Units 2 and 5 is also conducted periodically. The results to date are that plutonium is below the detection limit, while that strontium is detected.

d Soil

At the three points, each of which is 500m away from the ventilation stack of Units 1 and 2 and is large soil appropriate for sampling, samples are taken periodically and nuclide analysis of gamma ray, plutonium (Pu-238, Pu-239, Pu-240), uranium (U-234, U-235, U-238) and strontium (Sr-89, Sr-90) contained in the soil is conducted (Figure II-2-72, Tables II-2-32 to II-2-35).

The result of gamma-ray nuclide analysis was that higher-level radioactive materials were detected compared to the result measured in Fukushima prefecture for fiscal year 2009.

For plutonium, the radioactive concentration is the level similar to the fallout observed in Japan at the past atmospheric nuclear testing, but as the radioactive ratio (Pu-238/Pu-239+Pu-240) is greater than 0.026, a ratio indicated as the effect of the past atmospheric nuclear testing, cause of the detection is estimated to result from the accident this time.

For uranium, as the radioactive concentration of U-234 and U-238 are similar level each other, and the abundance ratio (U-235/U-238) are almost the same as 0.073, natural abundance ratio, detected uranium is evaluated to be the same level of the naturally-occurring uranium.

For strontium, as the radioactive concentration is higher than the fallout observed in Japan at the past atmospheric nuclear testing, it is estimated to result from the accident this time.

Additionally, in case that plutonium is detected, analysis of americium (Am-241) and curium (Cm-242, Cm-243, Cm-244) contained in the soil is also conducted. From the detection results of americium and curium, those nuclides are estimated to result from the accident this time from the following facts (Table II-2-36).

・curium (Cm-242, Cm-243, Cm-244) is not a nuclide existing in nature and particularly Cm-242 of which half-life is relatively short (half-life: about 160 days) is detected.

・For each sample, concentration ratio of each nuclide (Am-241, Cm-242, Cm-243 and Cm-244) to Pu-238 is almost the same as that of the average composition of the Units 1 to 3.

e Accumulated water

Concentration measurement of samples of accumulated water is conducted at the time of measurement for decontamination factor (DF) at the Accumulated Water Treatment Facilities. For iodine (I-131), downward trend for the concentration, which is estimated to be caused by decay, is observed. For cesium (Cs-134, Cs-137), the concentration stays at almost the same level and no significant change is observed (Table II-2-37).

f Dose rate in site

TEPCO made a survey map indicating the points of high dose rate and updates it occasionally by measuring the dose rate inside of the plant site in order to safely conduct recovery works with prior knowledge of environmental dose (Figure II-2-74).

Table II-2-32 Results of Gamma Nuclide Analysis in the Soil at Fukushima Dai-ichi NPS

1. Analysis results: results of gamma nuclide analysis in the soil on the premises of the plant are shown in the below table. All samples analyzed for plutonium were analyzed.

2. Evaluation: the following is analysis result of gamma nuclide in the soil measured in the Fukushima Prefecture in FY 2009, and higher concentrations of radioactive materials have been detected compared to this value.

   <Soil analysis result by Fukushima Prefecture in FY 2009>
   Cs-137: ND-21Bq/kg (dry soil), Others: ND

(Unit: Bq/kg, dry soil)

Sampling point		[Fixed point (1)]*1 Sports ground (WNW approx. 500m)*2	[Fixed point (2)]*1 Wild Birds' Forest (west approx. 500m)*2	[Fixed point (3)]*1 Near landfill site for industrial waste (SSW approx. 500m)*2
Date of sampling		August 8	August 8	August 8
Analysis organization		Japan Chemical Analysis Center*3	Japan Chemical Analysis Center*3	Japan Chemical Analysis Center*3
Date of measurement		August 9	August 9	August 9
Nuclide	I-131 (approx. 8 days)	ND	ND	ND
	I-132 (approx. 2 hours)	ND	ND	ND
	Cs-134 (approx. 2 years)	1.8E+04	1.6E+03	1.8E+06
	Cs-136 (approx. 13 days)	ND	ND	ND
	Cs-137 (approx. 30 years)	2.1E+04	1.7E+03	2.0E+06
	Sb-125 (approx. 3 years)	ND	ND	ND
	Te-129m (approx. 34 days)	ND	ND	1.5E+05
	Te-132 (approx. 3 days)	ND	ND	ND
	Ba-140 (approx. 13 days)	ND	ND	ND
	Nb-95 (approx. 35 days)	ND	ND	ND
	Ru-106 (approx. 370 days)	ND	ND	ND
	Mo-99 (approx. 66 hours)	ND	ND	ND
	Tc-99m (approx. 6 hours)	ND	ND	ND
	La-140 (approx. 2 days)	ND	ND	ND
	Be-7 (approx. 53 days)	ND	ND	ND
	Ag-110m (approx. 250 days)	ND	ND	ND

*1 For the fixed points of "(1) sports ground" and "(3) near landfill site for industrial waste," samples were collected from adjacent areas to avoid previously sampled spots. For "(2) Wild Birds' Forest," in-depth sampling was conducted at the same point (the point was changed when sampling was no longer possible).
*2 Distance from the stacks of Units 1 and 2
*3 The analysis results of Japan Chemical Analysis Center have not been corrected for the half-life up to the time of sample collection.

Table II-2-33 Results of Plutonium Analysis in the Soil at Fukushima Dai-ichi NPS

1. Measurement results

(Unit: Bq/kg, dry soil)

Sampling point ( ): distance from the stacks of Units 1 and 2	Date of sampling/ Analysis organization	Pu-238	Pu-239,Pu-240
(1) Sports ground (west-northwest approx. 500 m)	August 8 Japan Chemical Analysis Center	$(5.4\pm0.75)\times10^{-2}$	$(2.9\pm0.54)\times10^{-2}$
(2) Wild Birds' Forest (west approx. 500 m)		N.D. [$<1.0\times10^{-2}$]	$(2.0\pm0.46)\times10^{-2}$
(3) Near landfill site for industrial waste (south-southwest approx. 500 m)		$(9.2\pm1.3)\times10^{-2}$	$(4.8\pm0.90)\times10^{-2}$
Domestic soil*		N.D.–1.5×10^{-1}	N.D.–4.5

Values in [ ] show detection limit.

* Ministry of Education, Culture, Sports, Science and Technology “Environmental Radiation Database” 1978-2008

* For the fixed points of "(1) sports ground" and "(3) near landfill site for industrial waste," samples were collected from adjacent areas to avoid previously sampled spots. For "(2) Wild Birds' Forest," in-depth sampling was conducted at the same point (the point was changed when sampling was no longer possible).

2. Assessment

The concentrations of Pu238, Pu239, and 240 detected on August 8 are almost equivalent to the level of fallouts observed in Japan in the past atmospheric nuclear tests; however, the ratio of radioactivity (Pu-238/Pu-239 + Pu-240) was greater than the ratio 0.026 which is the indicated value affected by the past atmospheric nuclear tests, so that we have determined that the detected values were derived from the accident at Fukushima.

Some samplings taken after March 21 revealed that Pu-238, Pu-239, and Pu-240 were detected in several locations. However, major differences were not identified in the values.

Table II-2-34 Results of Uranium Analysis in the Soil at Fukushima Dai-ichi NPS

1. Measurement results

(Unit: Bq/kg, dry soil)

Sampling point ( ): distance from the stacks of Units 1 and 2	Date of sampling/ Analysis organization	U-234	U-235	U-238
(1) Sports ground (west-northwest approx. 500 m)	June 20 Japan Chemical Analysis Center	11±0.58	0.57±0.097	12±0.59
(2) Wild Birds' Forest (west approx. 500 m)		6.4±0.37	0.40±0.079	6.2±0.35
(3) Near landfill site for industrial waste (south-southwest approx. 500 m)		5.7±0.33	0.22±0.055	5.7±0.33
Natural uranium specific radioactivity (Bq/g)		1.2×10^4	5.7×10^2	1.2×10^4
Natural uranium abundance ratio (wt%)		0.0054	0.72	99.3

2. Assessment

The level of the uranium detected this time is assessed to be equivalent to that of naturally-occurring uranium, based on the following findings.

- The naturally-occurring uranium is radioactively equilibrium, that is, the radioactive concentrations of U-234 and U-238 are the same. It was found that all of the samples No. 1 to No. 3 have almost the same radioactive concentrations in U-234 and U-238.
- Samples No.1 to No.3 have almost the same abundance ratio as in naturally-occurring U-235; that is, U-235/U-238 = 0.0073.

  U-235 in Sample No.1: 7.1×10-6g/kg - dry soil (0.57Bq/kg – dry soil)
  U-238 in Sample No.1: 9.6×10-4g/kg - dry soil (12Bq/kg - dry soil)
  U-235/U-238=0.0074※
  U-235 in Sample No.2: 5.0×10-6g/kg - dry soil (0.40Bq/kg - dry soil)
  U-238 in Sample No.2: 5.0×10-4g/kg - dry soil (6.2Bq/kg - dry soil)
  U-235/U-238=0.010※
  U-235 in Sample No.3: 2.7×10-6g/kg - dry soil (0.22Bq/kg - dry soil)
  U-238 in Sample №.3: 4.6×10-4g/kg - dry soil (5.7Bq/kg - dry soil)
  U-235/U-238=0.0060※

※Due to rounding, some calculation values may not correspond with those shown above.

Table II-2-35 Results of Strontium Analysis in the Soil at Fukushima Dai-ichi NPS

1. Measurement results

(Unit: Bq/kg, dry soil)

Sampling point ( ): distance from the stacks of Units 1 and 2	Date of sampling/ Analysis organization	Sr-89	Sr-90
(1) Sports ground (west-northwest approx. 500 m)	July 11 Japan Chemical Analysis Center	$(7.5\pm0.08)\times10^{2}$	$(3.2\pm0.04)\times10^{2}$
(2) Wild Birds' Forest (west approx. 500 m)		$(1.3\pm0.10)\times10^{1}$	$(3.6\pm0.50)\times10^{0}$
(3) Near landfill site for industrial waste (south approx. 500 m)		$(9.3\pm0.30)\times10^{1}$	$(4.0\pm0.17)\times10^{1}$
Previous measurement range*		–	ND – 4.3

* From FY 2009 "Report on Measurement Results of Environmental Radioactivity around NPS" (FY 1999-2008)

* For the fixed points of "(1) sports ground" and "(3) near landfill site for industrial waste," samples were collected from adjacent areas to avoid previously sampled spots. For "(2) Wild Birds' Forest," in-depth sampling was conducted at the same point (the point was changed when sampling was no longer possible).

2. Assessment

The concentration of Sr-90 detected is higher than that of the fallouts observed in Japan in the past atmospheric nuclear tests; therefore, it is determined that the detected value was derived from the accident at Fukushima.

Table II-2-36 Results of Americium and Curium Analyses in the Soil at Fukushima Dai-ichi NPS

1. Measurement results

(Unit: Bq/kg, dry soil)

Sampling point ( ): distance from the stacks of Units 1 and 2	Date of sampling/ Analysis organization	Pu-238*1	Pu-239*1 Pu-240*1	U-234*2	U-235*2	U-238*2	Am-241	Cm-242	Cm-243 Cm-244
(1) Sports ground (WNW approx. 500 m)	June 20 Japan Chemical Analysis Center	$(1.2\pm0.12)\times10^{-1}$	$(5.8\pm0.77)\times10^{-2}$	$(1.1\pm0.058)\times10^{1}$	$(5.7\pm0.97)\times10^{-1}$	$(1.2\pm0.059)\times10^{1}$	$(2.0\pm0.45)\times10^{-2}$	$(1.4\pm0.055)\times10^{0}$	$(9.5\pm0.98)\times10^{-2}$
(2) Wild Birds' Forest (west approx. 500 m)		N.D. $[<1.0\times10^{-2}]$	$(2.9\pm0.56)\times10^{-2}$	$(6.4\pm0.37)\times10^{0}$	$(4.0\pm0.79)\times10^{-1}$	$(6.2\pm0.35)\times10^{0}$	N.D. $[<9.7\times10^{-3}]$	N.D. $[<9.5\times10^{-3}]$	N.D. $[<9.5\times10^{-3}]$
(3) Near landfill site for industrial waste (SSW approx. 500 m)		$(1.7\pm0.15)\times10^{-1}$	$(6.1\pm0.81)\times10^{-2}$	$(5.7\pm0.33)\times10^{0}$	$(2.2\pm0.55)\times10^{-1}$	$(5.7\pm0.33)\times10^{0}$	$(5.3\pm0.72)\times10^{-2}$	$(2.1\pm0.079)\times10^{0}$	$(1.0\pm0.11)\times10^{-1}$
Average nuclide concentration ratio at Units 1-3 (ratio when Pu-238 is 1) *3		1	-	-	-	-	0.1	10	1

*1: published on July 8, 2011 *2: published on July 21, 2011 *3: calculated value by ORIGEN code (round number)

2. Assessments

It is determined based on the following findings that Am and Cm detected this time were derived from the accident at Fukushima.

- Cm-242, Cm-243, and Cm-244 are not naturally-occurring nuclides, and especially, Cm-242 whose half-life is relatively short (half-life: approx. 160 days) has been detected.
- The concentration ratio of each nuclide (AM-241, CM-242, Cm-243, Cm-244) in relation to Pu-238 in Samples No.1 and No.3 is almost the same as the average ratio of composition in Units 1 to 3.

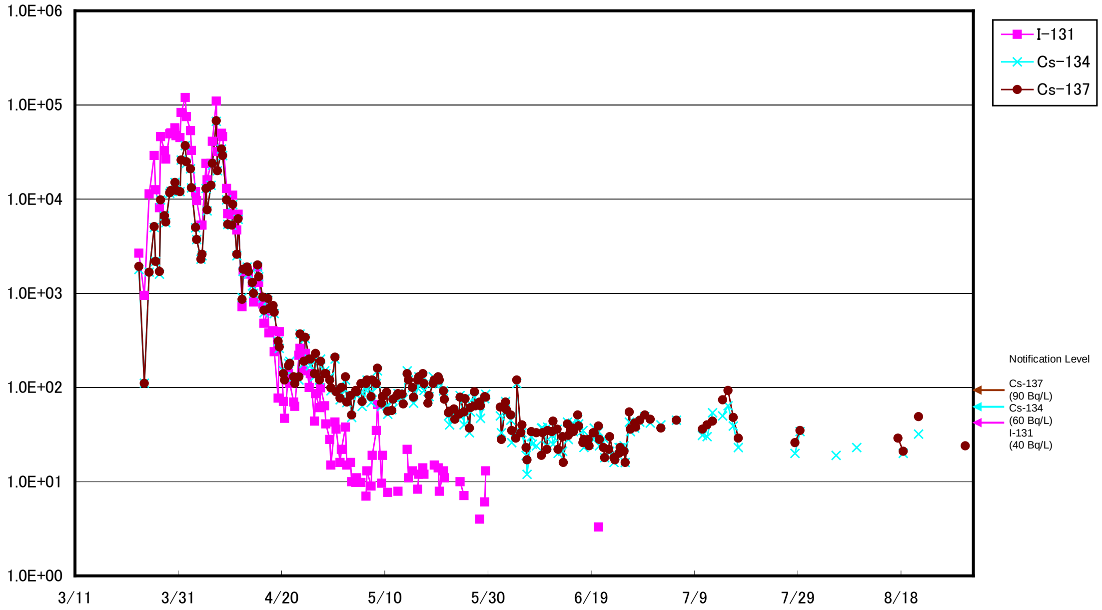
Sample No.1　Pu-238:(Am-241/Cm-242/Cm-243,Cm-244)≒1：(0.2/12/0.6)

Sample No.3　Pu-238:(Am-241/Cm-242/Cm-243,Cm-244)≒1：(0.3/12/0.6)

Table II-2-37 Accumulated Water (Evaluation at DF Measurement of Accumulated Water Treatment Facility)

Sample	Highly Concentrated Contaminated Water at Basement of Centralized RW (accumulated water)						High Level Contaminated Water in HTI Underground (accumulated water)
Date of Sampling Time	2011 June 17 20:50	2011 June 26 08:40	2011 July 5 07:30	2011 July 28 12:50	2011 August 9 15:00	2011 August 16 08:10	2011 August 19 21:40
Sampling Point	Sampling line at 3rd Floor of Centralized RW						Top of hatch on 1st floor of HTI
Nuclide	Concentration of sample (Bq/cm^3)						
I-131	6.9×10^3	3.4×10^3	ND (<8.7×10^3)	ND (<7.6×10^3)	ND (<6.4×10^3)	ND (<6.9×10^3)	ND (<7.2×10^3)
Cs-134	2.0×10^6	2.2×10^6	2.0×10^6	1.6×10^6	1.1×10^6	1.1×10^6	1.1×10^6
Cs-137	2.2×10^6	2.4×10^6	2.2×10^6	1.8×10^6	1.3×10^6	1.3×10^6	1.3×10^6

Radioactivity Concentration of Seawater at Northern Side of Water Discharge Canal of Units 5 and 6 of Fukushima Dai-ichi (Bq/L)



Radioactivity Concentration of Seawater near Southern Water Discharge Canal of Fukushima Dai-ichi (Bq/L)

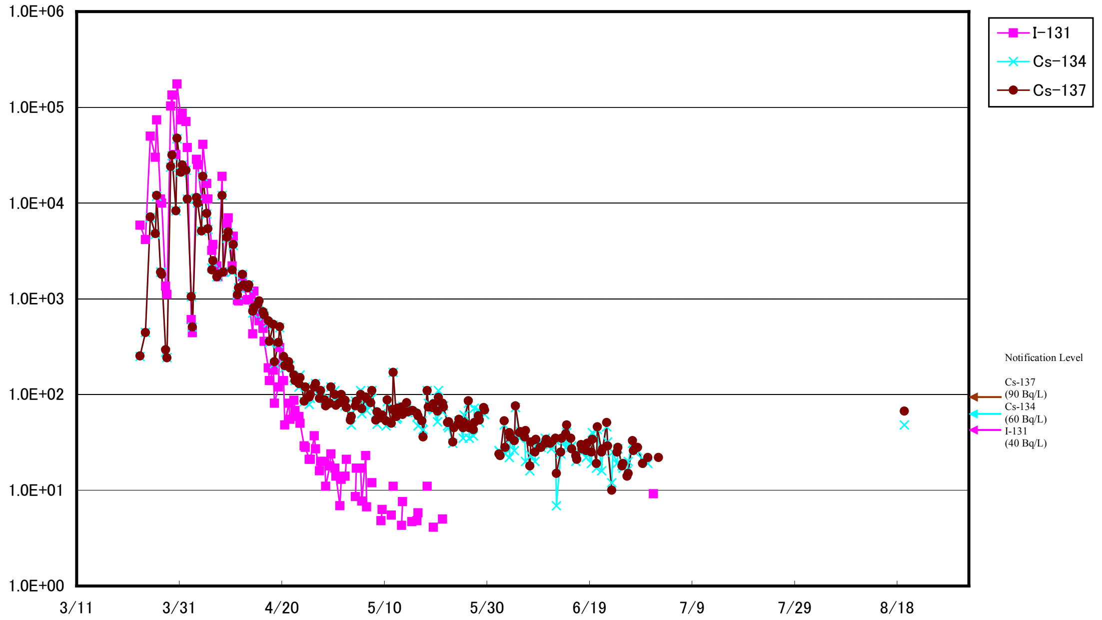


Figure II-2-70 Radioactive Concentration at Water Discharge Canal of Fukushima Dai-ichi NPS

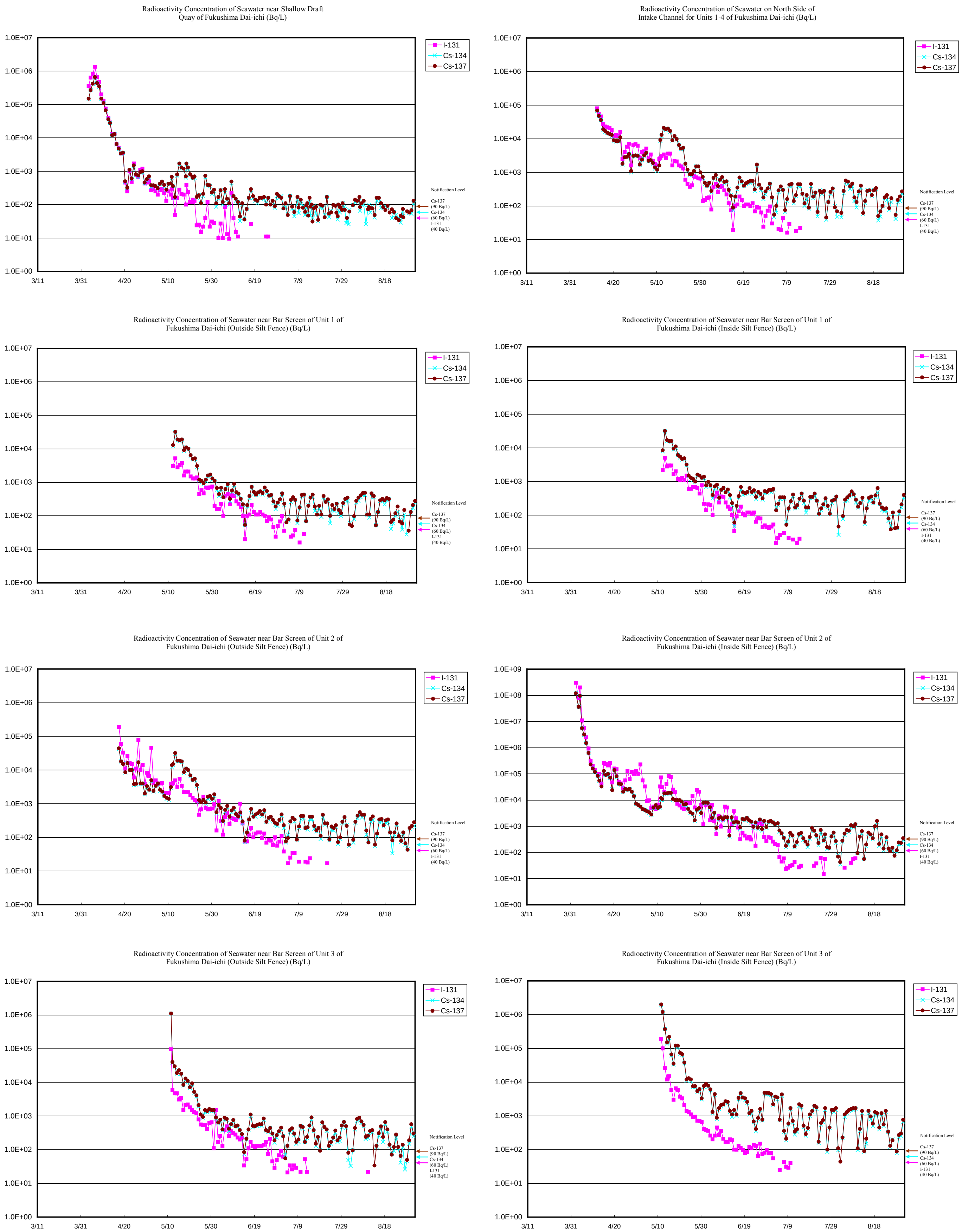
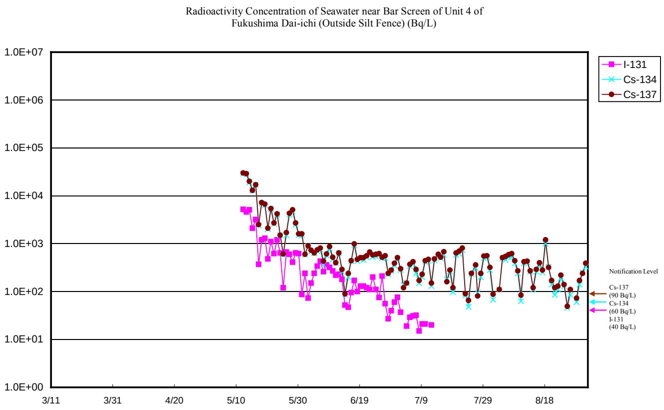
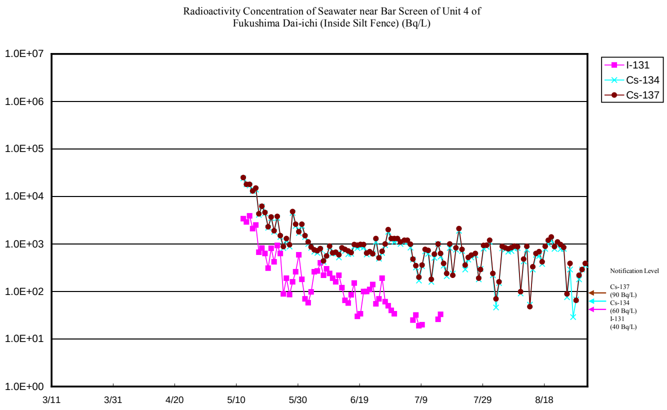


Figure II-2-71 Radioactive Concentration Near Bar Screen of Fukushima Dai-ichi NPS (1/2)





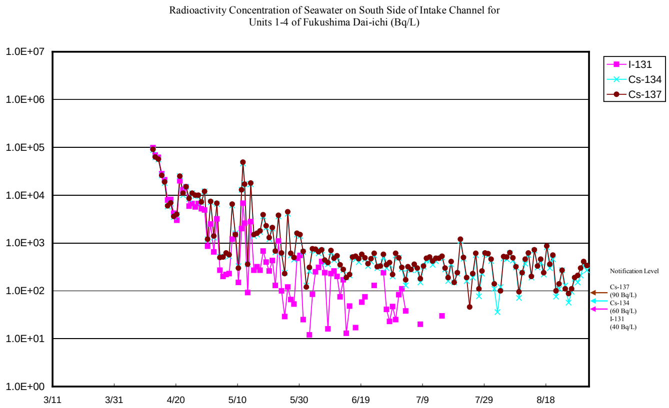
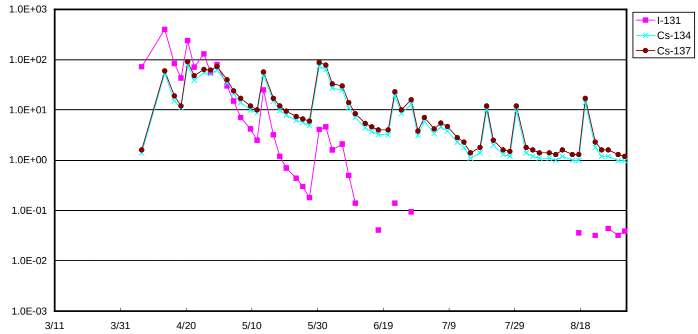
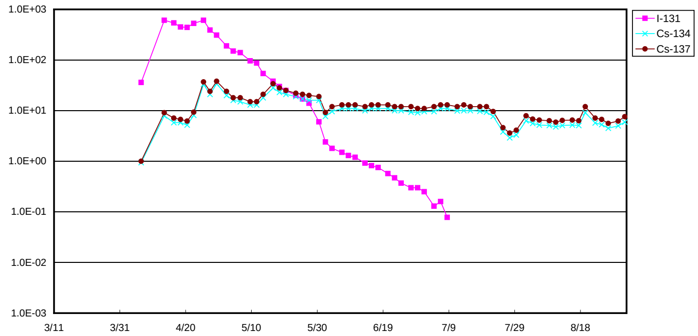


Figure II-2-71 Radioactive Concentration Near Bar Screen of Fukushima Dai-ichi NPS (2/2)

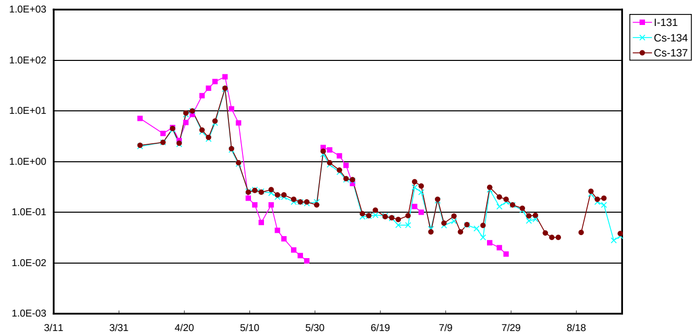
Radioactivity Concentration at Sub-drain of Unit 1 of Fukushima Dai-ichi (Bq/cm^3)



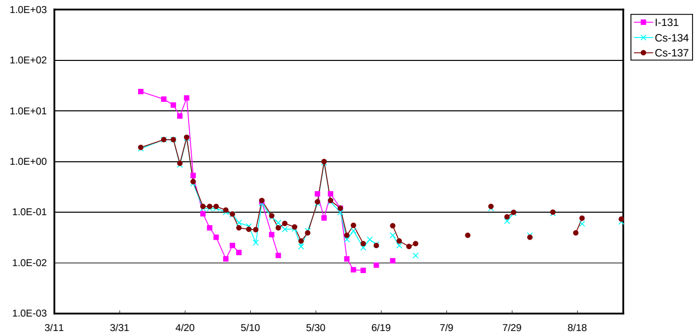
Radioactivity Concentration at Sub-drain of Unit 2 of Fukushima Dai-ichi (Bq/cm^3)



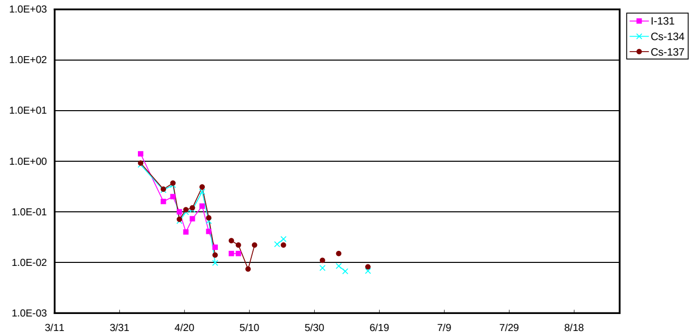
Radioactivity Concentration at Sub-drain of Unit 3 of Fukushima Dai-ichi (Bq/cm^3)



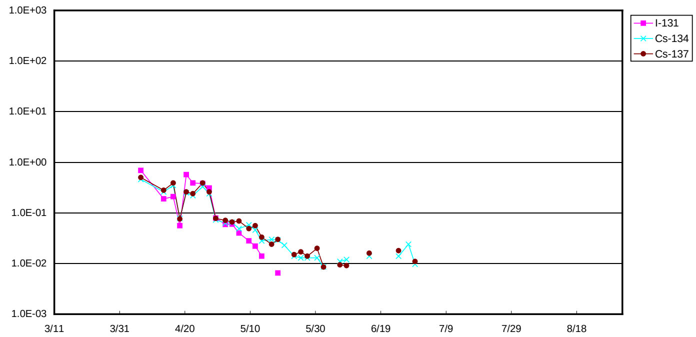
Radioactivity Concentration at Sub-drain of Unit 4 of Fukushima Dai-ichi (Bq/cm^3)



Radioactivity Concentration at Sub-drain of Unit 5 of Fukushima Dai-ichi (Bq/cm^3)



Radioactivity Concentration at Sub-drain of Unit 6 of Fukushima Dai-ichi (Bq/cm^3)



Radioactivity Concentration of Deep Well of Fukushima Dai-ichi (Bq/cm^3)

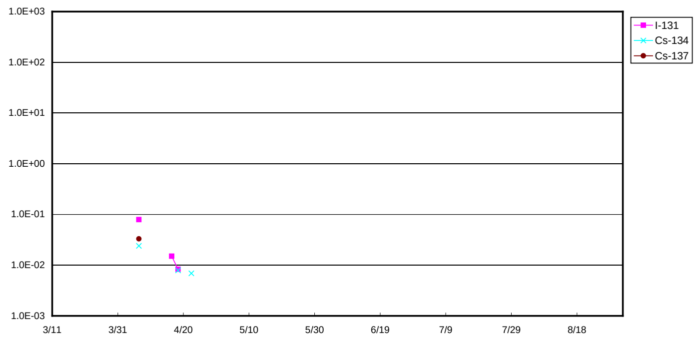
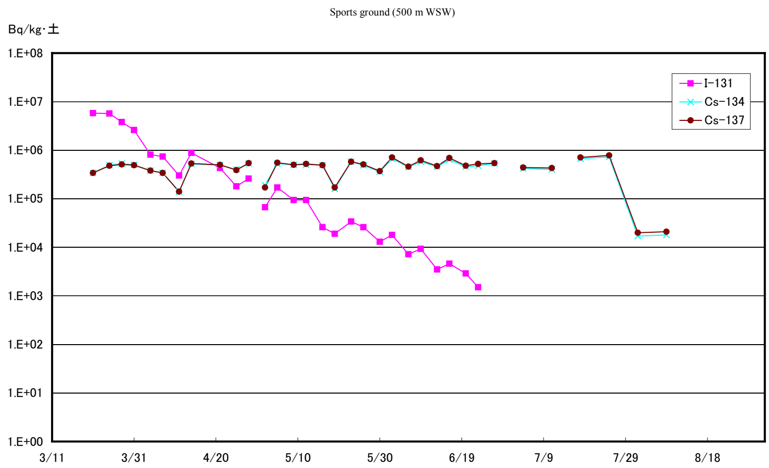
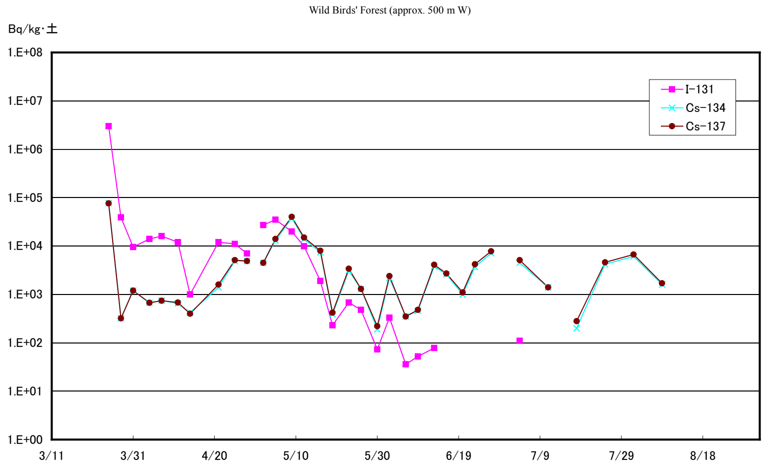


Figure II-2-72 Radioactive Concentration at Sub-drain and Other Places of Fukushima Dai-ichi NPS





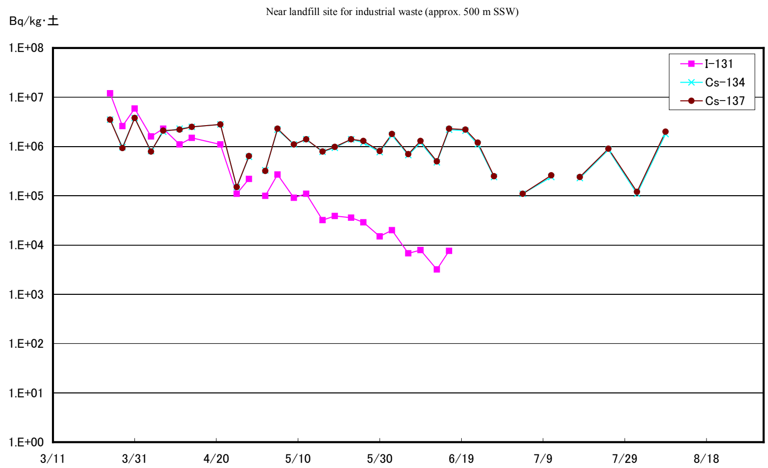


Figure II-2-73 Radioactive Concentration in the Soil at Fukushima Dai-ichi NPS

* For the fixed points of "sports ground" and "near landfill site for industrial waste," samples were collected from adjacent areas to avoid previously sampled spots. For "Wild Birds' Forest," in-depth sampling was conducted at the same point (the point was changed when sampling was no longer possible).

Radioactivity Survey Map of Fukushima Dai-ichi (as of 17:00, August 18, 2011)

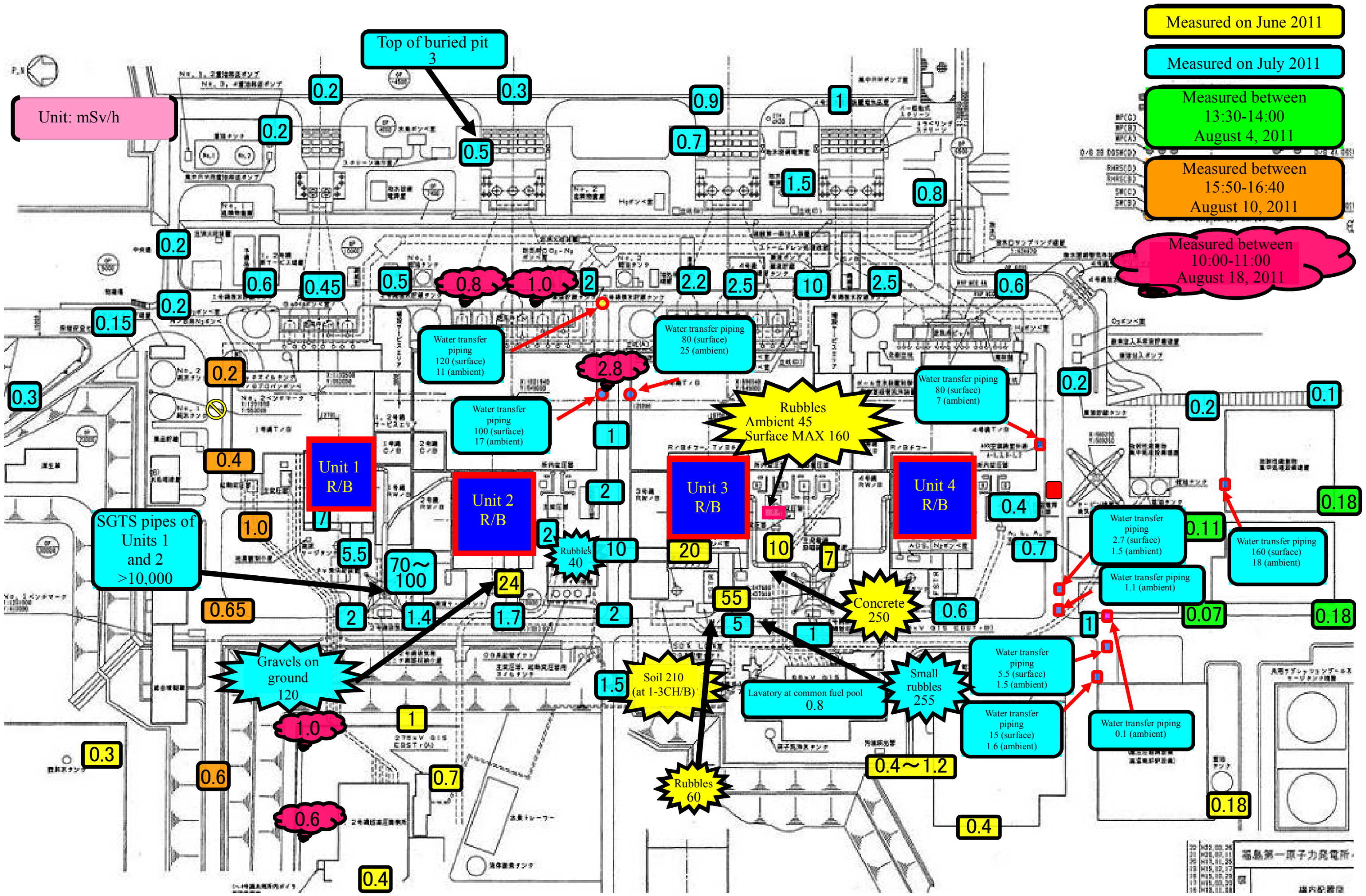


Figure II-2-74 Radioactivity Survey Map of Fukushima Dai-ichi NPS

4) Assessment of the seismic safety of major buildings, facilities, etc.

Some reactor facilities at the Fukushima Dai-ichi Nuclear Power Station suffered damages to their external walls, etc., as a result of explosion (probably of hydrogen) and fire. In order to be better prepared against aftershocks, etc., TEPCO studied the seismic safety of the reactor buildings in its present state together with the seismic reinforcement, which had been implemented as necessary, etc.

As a review plan, the present state of the damage at the reactor buildings was examined based on the photographs and video films because the radiation levels are too high to visually verify the damage directly inside the buildings. For each reactor building, a lumped mass model was produced to represent its damaged state such as scattered steel plates, steel frame roof structures, roof slabs, etc., above the operating floor to enable the analysis of its time historical response to the standard seismic motion Ss. The analysis was conducted on the impacts on facilities important to seismic safety, such as RPV, PCV, SFP, and so on.

As a basic assumption in the modeling of damaged buildings, the remaining portions of steel frame structures were not any more counted as structural components. As to floors and walls, it was assumed that their stiffness and strength had diminished from their integrity states depending on the severity of damages they received from explosion and/or fire. In the case of Unit 3, for example, it was assumed that the SFP and reactor well, which could have received partial minor damage, had decreased their stiffness to 80% of the initial level, and that the floor on the fourth level and the operating floor, which are very likely to have been partially damaged, had decreased their stiffness to 50% of the initial level.

Judging from the states of damages at the third and fourth floor levels of the Unit 3 and Unit 4 reactor buildings, the shell walls around SFP and PCV are the main seismic resisting elements. Therefore, for these reactor units, we also conducted local assessments using a three-dimensional finite element analysis model (Figs. II-2-75 and II-2-76) covering a part of the building (from the second floor level to the operating floor level).

The Nuclear and Industrial Safety Agency (NISA), after having also examined the result of another study conducted by JNES, admitted the adequacy of the following conclusions from TEPCO's study on the seismic safety of the reactor buildings [at

Fukushima Dai-ichi]:

a. Conclusions about Unit 1

At the Unit 1 reactor building, the structures above the operating floor (the fifth floor level) were damaged by an event, which is believed to be a hydrogen explosion, occurring on March 12, the day after the Tohoku District - off the Pacific Ocean Earthquake.

Studying damages from the available sources of information such as photographs and video films, modifications were made to a model (II2-6) that had been prepared for the reassessment of seismic safety using the updated guide for seismic design (hereinafter referred to as "seismic design back-check"); the steel frame structures that remained above the operating floor were no more counted as structural components. In other words, the structures above the operating floor were removed from the model that had been prepared for the seismic design back-check. In addition, the model that had been prepared for the back-check was modified to properly represent how the weight of the structures above the operating floor is distributed on the operating floor. Components such as seismic walls and floors below the operating floor were assumed as unaffected by the explosion, thus the structural performance of the back-check model was assumed to remain unchanged.

According to the results of time historical response analysis, the sheer strain that can appear in the seismic walls of the Unit 1 reactor building was estimated to be $0.12x10^{-3}$ at the maximum, leaving a sufficient margin to the criterion of $4.0x10^{-3}$. (See Fig. II-2-77.)

Since no part of the building was identified to have any danger of failure in ensuring the seismic safety, TEPCO, at this moment, does not plan any urgent implementation of seismic reinforcement works, etc.

b. Conclusions about Unit 2

The Unit 2 reactor building shows no apparent damage even though the blow out panel on the east end external wall is exposed. Access is restricted due to high dose level, hindering the inspection of building interior, but at this moment, it is believed that there is no damage.

In consideration of the above, the results of analyses conducted during the seismic design back-check (II2-6) were used, without change, to evaluate the seismic safety of the building. According to the results of time historical response analysis, the shear strain that can appear in the seismic walls of the Unit 2 reactor building was estimated to be $0.17x10^{-3}$ at the maximum, leaving a sufficient margin to the criterion of $4.0x10^{-3}$. (See Fig. II-2-78)

For more assurance, parameter studies were conducted considering the possibility of the shell wall stiffness having been reduced by a temporary rise of temperature inside the PCV and the identified noise on March 15 near the S/C at the underground level. The modifications to parameters caused some changes to the numerical outputs but did not significantly impact the analysis results.

c. Conclusions about Unit 3

As for the Unit 3 reactor building, the structures above the operating floor (the fifth floor level) were damaged by an incident which is believed to be a hydrogen explosion on March 14. According to available sources such as photographs and video films, a majority of the structures above the fifth floor level are in the state of a stack of iron frame and concrete structures which collapsed after the explosion. The floor at the fifth level at the northwestern corner has been damaged, causing some of the collapsed iron frame and concrete structures to pile up on the fourth floor, and many parts of the walls on the fourth level are damaged.

In consideration of the above information, modifications were made to a model (II2-6) that had been prepared for the seismic design back-check; the frame structures that remained above the operating floor and the damaged seismic walls below the operating floor were no more counted as structural components. In other words, the structures above the operating floor were removed from the model for the back-check, and modifications were made to the assumed structural performance of the structures below the operating floor by decreasing the shearing cross-sectional area and the cross-sectional secondary moment from their integrity states. In addition, the model was modified to properly represent how the weight of the structures above the operating floor is distributed on the operating floor. The model was further modified to properly represent how the weight of the collapsed northwestern corner of the operating floor, and the weights of the collapsed walls and frame structures on the fourth level, are distributed on the forth floor.

According to the results of time historical response analysis, the shear strain that can appear in the seismic walls of the Unit 3 reactor building was estimated to be $0.14x10^{-3}$ at the maximum, leaving a sufficient margin to the criterion of $4.0x10^{-3}$. (See Fig. II-2-79)

According to the results of local assessments that focused on shell walls and SFP, the shear strain that can appear in the iron frame structures was estimated to be $1.31x10^{-3}$ at the maximum, leaving a sufficient margin to the criterion of $5.0x10^{-3}$. The amount of stress that can appear at points that are most vulnerable to out-of-plane shear forces was also confirmed to be at a level that leaves a sufficient margin to the criterion.

Since no part of the building was identified to have any danger of failure in ensuring the seismic safety, TEPCO, at this moment, does not plan any urgent implementation of seismic reinforcement works, etc.

d. Conclusions about Unit 4

As for the Unit 4 reactor building, the building lost a majority of its roof slabs and walls above the fifth floor level due to unidentified cause on March 15, leaving only the frame structures of columns and beams, and furthermore, the available sources such as photographs and video films indicate that a majority of walls on the fourth level and some walls on the third level have also been damaged.

In consideration of the above information and also of the fact that Unit 4 was not loaded with fuel because of a scheduled outage underway on the day of the earthquake, modifications were made to a model (II2-7) for the seismic design back-check, referring to data concerning the load conditions during scheduled outages. The frame structures that remained above the operating floor and the damaged seismic walls below the operating floor were no more counted as structural components. In other words, the structures above the operating floor were removed from the model for the back-check, and modifications were made to the assumed structural performance of the structures below the operating floor. In addition, the model for the back-check was modified to properly represent how the weight of the structures above the operating floor is distributed on the operating floor.

According to the results of time historical response analysis, the shear strain that can appear in the seismic walls of the Unit 4 reactor building was estimated to be $0.17x10^{-3}$

at the maximum, leaving a sufficient margin to the criterion of $4.0x10^{-3}$. (See Fig. II-2-80)

According to the results of local assessments that focused on SFP, the shear strain that can appear in the iron frame structures was estimated to be $1.23x10^{-3}$ at the maximum, leaving a sufficient margin to the criterion of $5.0x10^{-3}$. The amount of stress that can appear at points that are most vulnerable to out-of-plane shear forces was also confirmed to be at a level that leaves a sufficient margin to the criterion.

No part of the building was identified to have any danger of failure in ensuring the seismic safety. However, since the earthquake occurred during scheduled outage, the SFP contains not only spent fuels but also all the fuel assemblies in use that otherwise would have remained inside the reactor. Even though the detailed inspection of the reactor building interior by eyesight still remains impossible, TEPCO is implementing reinforcement works (Fig. II-2-81) to SFP in order to increase the safety margin at the bottom, as the dose at some locations is low,.

e. Conclusions about Units 5 and 6

Units 5 and 6 have already been brought to the cold shutdown state. No visual damages to the reactor buildings of these units can be found and their interior has not been inspected in details. There has been no report of information that suggests any structural damage. In consideration of the above and like in the case of Unit 2, the results of analyses conducted during the seismic design back-check (II2-8) were used as they were for studying the seismic safety of the buildings.

According to the results of time historical response analysis, the shear strain that can appear in the seismic walls of the Unit 5 reactor building was estimated to be $0.19x10^{-3}$ at the maximum, while the shear strain that can appear in the seismic walls of the Unit 6 reactor building was estimated to be $0.33x10^{-3}$ at the maximum, both leaving a sufficient margin to the criterion of $4x10^{-3}$. (See Figs. II-2-82 and II-2-83)
Further on-site investigation will check for damages of buildings.

Reference

[II2-6] Interim Report of Results of Seismic Safety Evaluation in Accordance with Revised Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities for Fukushima Dai-ichi Nuclear Power Station, Rev. 2, April 19, 2010, TEPCO

[II2-7] Interim Report of Results of Seismic Safety Evaluation in Accordance with Revised Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities for Fukushima Dai-ichi Nuclear Power Station, Rev., June 19, 2009, TEPCO

[II2-8] Interim Report of Results of Seismic Safety Evaluation in Accordance with Revised Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities for Fukushima Dai-ichi Nuclear Power Station, March 31, 2008, TEPCO

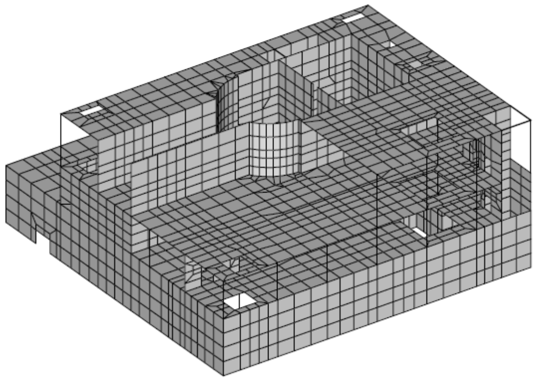


Fig. II-2-75 Finite Element Model for Unit 3 (TEPCO Report, July 13)

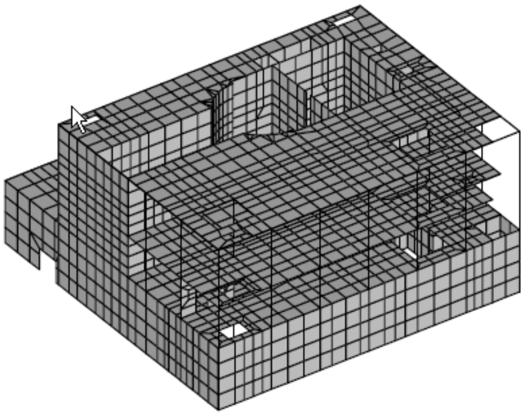


Fig.II-2-76 Finite Element Model for Unit 4 (TEPCO Report, May 28)

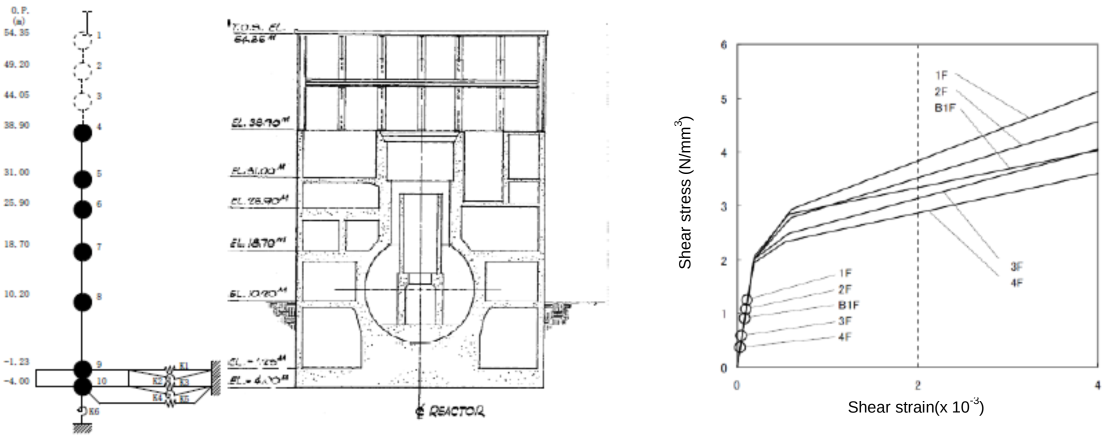


Fig.II-2-77 Lumped Mass Model and Maximum Shear Strain in the
Seismic Wall for Unit 1
(TEPCO Report, May 28)

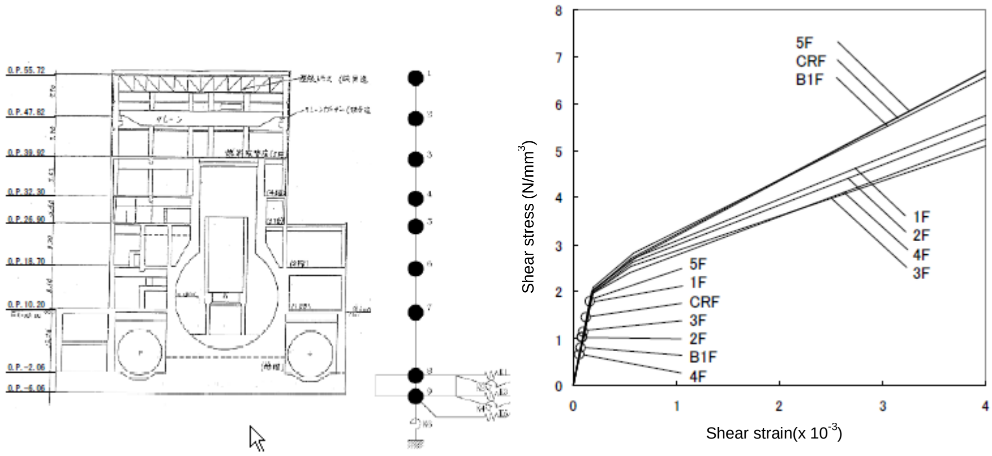


Fig.II-2-78 Lumped Mass Model and Maximum Shear Strain in the Seismic Wall for Unit 2 (TEPCO Report, August 26)

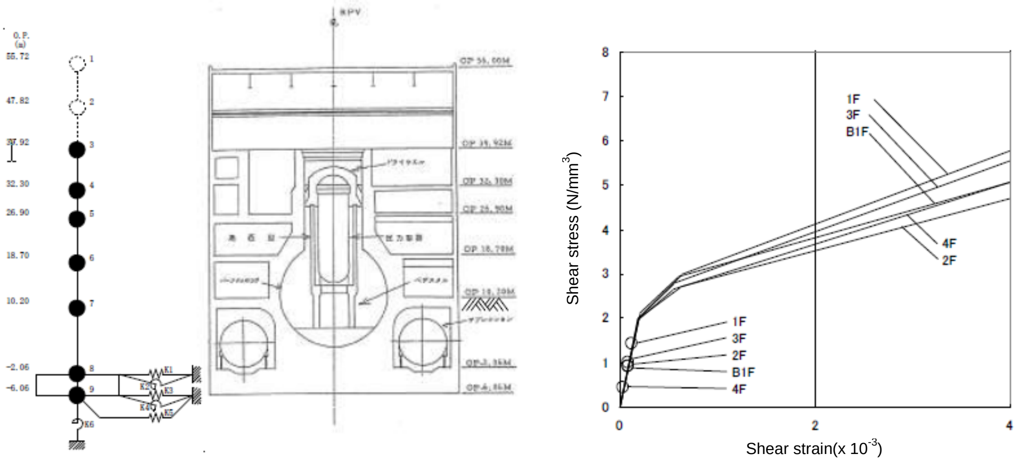


Fig. II-2-79 Lumped Mass Model and Maximum Shear Strain in the Seismic Wall for Unit 3 (TEPCO Report, July 13)

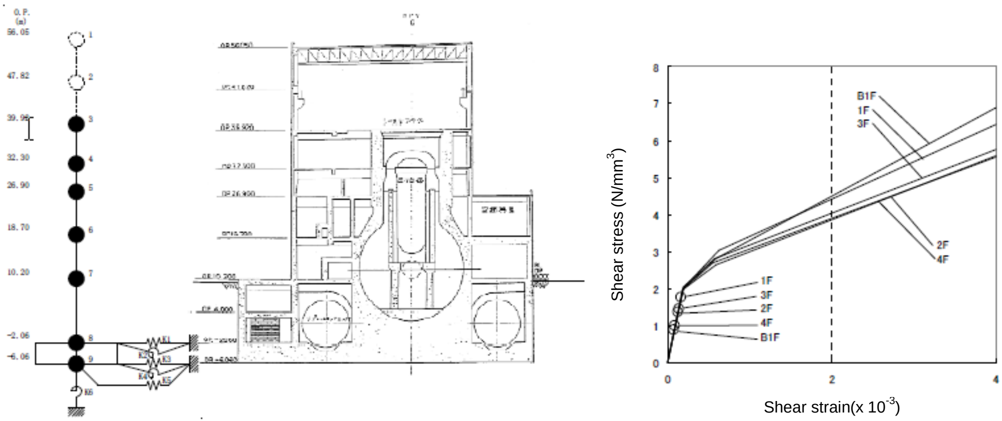
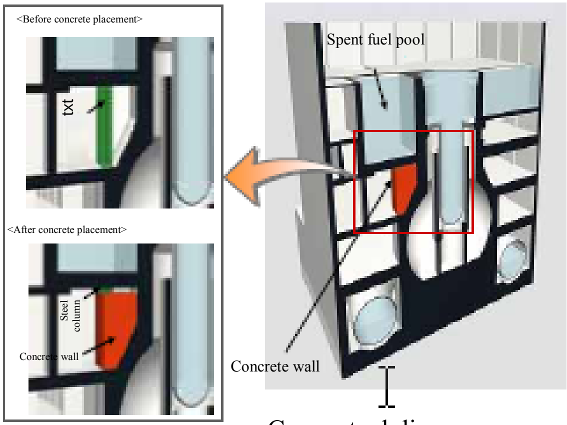


Fig. II-2-80 Lumped Mass Model and Maximum Shear Strain in the Seismic Wall for Unit 4 (TEPCO Report, May 28)



Conceptual diagram

Grout injection
(photographed on July 30)

Fig.II-2-81 Overview of Reinforcement of Unit 4 Spent Fuel Pool
(Press release material, TEPCO's homepage, July 30)

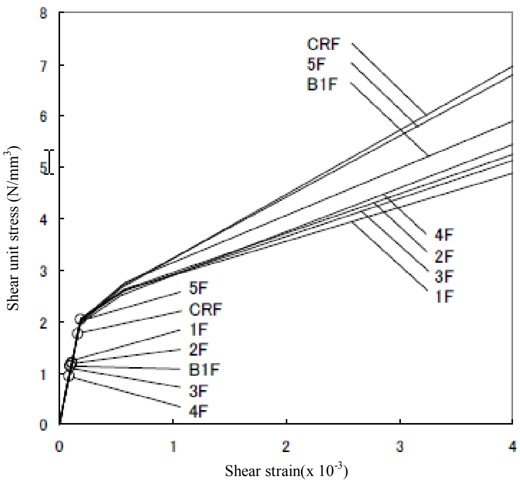


Fig.II-2-82 Maximum Shear Strain in the Seismic Wall for Unit 5 (TEPCO Report, August 26)

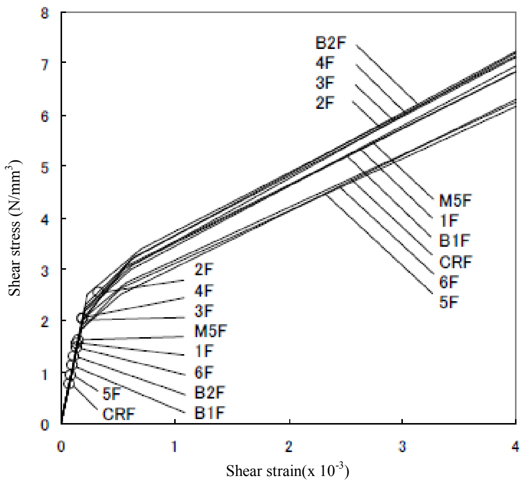


Fig.II-2-83 Maximum Shear Strain in the Seismic Wall for Unit 6 (TEPCO Report, August 26)