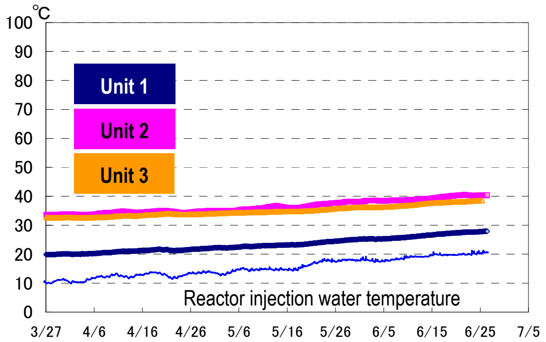
Progress Status and Future Challenges of Mid-and-Long-Term Roadmap towards the Decommissioning of Units 1-4 of TEPCO's Fukushima Daiichi Nuclear Power Station (Outline)

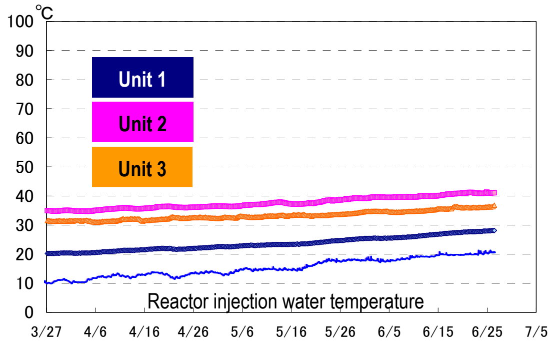
I. Confirmation of the reactor conditions

1. Internal reactor temperatures

Through continuous reactor cooling by water injection, the temperatures of the RPV bottom and PCV gas phase have been maintained within the range of approx. 20 to 45℃ for the past month, though they vary depending on the unit and location of the thermometer.



RPV bottom temperatures



PCV gas phase temperatures

The trend graphs show part of the temperature data measured at multiple points

2. Release of radioactive materials from the Reactor Buildings

The density of radioactive materials newly released from Reactor Building Units 1-3 in the air measured at site boundaries were evaluated at approx. 1.4×10^{-9} Bq/cm³ for both Cs-134 and -137. The radiation exposure dose due to the radioactive materials released was 0.03 mSv/year (equivalent to approx. 1/70 of the annual radiation dose by natural radiation (annual average in Japan: approx. 2.1 mSv/year)).

(Reference)

*** The density limit of radioactive materials in the air outside the surrounding monitoring area:**

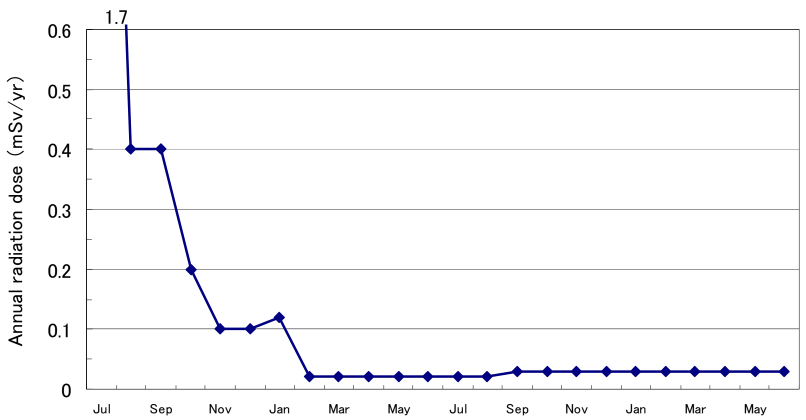
[Cs-134] : 2×10^{-5} Bq/cm³, [Cs-137] : 3×10^{-5} Bq/cm³

*** Dust density around the site boundaries of Fukushima Daiichi Nuclear Power Station (actual measurement value):**

[Cs-134] : ND (Detection limit: approx. 1×10^{-7} Bq/cm³)

[Cs-137] : ND (Detection limit: approx. 2×10^{-7} Bq/cm³)

Annual radiation dose at site boundaries by radioactive materials (cesium) released from Reactor Building Units 1-3



(Note) To evaluate the radiation dose, various formulas and coefficients were used in the facility operation plan and monthly report. The evaluation method was integrated in September 2012.

3. Other indexes

There was no significant change in parameters; including the pressure in the PCV and the PCV radioactivity density (Xe-135) for monitoring criticality, nor was any abnormality of cold shutdown condition or criticality sign detected.
Based on the above, it was confirmed that the comprehensive cold shutdown condition had been maintained and reactors remained in a stabilized condition.

II. Progress status and future challenges

1. Reactor cooling plan

- The cold shutdown condition will be maintained by cooling the reactor with water injection and measures to complement status monitoring will continue to be implemented -

➢ Operation start of the Condensate Storage Tank (CST) Reactor Coolant Injection System

- The operation of the Reactor Coolant Injection System taking water from Unit 3 CST will commence. In addition to reducing the external line length installed compared to the existing circulating coolant injection line taking water from the buffer tank (approx. 4 km -> approx. 3 km), the reliability of the Reactor Coolant Injection System will be improved, e.g. by increasing the water source volume stored and improving seismic safety. After verifying the coolant injection into the reactor in early July, system operation will commence (see Figure 1).

* CST: Condensate Storage Tank which temporarily stores water used in the plant.

➢ Investigation of the inside of Unit 2 and installation of thermometers using TIP guiding pipes

- Using TIP* guiding pipes, the internal status of the reactor was investigated and permanent thermometers installed. Based on the results of the internal status investigation on the TIP guiding pipes (4 locations) using fiber scopes, which showed that it was impossible to insert endoscopes or thermocouples, work was suspended and resolution measures examined. Consequently, a method to push up attachments and obstacles inside the same guiding pipes (applying a wire with a wedge-shaped end and forcibly pushing up the roller) was adopted. <u>Production of the feeding equipment and skill-mastering training are currently ongoing (from April 27, to be completed June 27).</u> Subsequently, the investigation using the fiber scope will be restarted (from early July).

* TIP: Traversing Incore Probe, which moves the detector up and down in the incore to measure neutron distribution

➢ Nitrogen injection into the PCV to mitigate hydrogen-related risks

- To mitigate the hydrogen-related risks, nitrogen is injected inside the PCVs and RPVs of Units 1 to 3. At present, for Unit 1, various volumes of nitrogen are injected into each nitrogen injection line to identify the impact of change in nitrogen injection volume into the PCV on the PCV internal temperature. Another test is also being performed to check the potential for injection only through reliable RPV injection lines by stopping nitrogen injection through RPV injection lines currently working (from June 18, to be completed on July 8).
- Residual air with high hydrogen concentration in the upper part of the S/C, which was generated in the early stage of the accident, is purged using nitrogen to reduce the hydrogen-related risks. As for Unit 1, the injection commenced in December 2012. Though the estimated hydrogen concentration was reduced to below the flammability limit*1 at Unit 1, nitrogen injection has continued intermittently to monitor the residual air status. As for Unit 2, nitrogen has been injected intermittently since May 2013 and in Unit 3, while no rise in hydrogen concentration was observed, monitoring of parameter changes continues.

*1 The flammability limit represents the limit allowing for combustion of hydrogen (4% or more of hydrogen and 5% or more of oxygen must be present). Combustion does not necessarily occur once the hydrogen concentration exceeds 4%.

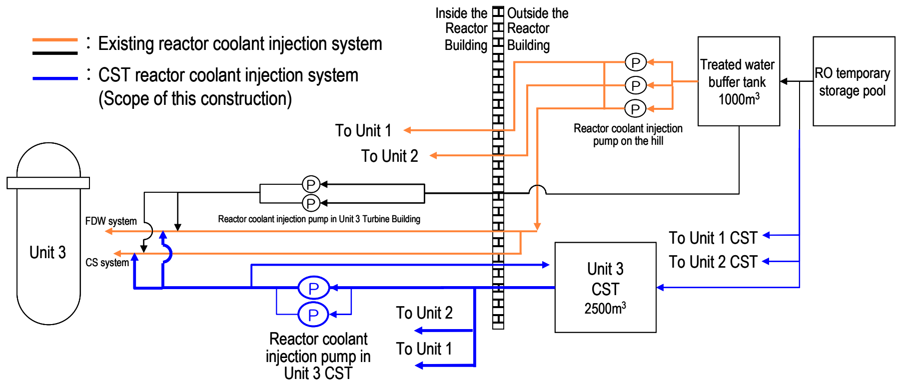


Figure 1: CST reactor water injection system diagram (Unit 3)

2. Accumulated water treatment plan

- As a countermeasure for the increasing amount of accumulated water due to inflowing groundwater, a drastic measure to prevent groundwater from flowing into the Reactor Buildings will be implemented while improving the decontamination capability of water treatment facilities and preparing facilities for contaminated water control -

➢ Preventing groundwater from flowing into the Reactor Buildings

- Preparation for a system to prevent groundwater from flowing into the Reactor Buildings by pumping the groundwater flowing from the mountainside upstream of the buildings (groundwater bypass) is being built. As for System A, the test operation and quality check was completed (System A: March 31 – April 23). As for Systems B and C, once the test operation is complete, the water quality will be checked (Systems B and C: to be completed after July). As for System A, the results of the water quality test showed that the density of the representative indicator nuclide Cs-137 was sufficiently low compared to that in the neighborhood ocean area and rivers. Based on these results, explanatory meetings for local residents are being held.

➢ Installation of multi-nuclide removal equipment

- Multi-nuclide removal equipment will be installed to further reduce the density of radioactive materials (except for tritium) contained in the accumulated water in the power station site as well as preventing unexpected leakage risks. At present, hot testing using water containing radioactive materials is being performed (Systems A and B) (System A: from March 30, System B: from June 13). As of June 25, treatment of approximately 13,000m^3 had been completed. As for System A, samples were taken from the treated water, and detailed measurements and evaluation for 62 nuclides subject to removal were completed (May 29). The evaluation results confirmed that all nuclides had been removed to a level below the announced density limit.
- The reduction of most nuclides such as Sr-90, Cs-134 and Cs-137 to a level below the detection limit was confirmed. However, for Co-60, Ru-106, Sb-125 and I-129, small amounts of radioactive materials were detected, albeit within the announced density limit. For the several nuclides detected, test results using activated carbon adsorbent confirmed an improvement in removal performance. Next, after reexamining the absorption tower configuration, the equipment will be applied in the production environment. As for System C, hot testing will commence in late July.
- Conversely, a small amount of leakage was detected from the tank (batch process tank 2A) used to pretreatment contaminated water (removing α nuclide by chemical treatment) (June 15). System A was suspended to investigate the leak, whereupon two through-holes were found (June 18) (see Figure 2). In addition, the same through-hole was found in one part of the 1A tank (June 20). Based on the investigative results, the cause and measures for resolution are currently being examined (from June 21).

➢ Status of leak from underground water storage pool and remedial measures

- As leak was detected at Nos. 1 to 3 of underground water storage pool Nos. 1 to 7 for contaminated water, we decided to terminate the use of all underground water storage pools. Treated water in these water storage pools is being transported to tanks on the ground. The transfer of treated water from Nos. 1, 2, 3 and 6 was completed by June 9. At present, treated water from No. 4, which stores treated water from Units 5 and 6, is being transferred (from June 11). Nos. 5 and 7 contain no treated water.
- The sampling results of underground water from the observation holes (new: 30 holes, existing: 7 holes) confirmed that the total β radioactivity density was lower than the detection limit. In addition, to identify leak locations, boring holes were drilled behind No. 2 for sampling. The results detected total β radioactivity density at three points (May 24). As for No. 1, total β radioactivity density was detected at one point (June 24). As for No. 2, the results of the boring survey additionally conducted to identify the distribution status confirmed that the distribution of contaminated water was very limited at present.
- Next, soil removal of the subject scope will be performed (to commence mid-July) (see Figure 3).
- In addition, boreholes will also be drilled behind No. 1 to identify the scope of the contaminated soil. To reduce the level of contaminated water leaking into the inside of the No. 1 detection hole, the residual water will be diluted by repeatedly injecting water into and discharging it from the storage pool (to be conducted in early July).

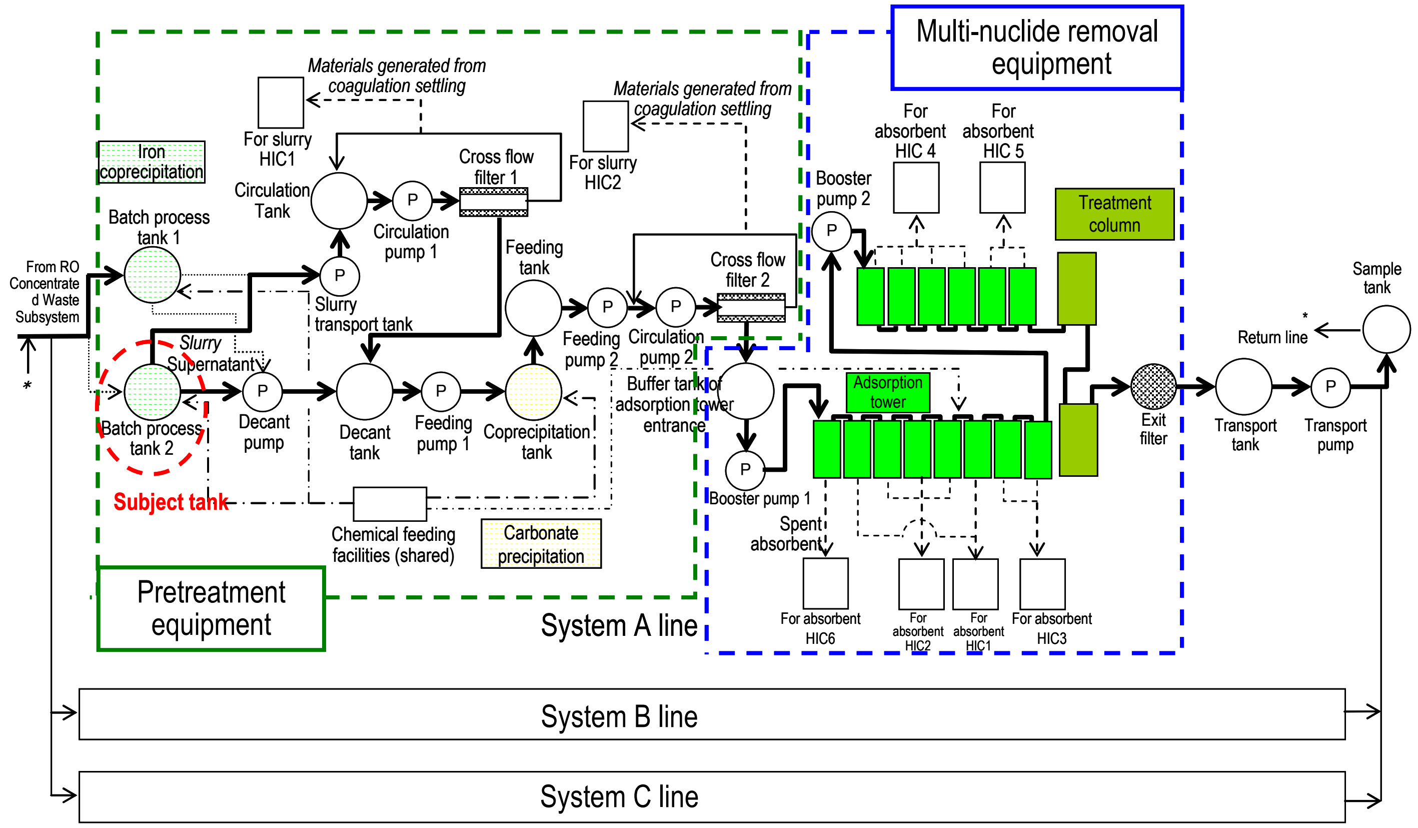


Figure 2: Diagram of overall multi-nuclide removal system

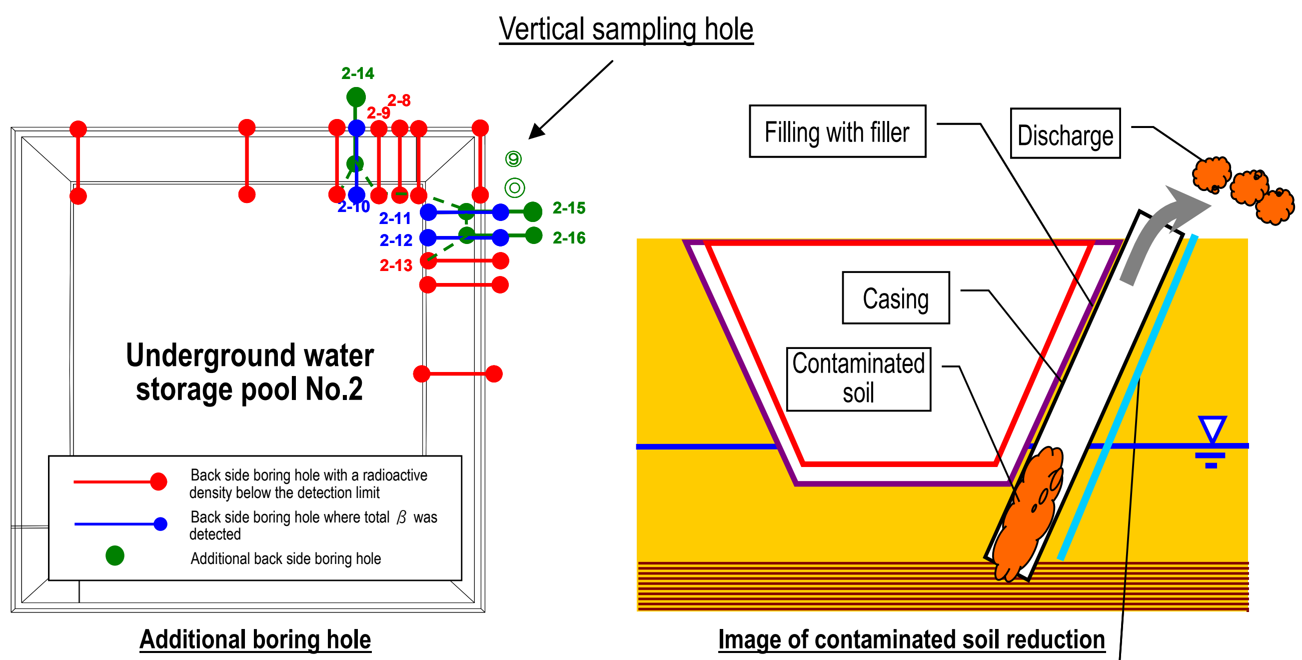


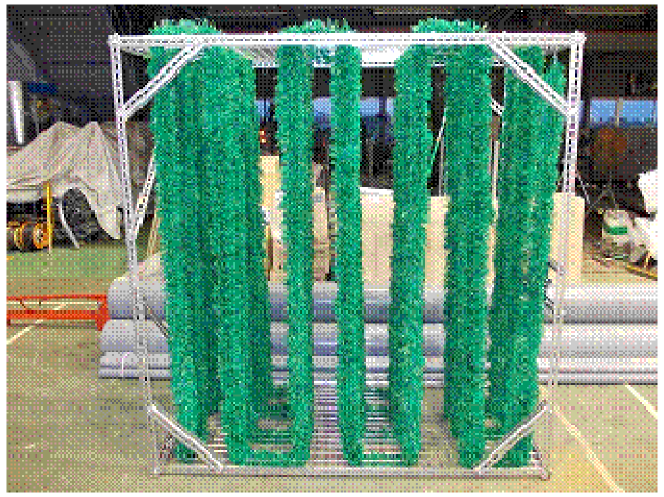
Figure 3: Removal of contaminated soil from underground water storage pool No.2

3. Plan for radiation dose reduction and contamination mitigation

- Effective dose reduction at site boundaries (targeting 1 mSv/year by the end of FY 2012) and purification of the water in the port to mitigate the radiation impact on the outside environment -

➢Reducing the density of radioactive materials within seawater in the port

- As of March, the density of radioactive materials (Cs-134, 137) within samples obtained within the silt fence installed near the Unit 3 water intake channel exceeded the announced density limit. At present, prevention of further seawater contamination in the open duct has been maintained, while for Cs, purification using fiber adsorbent installed within Unit 3 silt fence is ongoing (from June 17) (see Figure 4). As for Sr, a purification plan using a method applicable at the site is currently being considered.
- To examine factors contributing to the constantly higher density of radioactive materials within seawater than the announced density limit at certain locations of the port and verify the measures implemented by TEPCO, a review committee consisting of experts was established and held two meetings (1st: April 26, 2nd: May 27).
- To investigate the factors estimated by the above review committee, underground water was taken, sampled and measured from observation holes drilled on the east side of Turbine Building Units 1 to 4. The investigative results showed that from the samples taken on May 24, high densities of tritium (500,000 Bq/L) and Sr-90 (1,000 Bq/L) were found from the underground water at sampling points between Units 1 and 2. Highly probable causes include leaks from the Unit 2 intake channel in April 2011.
- As for the tritium density in seawater, a significant increase compared to previous values was found on the north side inside the intake channels of Units 1 to 4 with 1,100 Bq/L (sampled on June 21) and 1,500 Bq/L (sampled on June 24). The densities between the intake channels of Units 1 and 2 were 910 Bq/L (sampled on June 21) and 420 Bq/L (sampled on June 24).
- Based on these investigative results, monitoring will be immediately enhanced to identify the cause, and measures to prevent contamination expanding into the ocean will be taken promptly. At present, preparatory work to improve the foundations by injecting chemicals near the revetment is being performed (from June 26). Next, additional measures will be taken at previous leak points (from early July). In addition, to reduce the risk of leakage, efforts to reduce and drain the density of radioactive material in contaminated water having accumulated at the seawater pipe trench will be examined.



Fiber adsorbent purification equipment

Installation work

Figure 4: Fiber adsorbent purification equipment

4. Plan for fuel removal from the spent fuel pools

- Work towards removal of spent fuel from the pool is progressing steadily, while ensuring seismic capacity and safety. In particular, efforts are being made to achieve an early start and completion of spent fuel removal from the Unit 4 pool (planned to commence in November 2013 and completed at around the end of 2014) -

➢ Work towards spent fuel removal at Unit 4

- The cover installation for fuel removal is ongoing (to be completed around mid-FY 2013). Work on carrying the overhead crane into the cover was completed (June 7-14) (see Figure 5). At present, assembly and installation work is ongoing. Next, the Fuel Handling Machine will be lifted (to commence in early July).

➢ Main work towards spent fuel removal at Unit 3

- At present, debris removal from the upper part of the Reactor Building is ongoing. In future, work on the operating floor will be required when installing a cover for fuel removal and the Fuel Handling Machine. To reduce the radioactive dose on the operation floor, decontamination and shielding will be performed (see Figure 6).

Figure 5: Lifting of overhead crane for Unit 4

Fixed decontamination equipment

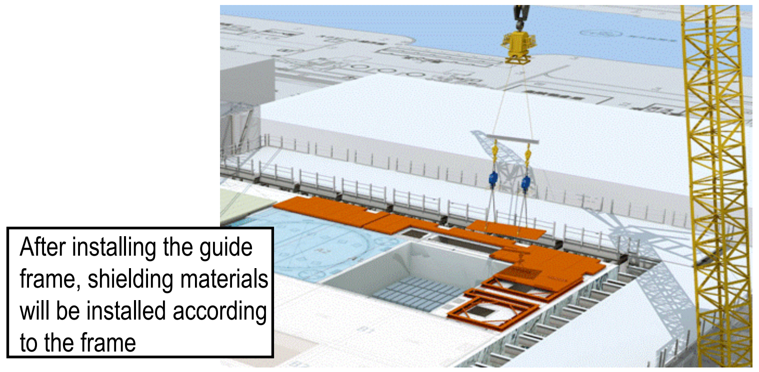


Image of shielding materials installation

Figure 6: Measures to reduce the radiation dose on the operating floor of Unit 3 Reactor Building

5. Fuel debris removal plan

- In addition to decontamination and shield installation carried out to enhance accessibility to the PCV, technology development and data acquisition necessary to prepare for fuel debris removal (such as investigating and repairing the leak location of the PCV) are being advanced -

- Installation of water level gauges inside Reactor Building Units 1 and 2
  - To evaluate the behavior of accumulated water in the reactor buildings (flow direction between Reactor Buildings and inflow points of underground water), installation of water level gauges inside Reactor Building Units 1 and 2 is currently underway (from May 27 and to be completed June 28). After the installation is completed, the water level data will be collected and analyzed.
- Investigation of the upper space on the 1st floor of Unit 2 Reactor Building
  - To contribute to the decontamination and shielding plan and work plans such as PCV investigations and repairs, the radiation dose was measured and interference of the upper space on the 1st floor of Unit 2 Reactor Building investigated using a "high-access survey robot"*.
  - First, for the area from the western side aisle to the southwest, while identifying the status of the upper space, the radiation dose was measured and interference investigated up to a point where the arm no longer interfered with the machine (June 18) (see Figure 7). The investigative results confirmed that despite the lack of any significant difference, the radiation dose was higher in the upper part. In addition, verification of the upper space using a camera confirmed the lack of specific damage to any equipment. Next, the potential to conduct investigation around PCV penetration openings at elevation and expansion of the investigation area will be examined.

  * The "high-access survey robot" jointly developed by the National Institute of Advanced Industrial Science and Technology (AIST) and Honda R&D Co., Ltd. is operated in the joint research of three companies including TEPCO.

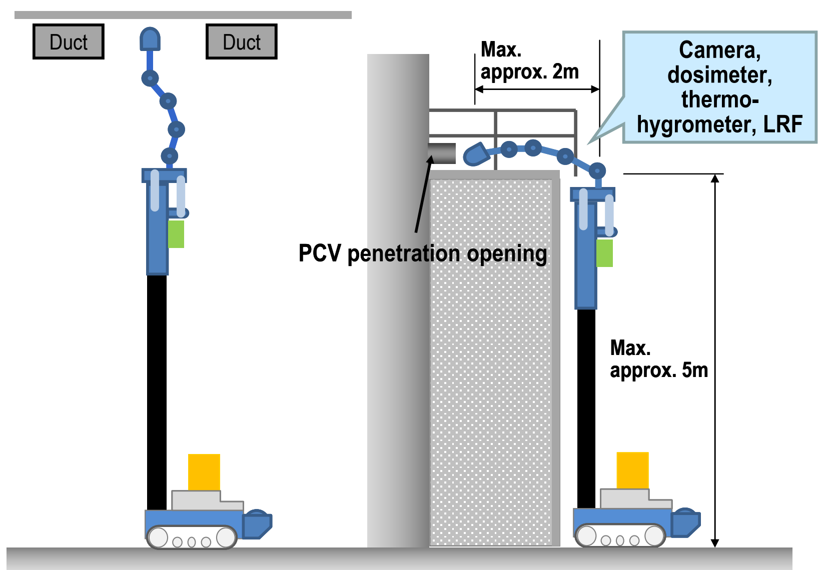


Image of investigation by the high-access survey robot

External appearance of the high-access survey robot

Figure 7: Investigation of the upper space on the 1st floor of Unit 2 Reactor Building

6. Plan for reactor facilities dismantling and radioactive waste processing/disposal

- Installation of a radioactive waste storage facility with high shielding capability and R&D towards adequate and safe storage, processing and disposal of radioactive waste -

- Processing /disposal of the secondary waste generated from contaminated water treatment
  - Nuclide analysis of the samples collected before and after water treatment equipments were performed. The analysis was completed for 32 nuclides in 9 samples in FY 2012 (August 31, 2012). For a further 3 samples, the analytical results of all 18 nuclides subject to analysis were obtained (May 31). In addition, samples newly collected (highly contaminated water of the concentrated Process Main Building (accumulated water), highly contaminated water of the High Temperature Incinerator Building (accumulated water), post-treatment water of the cesium adsorption apparatus and secondary cesium adsorption apparatus respectively) were transported to JAEA for additional analysis. The results of this analysis will be used to evaluate the radioactivity density contained in secondary waste of collected materials generated from the water treatment.

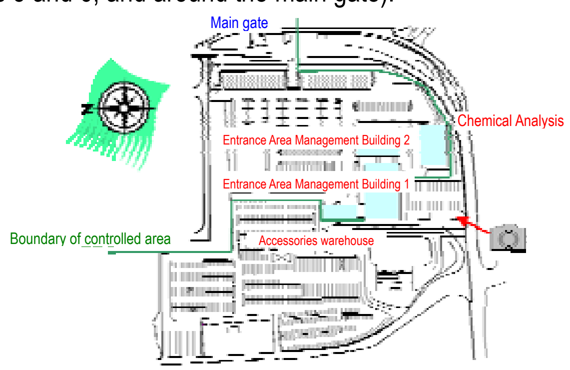
7. Plan for staffing and ensuring work safety

- Securing appropriate staff strength for the long term, while thoroughly implementing workers' exposure dose control. Continuously improving the work environment and labor conditions based on an understanding on the needs of the workers at site -

- Staff management
  - The monthly average number of people who were registered for one day or more in a month to work at the power station within the past quarter from February to April 2013 was approx. 8,900 (TEPCO and cooperative company workers), which exceeds the monthly average number of people who actually worked there previously (approx. 6,200). Thus, there are sufficient people registered to work at the power station.
  - It was confirmed that the estimated manpower necessary for the work in July (approx. 3,000: TEPCO and cooperative company workers) will be secured.
  - The local employment rate of cooperative company workers was approx. 50% as of April and May.
- Preventive measures of heat stroke
  - Continued from last year, measures to prevent heat stroke were started from May towards the hottest season.
  - Using WBGT (*), changes in work time, frequency and times of breaks, and work intensity were made.
  - Work under the blazing sun is prohibited in principle from 14:00 to 17:00 in July and August.
  - Appropriate rest and frequent intake of water and salt are encouraged.
  - Physical management using check sheets and wearing cool vests.
  - A workplace environment where workers are allowed to claim poorly condition is established and early diagnosis at the emergent medical room is encouraged.

  * WBGT: Index using three perspectives of humidity, radiation heat, and temperature, which have a considerable impact on the heat balance of human bodies
- Installation of entrance control facilities
  - Entrance control facilities, which are currently under construction near the main gate of the Fukushima Daiichi Nuclear Power Station, will start operation on June 30. After starting operation, these facilities will provide services such as contamination investigation and decontamination, a changing area for protection clothes, and distribution and collection of dosimeters, which have been provided at the J Village (see Figure 8).
  - Together with the commencement of entrance control facility operations, the area around the site circulation bus stop (entrance area management facilities and company center welfare building) will be additionally specified as that in which work in general work clothing is allowed since June 30 (existing specified areas: around the Main Anti-Earthquake Building, around the service buildings of Units 5 and 6, and around the main gate).

External appearance of the entrance area management facilities



Plain view of the site

Figure 8: Entrance area management facilities