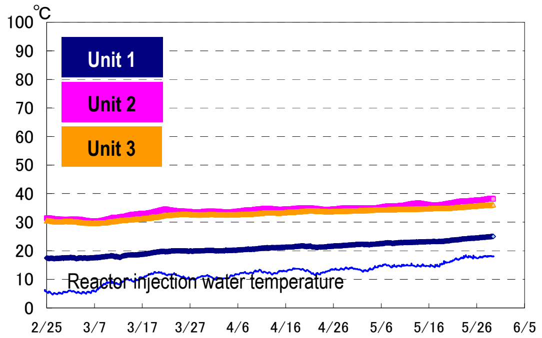
Progress Status and Future Challenges of Mid-and-Long-Term Roadmap towards the Decommissioning of Units 1-4 of TEPCO's Fukushima Daiichi Nuclear Power Station (Outline)

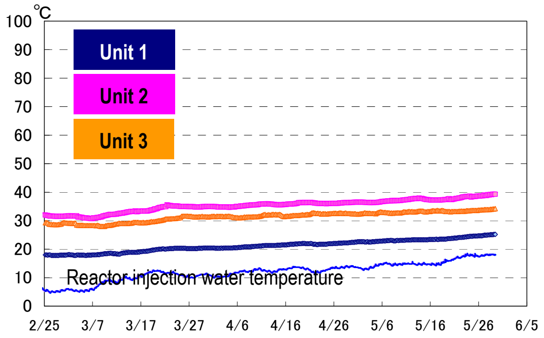
I. Status confirmation of the reactors

1. Temperatures inside the reactors

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. 15 to 45°C for the past month, though they vary depending on the Unit and the thermometer location. The causes of temperature rise from the previous month include the rising temperature of injected water into the reactors due to rising air temperature. In addition, a temporary temperature rise of approximately 5 to 10°C was recorded by some thermometers inside the Unit 1 PCV. The causes of this temperature rise include nitrogen injection into the suppression chamber, which may change the gas flow inside the PCV and affect the instrument reading of the thermometers. We will continue investigating to identify the cause.



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 into the air, as measured at site boundaries, were evaluated at approx. 1.3×10^{-9} Bq/cm³ for both Cs-134 and Cs-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. 2.09 mSv/year)).

(Reference)

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

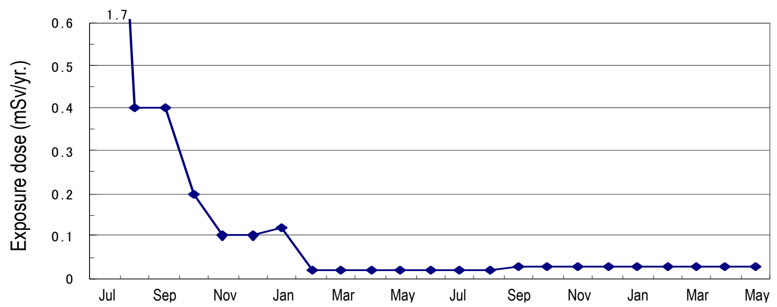
[Cs-134] : 2×10^{-5} Bq/cm³, [Cs-137] : 3×10^{-5} Bq/cm³

*** 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, different formulas and coefficients had been 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 a comprehensive cold shutdown condition had been maintained and the reactors were in a stabilized condition.

II. Progress status and future challenges

1. Reactor cooling plan

- A cold shutdown condition will be maintained through cooling the reactor via water injection and measures to complement status monitoring will be continued to be implemented -

➢ Investigation within 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 were installed. Based on the results of an inside status investigation on the TIP guiding pipes (4 locations) using fiber scopes (Feb 25–28) showing the inability to insert endoscopes or thermocouples, work was suspended and resolution measures were examined. Consequently, a method to push up attachments and obstacles inside the same guiding pipes (applying a wire with a wedge-shaped end to strongly push up the roller) was adopted. This method was verified in a test using a simulation of the fixed inner switch and its validity was confirmed (April 15-26) (see Figure 1). Production of the feeding equipment is currently ongoing (from April 27 and scheduled to be completed early June). When production is completed, assembly, mockup test and skill mastering training will be conducted (in around mid-June) and work at the site using the equipment will commence (from late June).

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

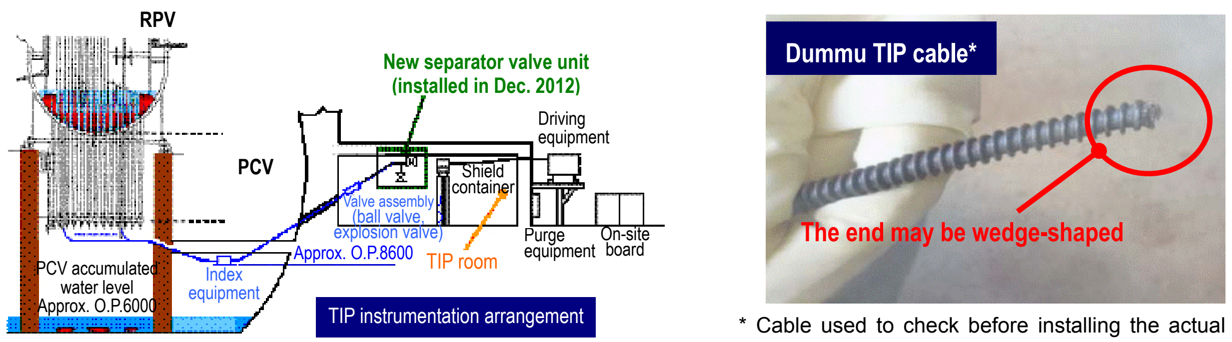
➢ Nitrogen injection to maintain internal PCV stability

- To maintain an inert atmosphere inside the PCVs of Units 1 to 3, nitrogen is injected by nitrogen gas separators. In addition to the two nitrogen gas separators (A) and (B) operated in parallel, redundant separators are installed to enhance the reliability of the nitrogen supply. By March 2013, the third separator (C) was installed and commenced operation from May 21. In future, a rotation to operate two of these three separators (A), (B) and (C) and keep the remaining one on standby will be adopted, and this rotation will be regularly switched. To prepare for the potential failure of all three nitrogen gas separators, one emergency nitrogen gas separator powered by a diesel generator is also installed.

➢ Nitrogen injection into the suppression chamber (S/C) to mitigate hydrogen-related risks

- Residual air with a high hydrogen concentration in the upper part of the S/C, which was generated in the early stage of the accident, was purged to reduce the hydrogen-related risks. Though the estimated hydrogen concentration was reduced to below the flammability limit*1 at Unit 1, nitrogen injection is continued to monitor the residual air status (December 7-26, January 8-24, February 26 - March 19, April 2-23, and from May 8). As for Unit 2, the design and production of nitrogen injection equipment (December 25 – March 12) and installation into the site (March 13-17) were completed, and nitrogen was injected (May 14-17). As for Unit 3, no rise in hydrogen concentration at the PCV gas control facilities was observed, and the closed space in the S/C is estimated to be stabilized. A check on the parameter change is ongoing.

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



* Cable used to check before installing the actual TIP detector during the plant construction

Figure 1: TIP guiding pipe validity check test

2. Accumulated water treatment plan

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

➢ Preventing groundwater from flowing into the Reactor Building

- A system to prevent groundwater from flowing into buildings by pumping the groundwater flowing from the mountain side in the upstream side 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, after the test operation is completed, the water quality will be checked (Systems B and C: to be completed after late June). As for System A, the results of the water quality test showed that the density of the representative indicator nuclide Cs-137 was low enough compared to that in the neighborhood ocean area and rivers. Based on these results, an explanatory meeting for local residents will be held (June 5) and the facilities will be commissioned once agreement is gained from the parties concerned.

➢ Installation of multi-nuclide removal equipment

- Multi-nuclide removal equipment was installed to further reduce the density of radioactive materials (except for tritium) included in the accumulated water in the power station site as well as prevent any unexpected risk of leakage. Based on approval by the Nuclear Regulation Authority gained for starting the hot testing (system A) using water containing radioactive materials, the hot test was started (from March 30). As of May 29, approximately $8100m^3$ had been treated. 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 stated density limit. The reduction of most nuclides such as Sr-90, Cs-134 and Cs-137 to a level below the detection limit was also confirmed. However, for Co-60, Ru-106, Sb-125 and I-129, small amounts of radioactive materials were still detected, although less than the stated density limit. For the several nuclides detected, measures to improve the removal performance will be examined. In addition, subject to approval at the (11th) Specified Nuclear Facilities Monitoring and Evaluation Meeting for the start of hot testing for Systems B and C (May 24), the treatment will be started as soon as possible (System B: to be started mid-June, System C: to be started mid-July), to reduce the risk of contaminated water and decrease the radiation dose measured at site boundaries from contaminated water stored in tanks.

➢ Status of leak from underground water storage pool and measures to resolve this issue

- As leaks were detected at underground water storage pools Nos. 1, 2 and 3 for contaminated water, we decided to terminate the use of all underground water storage pools. At present, treated water there is transported to tanks on the ground. Transportation of treated water from Unit Nos. 1 and 2 has been completed (No. 1: April 23 – May 6, No. 2: April 16-22). At present, treated water from Nos. 3 and 6 is being transported to a tank on the ground (in the G6 area) (No. 3: from May 18, No. 6: from May 21, scheduled for completion in early June). As for No. 4, which stores treated water from Units 5 and 6, transportation will start after mid-June. Nos. 5 and 7 have no treated water stored. In addition, new boreholes were drilled around the underground water storage pools (a total of 30 holes have been drilled and started monitoring operation) to take samples of underground water. At present (May 29), it was confirmed that total β radioactivity density including existing observation holes (at 7 points, such as the underground bypass pump up well) was lower than the detection limit. The sampling results conducted to identify the leak locations from the boreholes drilled near the underground water storage pools detected the total β radioactivity density at three points at present (May 29). Based on these results, the causes will be investigated and examination of measures such as removal of contaminated soil will continue, targeting their commencement within July.

➢ Contaminated Water Treatment Committee

- The Contaminated Water Treatment committee was established to treat contaminated water at the Fukushima Daiichi Nuclear Power Station, to totally review existing measures, and examine fundamental resolutions for the contaminated water treatment issue and actions to the contaminated water leak accident from underground water storage pools. First, the committee will discuss drastic measures to prevent underground water inflow and decide on specific actions by the end of May, alongside continuing ongoing examinations of the tritium treatment method.

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 stated density. At present, ongoing measures to prevent further contamination of the seawater in the open duct and purify Cs by installing a fiber-adsorbent within the Unit 3 silt fence are planned (from early June) (see Figure 2). As for Sr, a purification plan using an applicable on-site method is currently being considered.
- To examine the factors contributing to the density of radioactive materials in seawater not going below the stated density at certain port locations and verify the measures implemented by TEPCO, a review committee comprising experts was established and met twice (1st: April 26, 2nd: May 27). Based on these review results, it was decided to continue verification, the results of which will be reported around July.

➢ Decontamination inside the site

- To reduce the exposure of the main gate security guards, decontamination around the main gate was performed (December 2012 to April 2013). For the pavement, ultrahigh-pressure cleaning was conducted, while for the greenery, the soil was turned over and paved with asphalt, reducing the average dose rate from 13.6 to 3.8 μSv/h (achieving the target dose rate of 5 μSv/h). Thanks to this reduction, the annual dose of workers was improved within the work environment to a level lower than 20 [mSv/year] (annual average dose of five-year dose limit of 100 mSv specified by law) (see Figure 3).

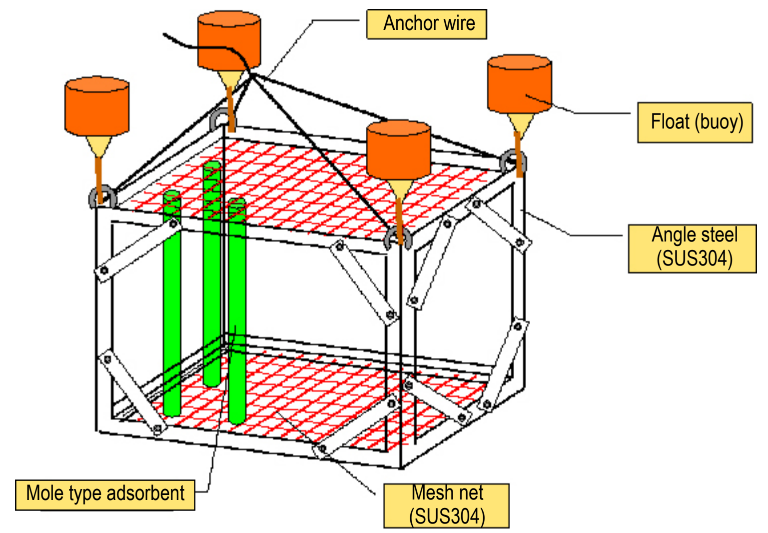


Figure 2: Fiber-adsorbent cleaning equipment

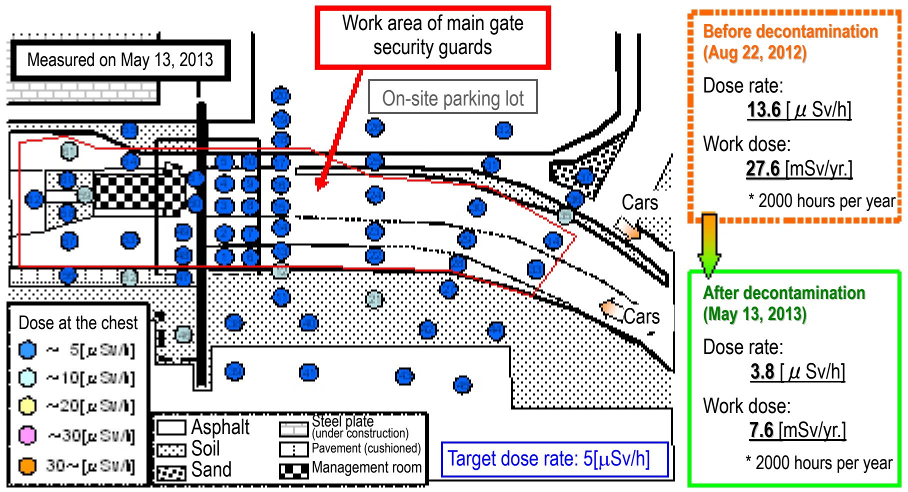


Figure 3: Dose reduction results by decontamination around the main gate

4. Plan for fuel removal from the spent fuel pools

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

➢ Work towards removing spent fuel at Unit 4

- The cover installation for fuel removal is ongoing (to be completed around mid-FY 2013). The steel frame construction was completed (May 29) (see Figure 4) and work on installing the ceiling crane is currently ongoing (from early June, to be completed in October).

➢ Main work towards removing spent fuel at Unit 3

- The platform installation was completed (March 13) and debris is still being removed from the upper part of the Reactor Building. The area surrounding the spent fuel storage pool was cleaned up, and protection on the pool (cover) was installed, except for the part with no interference from the steel frame truss debris (April 22). Based on current progress, the debris removal work is ongoing while adopting further safety measures such as protection for the pool (completed on May 25).

➢ Effort to remove spent fuel from Unit 1

- To remove debris from the upper part of the operating floor, the destruction of the reactor building cover is planned. Specific procedures and methods to prevent the release of radioactive materials are currently under consideration.

➢ Inspection and transportation of all dry storage casks in the cask storage building

- Inspection of the existing nine dry storage casks stored in the cask storage building was completed and it was confirmed that there was no problem with the safety functions of all the casks. After replacing the components required, the nine casks were all transferred to the temporary cask storage facilities (May 21).

➢ The health of Unit 4 reactor building was confirmed

- To check the health of the Reactor Building and spent fuel pool, a 5th regular inspection was performed (May 21-29), which confirmed that the reactor building was healthy and maintained in a condition capable of storing spent fuel safely. In addition, a third-party expert also attended the inspection and confirmed the results of previous examinations, including aseismic analysis.

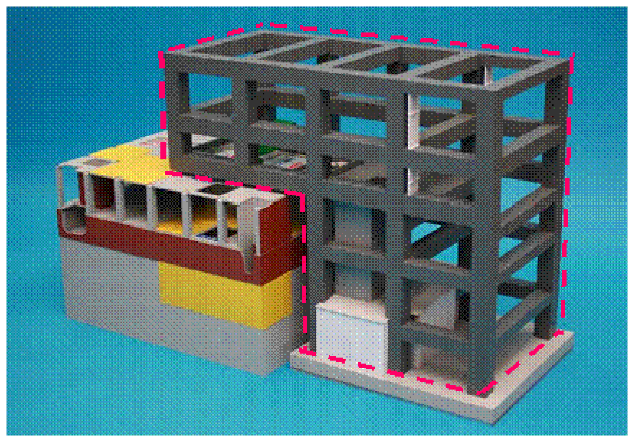


Image of the completed steel frame

The steel frame was completed (Photo taken on May 29)

Figure 4: Installation of cover for Unit 4 spent fuel removal

5. Fuel debris removal plan

- In addition to decontamination and shield installation performed to improve accessibility to the PCV, technology is being developed and data acquired to prepare for fuel debris removal (such as investigating and repairing the leak location of the PCV) -

➢ Investigation within the Torus Room

- With the need to develop equipment to investigate the leak locations in mind, an investigation of the radiation dose, temperature, accumulated water level and images acquired inside the Torus Room on the basement of Reactor Buildings Units 1 and 2 is being performed. As for accumulated water, the analytical results of chloride and Cs densities were obtained (see Table 1). With the chloride density, no significant difference was identified between Units 1 and 2, nor was any significant difference identified compared with the analytical results of samples obtained from nearby triangle corners. As for the Cs density, the results of Unit 1 slightly exceeded those of Unit 2. Accumulated water levels and other analytical items are currently being evaluated. As for sediment, γ nuclide will be analyzed (late June). Investigation of Unit 3 will be performed after decontamination due to the high dose within the reactor building.

Table 1: Investigative results of basement Torus Rooms in Reactor Buildings Units 1 and 2 (analytical results of accumulated water)

Sampling point	Accumulated water in Unit 1 Torus Room		Accumulated water in Unit 2 Torus Room
	Upper part (approx. 1m below the surface)	Lower part (approx. 1m above the bottom)	1m below the surface
Sampling date	Feb 22, 2013	Feb 22, 2013	Apr 12, 2013
Chloride (ppm)	29	29	45
Cs-134 (Bq/cm^3)	7.383×10^4	7.294×10^4	1.268×10^4
Cs-137 (Bq/cm^3)	1.513×10^5	1.508×10^5	2.369×10^4

➢ Installation of water level gauges inside Reactor Buildings Units 1 and 2

- To evaluate the behaviors of accumulated water in the reactor buildings (flow direction between Reactor Buildings and underground water inflow points), the installation of water level gauges inside Reactor Buildings Units 1 and 2 is currently underway (from May 27, to be completed mid-June).

➢ Investigation within Unit 2 PCV

- To investigate the status inside Unit 2 PCV, investigative equipment was inserted from the penetration opening of the PCV (X-53), but could not reach the control rod drive (CRD) replacement rail, and the guiding pipe could not be pulled out (March 19). Work to extract the guiding pipe was completed (Apr 24-26) and the investigation will be restarted (within the 1st half of FY2013).

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 -

➢Installation of a Miscellaneous Solid Waste Incinerator

- To reduce the volume of used protective clothing, work on installing a Miscellaneous Solid Waste Incinerator started on May 1 (the target operation start is the 2nd half of FY2014).

➢Processing /disposal of secondary waste generated from contaminated water treatment

- By performing nuclide analysis on samples collected before and after water treatment equipment, the radioactivity density included in the secondary waste generated from water treatment facilities is evaluated. The analysis was completed for approx. 30 nuclides in 9 samples, while for a further 3 samples, the analytical results (including provisional values) of some nuclides such as strontium 90 were obtained. The analytical results of all planned nuclides in these 3 samples will be obtained at the end of June.
- An evaluation such as investigating the property of the secondary waste and a corrosion test on storage container materials was performed to provide insight into the long-term storage of secondary waste generated from water treatment.

7. Plan for staffing and ensuring work safety

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

➢ Staff management

- The monthly average number of people who were registered for one day or more per month to work at the power station in the past quarter from January to March, 2013 was approx. 8,800 (TEPCO and cooperative company workers), which exceeds the monthly average number of people who actually worked there (approx. 6,200). Accordingly, sufficient people are registered to work at the power station.
- It was confirmed that the estimated manpower necessary for the work in June (approx. 3,000: TEPCO and cooperative company workers) will be secured.
- The local employment rate of cooperative company workers was approx. 50% as of March.

➢ Measures for ensuring appropriate work conditions

- Good practices found in the survey results performed for contractors included (1) checking the employment insurance documents for confirming their employer companies of subcontract workers, and (2) adding the agreement signature column of the worker in the employment conditions statement to show that the worker agrees to the conditions. Main contractors were requested to take the same procedures (May 14).
- To track improvement status of work conditions, regular surveys will be conducted.

➢ Expansion of areas not requiring full-face mask

- As for the areas not requiring full-face mask, in addition to the standard density level of radioactive materials in air requiring to wear masks (1/10 of the density specified by law), operation rules were defined based on the decontamination ionization rules. Based on these rules, the areas not requiring full-face mask were expanded (excluding areas around Units 1 to 4, tank areas, and debris storage areas) since May 30.
- During the work within the areas not requiring full-face mask, disposable antidust masks (N95, DS2) are allowed to be used except for the work in high density dusty environment. Surgical masks are also allowed to be used in areas around the main gate and the entrance control facilities (areas with density of radioactivity materials in soil is lower than 1×10^4 Bq/kg in the whole area). Protection clothing will be optimized with a phased approach to reduce burden of workers and improve their productivity.

➢ Measures to improve the working environment

- A survey on the overall working environment was performed for workers (during the period from February to March). A total of 3,198 workers responded to the survey (collection rate: 80.9%), and the aggregated results were published (May 30). Many opinions and requests were submitted. Each of them will be addressed for improvement including installation of a new "large rest house" as future efforts in the field of workplace environment and facilities for rest, break and meals.

➢ Heat stroke preventive measures

- Continued from last year, heat stroke preventive measures were started from May towards the hottest season.
- Using WBGT (*), changes were made to work time, break time/frequency, and work intensity.
- 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 have scope to report poor condition and obtain an early diagnosis at the emergency medical room is encouraged.

* WBGT: Index using three perspectives of humidity, radiant heat, and temperature which have a great impact on the heat balance of the human body.

➢ 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 (see Figure 5). After starting the operation, these facilities will provide services such as contamination investigation and decontamination, putting protective clothes on and off, and distributing and collecting dosimeters which have been provided at the J Village.

8. Other issues

➢ The IAEA peer review mission

- For the period Apr. 15-22 in 2013, the IAEA peer review mission visited the site to provide evaluation and advice on the overall Mid-and-Long-Term Roadmap and immediate specific issues. Based on the recommendations of the report submitted on May 23, the Mid-and-Long-Term Roadmap will be revised.

➢ Measures to improve the reliability of the Fukushima Daiichi Nuclear Power Station

- To ensure mid- and long-term safety of the power station, TEPCO formulated the "Action plan concerning reliability improvement measures" and is continuously implementing measures to improve and maintain the reliability of the power station, including renewal from temporary to permanent facilities that guarantee long-term use.
- In addition to these methods, in response to repeated troubles such as outages and leakage accidents involving contaminated water, TEPCO has established the "Fukushima Daiichi reliability improvement emergency task force" led by the President on April 7. Each of the six expert teams including Electric Facilities Measures Team, Machinery Facilities Measures Team, and Contaminated Water Measures Team, establishes a framework whereby each team examines the measures urgently required to enhance the reliability of facilities and operation management, and immediately implements the same. The task force is currently reviewing facility-related literature and performing walk-downs at the site, as well as implementing some measures in phases. As the progress status, extracted issues and examples of resolutions were published (May 16). The issues and measures are currently being compiled and the report will be published when the summarization is completed (to be published mid-June).

Figure 5: Exterior appearance of the entrance control facilities