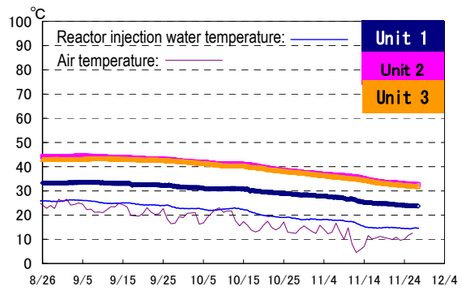
November 28, 2013
Secretariat of the Council for the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station

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

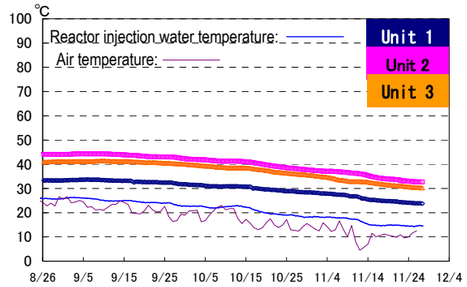
I. Confirmation of the reactor conditions

1. Temperatures inside the reactors

Through continuous reactor cooling by water injection, the temperatures of Reactor Pressure Vessel (RPV) bottom and Primary Containment Vessel (PCV) gas phase have been maintained within the range of approx. 25 to 45℃ for the past month, though they vary depending on each unit and location of the thermometer



RPV bottom temperatures



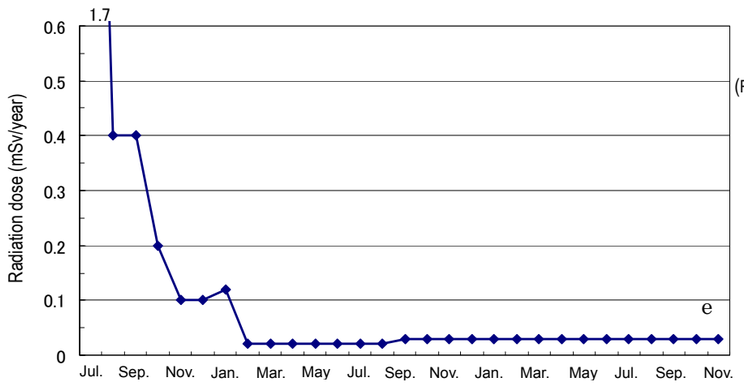
PCV gas phase temperatures

* The trend graphs show a part of temperature data measured at multiple points.

2. Release of radioactive materials from the Reactor Building

Regarding the radioactive materials newly released from the Unit 1-4 reactor buildings, the density of radioactive material released in the air at the site boundaries was evaluated to be approx. 1.5×10^{-9} Bq/cm^3 for both Cs-134 and Cs-137. The radiation dose at the site boundaries was evaluated to be 0.03mSv/year (which is equivalent to about 1/70 of the annual natural radiation dose (annual average in Japan, approx. 2.1mSv/year)).

Annual radiation dose at site boundaries by radioactive material (cesium) released from Reactor Building Units 1-4



(Reference)
*The density limit of radioactive materials in the air outside the surrounding monitoring area:
[Cs-134] : 2×10^{-5} Bq/cm^3
[Cs-137] : 3×10^{-5} Bq/cm^3
*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 /cm^3
[Cs-137] : ND (Detection limit: Approx. 2×10^{-7} Bq /cm^3)

Note: Different formulas and coefficients were used to evaluate the radiation dose in the facility operation plan and monthly report. The evaluation methods were integrated in September 2012. The Unit 4 reactor building was included in the targets to be evaluated from November, 2013 in response to the work of removing fuel from the spent fuel pool.

3. Other indices

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

II. Progress status by each plan

1. Reactor cooling plan

～The cold shutdown condition will be maintained through reactor cooling by water injection, and measures to complement monitoring the status will continue to be implemented.～

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

- The residual air with high hydrogen concentration in the upper part of the Suppression Chamber (S/C) which was generated in the early stage of the accident is purged using nitrogen. As for Unit 1, intermittent injection into S/C was started in December, 2012, and since September 2013, it has been changed to continuous injection. As for Unit 2, to check whether or not residual hydrogen remained, the second nitrogen injection test was conducted (Oct. 16 through Nov. 11). But since no rise in hydrogen concentration was observed, the necessity of the test in future is under discussion. As for Unit 3, since no raise in hydrogen concentration in the drywell was observed, the monitoring of parameters is being continued.

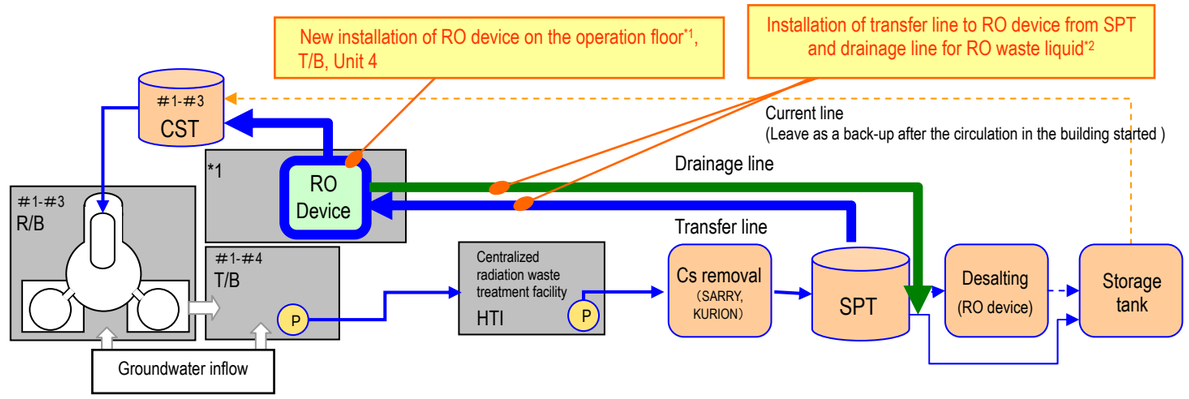
➢ **Review on the reduction of the volume of water injection into reactors**

- To reduce the load on water treatment facilities, the reduction of the volume of water injection into reactors is under study. As the result of evaluation, etc. on heat balance of reactors, it is planned to reduce the amount of water injection into Unit 2 and 3 by 1.0m^3/h respectively (approximately 50m^3/day in total) after January, 2014.

➢ **Study status on the shortening of circulation loop**

- To improve the reliability of circulated water injection line and reduce the risk of contaminated water leakage to outside the building, the shortening of circulation loop in size is under study. It is planned to install RO device inside the building by the end of 2014 to shorten the reactor water injection loop (circulation loop) from about 3 km to 0.8 km* by stopping water running through the RO device installed on the hill (see Figure 1).

*: The total length of the pipe for transferring contaminated water is approx. 2.1 km including a transfer line of surplus water to a hill. (approx. 1.3km)



*1 Operation floor, T/B, Unit 4, is currently one of the suggestions for installation. Taking into consideration the work environment, etc., the final decision will be made upon further review and discussion.
*2 Detailed line configuration, etc will be decided upon further review and discussion.

Figure 1: Circulation loop image in building

2. Accumulated water treatment plan

～To deal with the increase of accumulated water due to groundwater inflow, fundamental measures to prevent groundwater from flowing into the reactor buildings will be taken while improving the decontamination capability of the water treatment facilities and improving facilities to control contaminated water.～

➢ **Preventing groundwater from flowing into the Reactor Buildings, etc.**

- Measures are taken to reduce the groundwater volume flowing into the reactor buildings by means of pumping the groundwater, flowing from the mountain side, at upstream before it enters into the buildings, and test operation and water-quality check for systems A, B, and C have been completed. In terms of a major target nuclide of Cs-137, it was verified that the concentration level has been at quite low level compared with that of surrounding sea and neighboring rivers.
- In order to control the increase of contaminated water caused by groundwater flowing into the building, impermeable wall by frozen soil is planned to be installed around the buildings of Unit 1 to 4. Currently, a concept design is being performed as the "Project on Countermeasures towards Contaminated Water Treatment for FY2013 (Major Maintenance and Demonstration Project for Impermeable Wall by the Soil Freezing Method)" (Agency for Natural Resources and Energy). Furthermore, on-site investigation, measurement, and yard maintenance, etc were started

on Nov. 27. In addition, along with it, a demonstration is under way as the "Project on decommissioning of reactors for power generation/ maintenance of safety technology base (feasibility study project on water shielding technology by the freezing soil method to control the inflowing groundwater) "(Agency for Natural Resources and Energy)

➢ **Operation of multi-nuclide removal equipment**

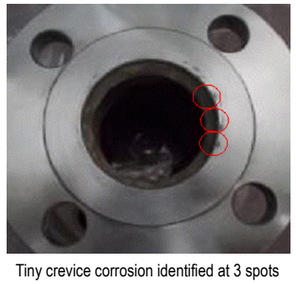
- Multi-nuclide removal equipment was installed in order to control the density of radioactive materials (except for tritium) included in the stored water in the premises as low as possible as well as preventing unexpected risks of leakage. Hot testing using water containing radioactive materials was started sequentially (System A: from Mar. 30, System B: from Jun. 13, and System C: from Sep. 27), and to date, approx. 31,000m^3 has been treated (as of Nov. 26)
- As for System A, a minor leakage was detected from the tank (for batch process) used to pre-treat contaminated water, and its operation has been suspended (Jun.15) to investigate the cause. As the result, corrosion was detected in the piping flange and within the absorption tower, for which repair and preventive action were taken and hot testing was restarted (from Oct. 28). The operation is scheduled to be suspended to verify the effectiveness of the preventive actions taken (in early December).
- As for System B, the operation was suspended on August 8 as planned. As with System A, repair and preventive actions were taken, and hot testing was restarted from Nov. 21.
- As for System C, preventive actions were taken with priority, and hot testing was started (from Sep. 27). Later, the operation was suspended as planned (Nov. 3 through 18) to verify the effectiveness of the actions taken. As the result, it was found that, although one flange had three tiny crevice corrosions, these were not the ones that affect the quality of sealing itself, and the occurrence of corrosion has been largely suppressed. Consequently, the actions taken were verified as effective (see Figure 2).
- The enhancement of knowledge will be addressed through conducting periodic checks in future.

➢ **Status of leakage from underground reservoirs and measures to resolve the issue**

- To identify the location where the leakage occurred at No. 1 and 2, boring holes were drilled on the backside of the reservoirs under the ground (No.1: 13 holes, and No.2: 13 holes). As for No. 2, as the contaminated area was identified, contaminated soil was removed (Jul. 13 through Aug. 2). As for No.1, additional boring holes (11 holes) were drilled from Oct. 3 to identify the area of contaminated soil. It is planned to conduct measures to remove contaminated soil, etc. after the contaminated area was indentified. (from December).

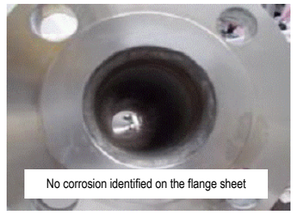
➢ **Water leakage at H4 area tank**

- Puddles were detected inside the dike in the H4 tank area that stores contaminated water and outside the drain valve of the channel (Aug. 19). As water had spread around the bolt fixed type No.5 tank in the same area, the water level of the said tank was checked to find that the level was lower by approximately 3m (equivalent to approx. 300m^3) compared to neighboring tanks, which was judged as high density contaminated water leakage having occurred (Aug. 20).
- To grasp the contamination status and investigate the impact, the investigation shown at figure 3 is underway. At sampling point, E-1, near the tank, the gross β radioactive density increased to approx. 300,000 to 400,000 Bq/L from 80～90Bq/L for the water taken after October 17, which makes it hard to deny the effect of the leakage in August.



Tiny crevice corrosion identified at 3 spots

Plumbing flange at the exist of Supply pump 1



Plumbing flange at the exit of slurry transfer pump

Figure 2: Verification status of effectiveness of corrosion in category C

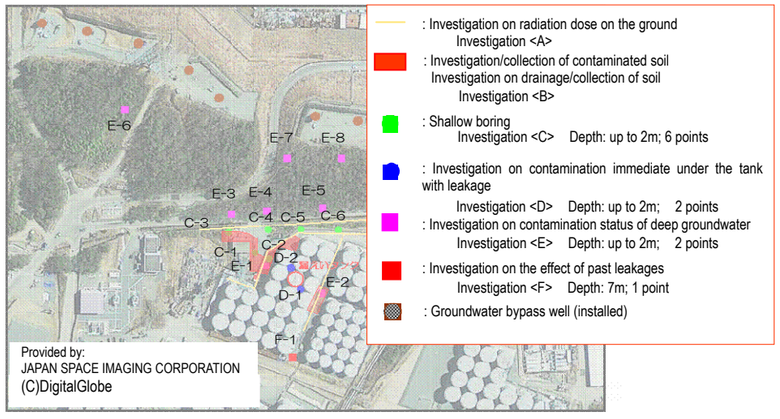


Figure 3: Investigation points around the tank

- In response to the increase of the gross β radioactive density, currently the removal of contaminated soil on the west side of E-1 is underway. In addition, testing of water abstraction from well point is under way. (from Nov. 26).
- To realize early detection of leakage, it was decided to set a water level gauge to all of the bolt-fixed type tanks (planned on Nov. 30) and start remote monitoring (from early December)
- Monitors for consecutive surveillance to detect radioactivity in drainage will be installed (planned on Nov. 30), and from December, trial operation will start.

➢ **Summary of preventive and multilevel countermeasures for contaminated water.**

- At the Committee on Countermeasures for Contaminated Water Treatment, potential risks related to contaminated water will be identified, and the whole picture of preventive and multilevel countermeasures for contaminated water within this year will be summarized.
- To deal with the potential risks with technical difficulties, wisdom from inside and outside Japan was sought for by a call for technical suggestions through IRID, and about 780 suggestions have been posted. Technologies suggested were summarized and categorized by IRID, which will be reflected on the annual report in the Committee on Countermeasures for Contaminated Water Treatment.

3. Plan for radiation dose reduction and contamination mitigation

～ Effective dose reduction at site boundaries (reduced to 1 mSv/year by the end of FY2012) and purification of water in the port to lower the impact of radiation on outside premises to the extent possible ～

➢ **Measures to address increased level of radioactive materials in groundwater on the seaside and in seawater.**

- Analytical results of data concerning the density and water levels of groundwater on the east (sea) side of the reactor buildings showed that contaminated groundwater have leaked into seawater.
- No significant fluctuation was found with radioactive materials in seawater within the port for the past month. The same is true of offshore, showing no significant fluctuation in the continuous measurement.
- Water quality survey of the water penetration layer at lower part (the second layer from the ground (alternate layer)) on the east side (sea side) of the turbine building in Unit 3 (one location) was conducted to find that the radioactive density is below the detection limit for Cs-134, Cs-137, and the gross β, and H3.
- As (emergency) measures to prevent expansion of the contamination to sea, the following shall be implemented. (see Figure 4)

① Preventing leakage of contaminated water

- Ground improvement behind the bank protection to prevent spread of radioactive materials.
  Between Unit 1 and 2: completed on Aug. 9; between Unit 2 and 3: started from Aug. 29 and to be completed by late December; between Unit 3 and 4: started from Aug. 23 and to be completed by late December.
- Pumping of groundwater in the contaminated areas
  By installing catchment pits and well points (compulsory pumping equipment by vacuuming), the groundwater level is reduced.
  Between Units 2 and 3, and between Units 3 and 4, since the operation of well points may draw contaminated water from the seawater pipe trench that contains highly concentrated contaminated water and expand contamination, it is decided to monitor the quality of groundwater without operating them until the ground improvement on the seaside is completed.
  Catchment pits: (between Units 1 and 2) from Aug. 9, the transfer started.
  Well points: (between Units 1and 2) from Aug. 15, transfer of some parts started. From Aug. 23, a full transfer started. (between Units 2 and 3), preparation for operation was completed. (between Units 3 and 4) preparation for operation was completed.

② Isolating groundwater from the contamination source.

- Enclosure of the mountain side bank protection by improving ground foundation
  Between Units 1 and 2: started from Aug. 13 and to be completed in the end of December; and between Units 2 and 3: started from Oct. 1 and to be completed early December.
  Between Units 3 and 4: Started from Oct. 19 and to be completed in the end of December.
- To prevent ingress of rainwater, ground surface will be paved with asphalt for the range enclosed by the ground improvement. (between Units 1 and 2: start from Nov. 28)

③ Removing the contamination source

- Removal of contaminated water from branch trench, etc.,and fill in the trench. (completed on Sep. 19)
- Purification and removal of contaminated water in the main trench.
  Purification of the main trench of Unit 2 and 3 started(Unit 2: from Nov. 14, Unit 3: from Nov. 15).
  Freezing method and water removal of the main trench (freezing is planned to start from February, 2014).
  Currently, freezing method is under demonstration.

➢ **Seaside impermeable wall**

- Seaside impermeable wall is under construction, for the purpose of preventing contaminated water from spreading into sea (scheduled to be completed by the middle of FY2014). Currently, the placement of steal pipe sheet piles is conducted. (progress rate: 76% as of Nov. 26)
- The placement of steal pipe sheet piles within the port will be completed tentatively by early December leaving 10 piles unfinished. Then, it is planned to place steal pipe sheet piles outside the port, reclaim inside the port, and install pumping equipment, etc., and complete the work by placing the above mentioned 10 piles afterward.

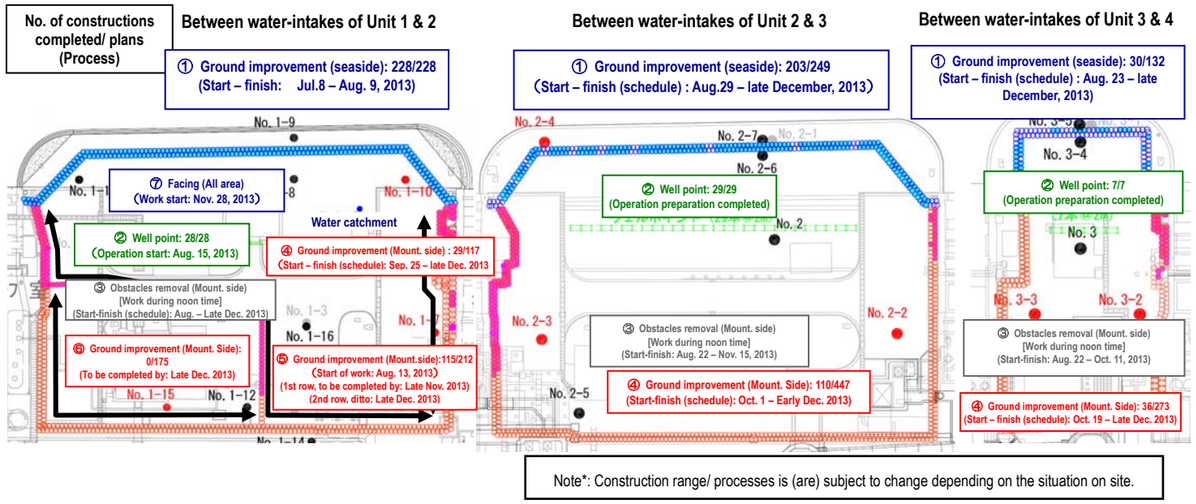


Figure 4: Progress in the constructions around the bank protection area

4. Plan for fuel removal from the spent fuel pools

～Work towards removing spent fuel from the pool is steadily progressing while ensuring seismic capacity and safety. Removal of spent fuel from the Unit 4 pool started on November 18, 2013, aiming its completion around the end of 2014～.

➢ **Removal of spent fuel from the Unit 4 pool**

- Works on removing spent fuel from the pool started on November 18 (see figure 6), which was conducted one month ahead of the original schedule (December, 2013), which became the milestone of entering into the second period of the Mid-and-Long-Term Roadmap.
- There were 1,533 fuel assemblies of fuel (spent fuel: 1331, unused fuel: 202) stored in the spent fuel pool at the start of the removal, all of which are planned to be transferred to the "Common pool" located in a separate building from Unit 4 for stable storage. The removal is intended to be completed around the end of FY 2014.
- The safety was confirmed through a check of actual equipments used for, such as, lifting a transportation cask for on-site use and a final check of fuel handling equipment (dated November 13).
- Regarding the safety of fuel removal operation, in addition to the review by Mr. Lake Barrett, an "International and Decommissioning" member of the Nuclear Reform Monitoring Committee and the Nuclear Safety Oversight Office under TEPCO, a third party review was conducted by International Expert Group (IEG). (see figure 5)
- As of November 28, 22 spent fuel and 22 unused fuel were removed from the fuel rack.

➢ **Verification of the soundness of Unit 4 reactor building**

- The seventh surveillance inspection is underway in the presence of an external expert, to verify the soundness of the reactor building and the spent fuel pool (from November 26 through the middle of December).

➢ **Main works towards removing spent fuel at Unit 3**

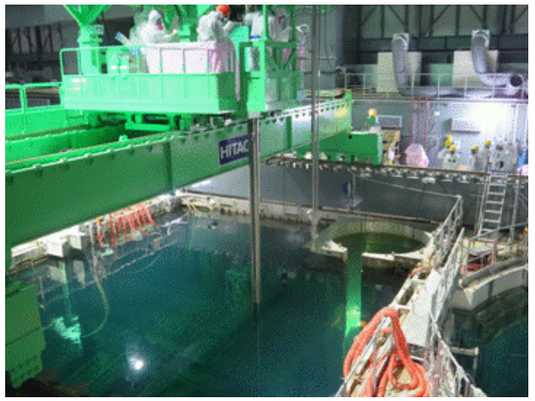
- For the installation work of a cover for removing fuel and fuel handling equipment on the operating floor, currently, measures to decrease radiation dose (decontamination and shield installation) have been addressed (from Oct. 15). From early December, the work to remove rubbles inside the spent fuel pool is planned to be started.

Mr.Lake Barrett (Nov. 13)

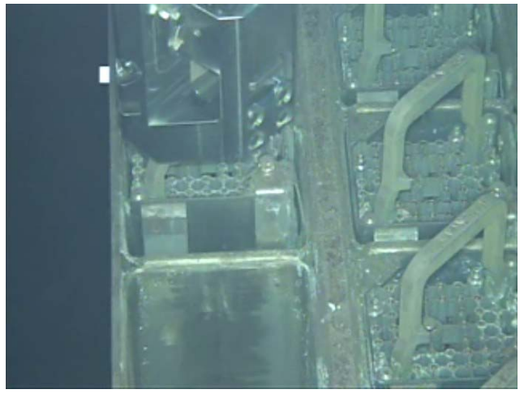
International Expert Group (Nov. 15)

Figure 5: On-site review

On-site transfer container moved into pool （Nov. 18）



Operation of fuel removal (Nov. 18）



Fuel removal operation (Nov. 18）

Loading of on-site transfer container on the trailer (Nov. 21）

*: Some modifications are made to the Images above as they contain sensitive information on nuclear material protection, etc.

Figure 6: Removal of fuel at Unit 4

5. Fuel debris removal plan

～In addition to the decontamination and shield installation to improve accessibility to the PCV, technology is being developed and data acquired as necessary to prepare for removing fuel debris (such as investigating and repairing the leak locations of the PCV)～

➢ **Demonstration of swimming inspection robot for Unit 1 (check on the leakage locations in the bottom part of vent pipes)**

- As a demonstration of long cable handling technology and self-position detection element technology which were developed by the "Technical platform Improvement project on handling of the accident of nuclear reactor, etc. for power generation for FY2012 (technical development of swimming inspection robot towards upgrading the remote

technology basis)" (Agency for Natural Resources and Energy) (November 13 and 14) (see figure 7), checks on the existence of leakage from sand cushion drain pipes and vent pipes; and the exterior appearance which was undertaken through camera image installed on a water-boat were conducted .

- Water leakage from a part of the upper part of vent pipe and sand cushion drain pipe was confirmed (see figure 8). It is planned to analyze the information gained and undertake investigation.

➢ **Decontamination in the reactor buildings of Unit 1 to 3**

- It is planned to start works such as investigation for the purpose of repairing primary containment vessels at the first floor of the reactors from FY2014. Currently, it is difficult to have operators work at the site for many hours due to the high radiation dose inside the reactor buildings, for which, the environment is addressed in such a way as to remove rubbles using unmanned heavy machine and to reduce such dose using remote-control typed equipment.
- Decontamination work has started at the first floor of the reactor building of Unit 2 from Nov. 28 using remote-control type equipment.

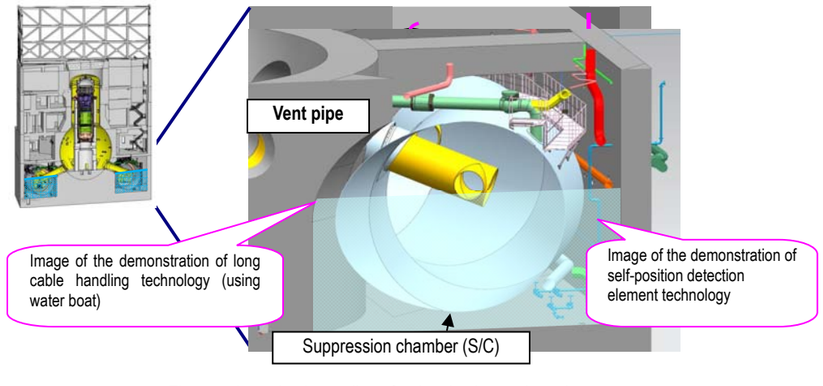


Figure 7: Investigation outline of swimming inspection robot

Figure 8: Water leakage from sand cushion drain pipe and upper part of vent pipe at Unit 1

6. Plan for storage, processing and disposal of solid waste and decommissioning of reactor facilities

〜Research and development for the promotion of waste generation reduction and storage adjustment; and the appropriate and thus safe storage, processing and disposal〜

➢ **For trial operation of equipment (scaffolding member) lending**

- To reduce waste, equipment, etc. brought in the premises is controlled. From Dec. 2, lending of scaffolding member was scheduled to start for trial operation.

➢ **Management of rubbles and felled tree**

- By now, as measures to reduce radiation dose, the installation of a soil covered temporary storage, intake of highly radiated rubbles into the storage for solid waste at the basement level, and transfer of rubbles to the site a certain distance away from the site boundaries were conducted. In addition, as a fire prevention measure, a container for interim storage for logs was installed.
- As of the end of October, the total amount of storage of concrete and metal rubbles is approx. 70,000m^3 (area occupancy: 76%). As for the logs, the said number is approx. 61,000 m^3 (area occupancy: 48%).

7. Plan for staffing and ensuring safety works

〜Securing personnel over a long period while conducting steadily the control of workers exposure dose. Also, improving labor conditions and work environment continuously while grasping the needs at the site〜

➢ **Personnel control**

- The number of persons who are registered as engaged in the operation one day or more in a month (partner companies' workers and TEPCO employees) is approx. 8,200 persons in average per month during the period from July to September. The number of persons who have practically engaged is approx. 6,000 persons per month, which shows that the adequate number of registered workers is secured.
- It is assumed that the number of personnel necessary for the operation in December (partners companies' workers and TEPCO employees) will be approx. 3,260 persons* per day, which was confirmed that sufficient personnel is being secured. To note, the average number of workers per day for each month of this fiscal year (practical value) is hovering with approx. 3,000 persons as shown at figure 9.

*: Some operations are not included in the estimation for December as they are currently in the process of concluding contracts

- The local employment rate as of October is around 50% (partner companies' workers and TEPCO employees)

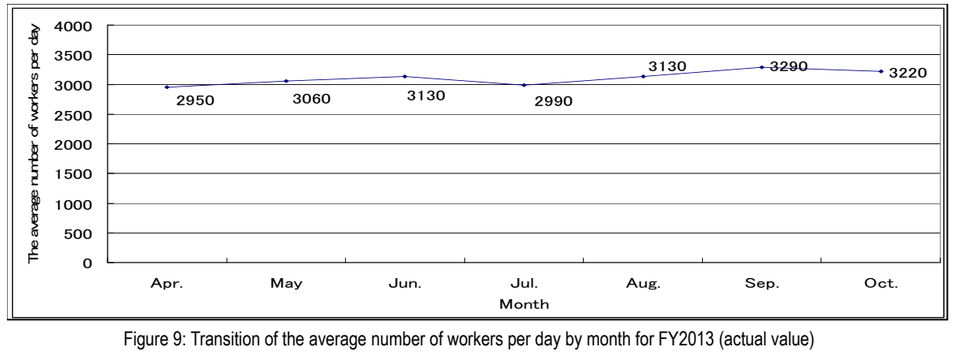


Figure 9: Transition of the average number of workers per day by month for FY2013 (actual value)

➢ **Efforts towards the improvement of work environment**

- Questionnaire on overall work environment targeting workers was conducted (Oct. 9 through Nov. 12). The feedback was given by 3,304 workers (response rate: 84.3%), which is currently being summarized. The result will be publicized in December, and necessary actions will be taken accordingly.
- To improve the work environment, creating of a large refresh room, etc. was in view since before. To deal with which, as an extra measure to enhance their motivation, it is planned to build additional mobile refresh room converted from large-type bus, new office building, and lunch center to improve their dietary life.

8. Others

➢ **Emergency safety measures at the Fukushima Daiichi nuclear power plant**

- Taking into consideration the instructions, etc. pointed out by the Nuclear Regulation Authority, safety measures necessary to be addressed urgently by Tokyo Electric Power Co. was summarized and publicized for the purpose of prompt handling of decommissioning of reactor facilities and issues on contaminated water and tanks; and improving reliability (Nov. 8).
- Overall measures with regard to enhancing motivation at site in the aspect of both tangible and intangible are addressed based on priorities.

➢ **Workshop concerning the R&D plan and basic research toward reactor decommissioning**

- In light of the Middle and Long Term Roadmap, workshops with a view to identifying and creating the basic research that universities or laboratories, etc. are expected to work on. (co-organized by MEXT and IRID) was conducted in the Kansai/ western Japan region for the 3rd (Nov. 1), the Tohoku/ Hokkaido region for the 4th (Nov. 20), and the Kanto region for the 5th (Nov. 26). Also, the 6th workshop is scheduled to take place in the Kansai/ western Japan region (ii) (Dec. 20).

➢ **IAEA review mission on work towards decommissioning the reactors**

- The second IAEA review mission for Fukushima Daiichi decommissioning work came to Japan from Nov.25 to Dec. 4 after the first visit in this April. The mission aims to provide acknowledgment and advice on the decommissioning efforts made, especially on the recent challenges such as countermeasures for the contaminated water issue and fuel removal from the spent fuel pool in Unit 4.

End