Nuclear Safety Reform Plan Progress Report

(FY2013 1st Quarter)

July 26, 2013

Tokyo Electric Power Company, Inc.

Contents

Introduction

We want to present our heartfelt apologies once again for the tremendous distress, torment, and hardship that the Fukushima Nuclear Accident still inflicts upon the residents of communities surrounding the power station and on society at large. We will continue gathering our workforce to maintain the stable state of Fukushima Daiichi Nuclear Power Station, and to undertake the processes of damage compensation, cleanup and recovery so that citizens including evacuated ones are able to return home and live with peace.

On March 29, 2013[1], TEPCO made public its report “Fukushima Nuclear Accident Summary and Nuclear Safety Reform Plan” (“Report”). The report summarized that the proximate cause of the accident was total loss of power including batteries, which had been extremely fatal and paralyzed most of safety systems, and that inadequacies in both soft skill and hardware for severe accident laid behind the cause. Accordingly, the cause of the accident cannot be simply swept aside as a natural disaster, being that it would have been difficult to anticipate an enormous tsunami. Rather, we believe it necessary to sincerely acknowledge the finding that TEPCO was unable to avoid an accident that should have been avoided through advance preparations making every use of the human intellect. Based on these reflections, TEPCO is ridding itself of its overconfidence and arrogance about the safety measures it previously had in place, and is working to clarify the problems that existed within the company's organization and continuing to fundamentally reform how it approaches safety.

TEPCO is working to implement the plan promptly and appropriately and to compile the progress made and issues need to be addressed in reports to be released quarterly. In this document, we published the status of progress on the Nuclear Safety Reform Plan and reported on whether the reform is progressing or not. Also, we reviewed the plan in light of the accidents and problems that had arisen during the period in question[2].

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[1] Hereinafter, dates displayed without a year are understood as this year 2013.

[2] Principally, the 1st quarter (April~June) of FY2013, but including also some of the periods before and after the 1st quarter.

1. Progress on Nuclear Safety Reform Plan (Facility Reform)

1.1. Fukushima Daiichi Nuclear Power Station

High risks in facilities of Fukushima Daiichi leading to environmental radioactive material release are identified as follows.

- Risks associated with failure to inject cooling water into reactor (Units 1-3)
- Risks associated with failure to inject nitrogen gas into PCV, etc. (Units 1-3)
- Risks associated with failure to cool spent fuel pool water (Units 1-4, and common-use pool)
- Risks associated with leakage of contaminated water
- Risks associated with power outages

Particularly the risks of power outage and contaminated water leakage are currently attracting public attention due to the power outage caused by mouse on March 18, and the leakage from the underground water storage on April 5. Immediate troubleshooting task force headed by the president for reliability improvement of Fukushima Daiichi facilities was established on April 7 in response to these troubles. We have been clarifying the risks in facilities and management leading to the following problems through in-depth site survey, planning and implementing countermeasures, and will keep working deliberately on improvement with priority-base.

- Loss of fuel cooling
- Additional environmental release of radioactive material
- Fire
- High-priority system blackout


Example of site survey: An opening for incoming cable lines as shown in the right picture was found as a result of transformer internal inspection. The opening was closed.

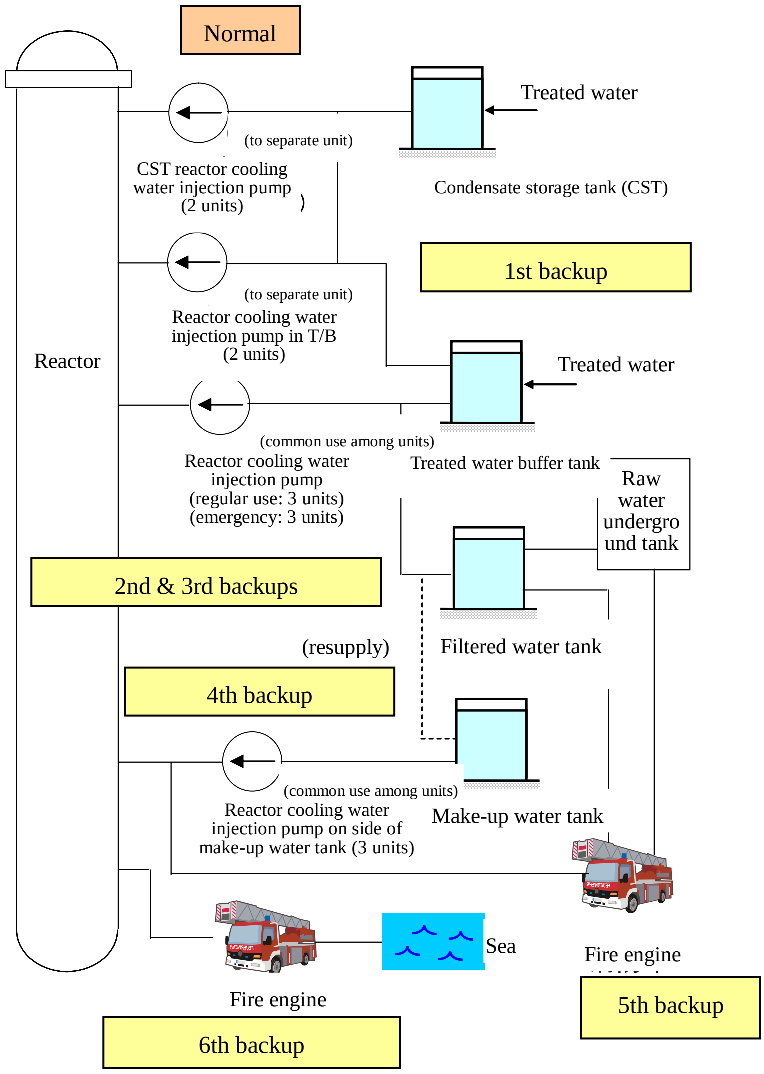
Some of countermeasures for risks of troubles triggered by external events like earthquakes and tsunamis are similar to the ones mentioned above. We take actions serially including prevention for pool-stored fuel defect and radioactive material proliferation depending on plant status. The most effective solutions for the risks are removal of spent fuel and fuel debris, and are being tackled in manners as follows:

- Moving up schedule for spent fuel removal from Unit 4: one month for beginning and one year for ending (Starting in November 2013 and completing by December 2014)
- Moving up schedule for fuel debris removal from each unit by a maximum of 18 months through specification of engineering schedules, holding points, and target dates of constituting projects

(1) Risks associated with failure to inject cooling water into reactor

Currently, reactors of Units 1, 2 and 3 are stably maintained in a state of cold shutdown (approx. 20 to 45ºC). The injection of cooling water into the reactors is comprised of a system capable of injecting water from multiple water sources and multiple cooling water injection pumps. Also, the power sources for these pumps are secured with power supplied from multiple power supply systems, and, moreover, fire vehicles have been deployed (3 units for injecting water, and several others held for firefighting) and other measures taken.

Accordingly, even if the function of all pumps for injecting cooling water into reactors were lost simultaneously, it would be possible to resume the injection of cooling water into the reactors within three hours by laying cooling water injection lines using fire engines running hoses from the filtered water tanks.



Furthermore, even if the injection of water into Units 1-3 shut down simultaneously for a period of 12 hours due to some sort of accident, the effective dose at the site boundary has been assessed at 6.3×10^{-5}mSv, with the result that no significant risk of radiation exposure would be posed to the public the surrounding area. [3]

[3] 1/15,000 of the annual exposure dose limit for the general public of 1mSv

(2) Risks associated with failure to inject nitrogen gas

To prevent the concentration of hydrogen gas from rising and reaching the flammability limit (4%), nitrogen gas is injected into the PCV and reactor pressure vessels. Three nitrogen gas generators (one regular use, two backups) have been installed, along with one emergency nitrogen gas generator driven by a diesel engine generator placed on high ground. This equipment setup makes it possible to respond even in the event of an unexpected breakdown.

Even if the supply of nitrogen be halted due to an equipment failure or other reason, there is a minimum margin of time of approximately 100 hours before the hydrogen reaches the flammability limit concentration of 4%, and the nitrogen supply can be restored before that point.

(3) Risks associated with failure to cool spent fuel pool

Cooling of spent fuel pools continues through a multiplexed configuration comprising primary and secondary pumps. If pool cooling shuts down, it has been assessed that based on the pool temperature of approximately 30℃ and the heat (approx. 0.56MW) generated from spent fuel as of June 14 at Unit 4, which has the most severe conditions, it would take:

- Time until the limit value (65ºC) set in safety regulations is reached: approx. 4.2 days
- Time until temperature of spent fuel pool water reaches 100ºC: approx. 8.5 days
- Time until pool water level falls to approximately 2 meters from top of the spent fuel[4]: approx. 36 days

During this time, it is possible to either restore the cooling system or restart the injection of cooling water using either fire trucks or concrete pumping vehicles deployed at the power station.

(4) Risks associated with leakage of contaminated water

The following three measures have been adopted for handling contaminated water, which continues to increase due to groundwater inflow.

(1) Measures to control groundwater inflow

- To prevent groundwater which flows from the west to the east side of the power station from infiltrating the reactor buildings and becoming contaminated, the groundwater is being drawn up at a location upstream from the buildings (groundwater bypass). In addition, the inflow of groundwater into the buildings is controlled by restoring the sub-drain equipment[5] in the surrounding area, lowering the groundwater level around the buildings, and cutting off external wall penetrations on buildings.
- In preparation for a case where these measures cannot be carried out or do not function as planned, work on concept designs for impermeable walls on the landward side using the

[4] A decline in the pool water level raises the spatial radiation dose on the 5th floor of the reactor building where the spent fuel pool is installed, the level is set at which people involved in restoration are no longer able to easily approach the area.

[5] Well dug in the area around building for drawing up groundwater.

frozen ground method are being advanced, and the status of the resolution of technical issues will be verified by December of this year.

(2) Improvement in decontamination performance of water treatment facilities

- Test operations are currently underway to ascertain the current performance of multi-nuclide removal system for decontaminating radioactive material in contaminated water. Results of the test samples taken in April show that all 62 of the nuclides the systems targets were brought below the concentration limit set by law. The equipment has demonstrated the anticipated effect (announced May 30).
- After test operation is completed, the multi-nuclide removal system will reliably operate to reduce the radioactivity concentration of contaminated water and lower the risk should an unexpected leak occur.

(3) Augmenting tanks for managing contaminated water

- It is necessary to secure sufficient tank capacity to permit storage of the increasing amount of contaminated water. Storage capacity will steadily be increased to approximately 440,000 m^3 during first half of the current fiscal year, approximately 700,000 m^3 by the middle of FY2015, and approximately 800,000 m^3 during FY2016. TEPCO will continue to ascertain the progress of these measures and prepare to further expand capacity as necessary.
- To secure tank storage volume, repairs will also be made to the flange connectors on existing tanks and renovations made to welded tanks will be reviewed. In addition, assessments will also be conducted into the feasibility of measures (such as increasing tank size, etc.) in the event that conventional tanks are not compatible.

In addition, with regard to the treatment of contaminated water, the central government established the Committee on Contaminated Water Treatment Countermeasures in April of this year. The Committee is conducting a comprehensive evaluation of previous countermeasures and studying measures for fundamentally resolving the problems of treating contaminated water as well as courses of action for responding to recent accidents involving contaminated water leaks. TEPCO is actively taking part as a member of the committee and discussing challenges toward realizing drastic measures.

Based on the findings of the committee on contaminated water treatment countermeasures, TEPCO will address contaminated water countermeasures with a sense of exigency and urgency, and will strive even more than we have been doing so that we carefully manage the project by appropriately assigning personnel and clarifying responsibility for effectuating the decommissioning of Fukushima Daiichi NPS at the earliest date possible.

(5) Risks associated with power outages (improved reliability of power source systems)

On March 18, there was a partial interruption in the power source equipment at Fukushima Daiichi Nuclear Power Station, and the spent fuel pool cooling system shut down at Units 1, 3, and 4. Consequently, we have implemented measures including the multiplexing of high-voltage power circuits, multiplexing of low voltage power sources, multiplexing and diversification of load systems and the multiplexing of remote monitoring systems for the electric equipment connected to crucial equipment (reactor cooling water injection, spent fuel pool cooling, common pool cooling, nitrogen injection and other such key systems).

With the completion on May 15 of the multiplexing of the power supplies for spent fuel pool cooling systems at Units 1, 3 and 4, work on nearly all of the measures has been completed at present. The multiplexing of the power source for the original on-site equipment used for cooling the spent fuel common pool is proceeding with a target date of mid-July for completion.

1.2. Fukushima Daini Nuclear Power Station

In accordance with the Restoration Plan drafted based on the Nuclear Operator Disaster Prevention Business Plan, restoration of facilities related to maintaining the cold shutdown at the plant has proceeded. As of May 30, work was completed on restoring the original on-site equipment to operation in place of the temporarily installed equipment with respect to systems involved in maintaining the cold shutdown at all four reactors Units 1 thru 4 (completion of the "post-nuclear disaster incident measures" in accordance with the Act on Special Measures Concerning Nuclear Emergency Preparedness). We will also strive to maintain stable cooling of the reactors and spent fuel pools.

1.3. Kashiwazaki-Kariwa Nuclear Power Station

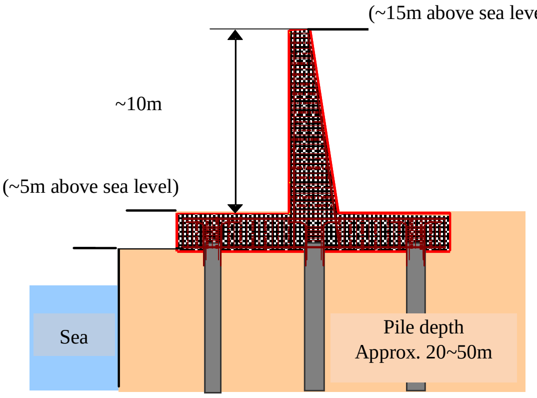
As protection against tsunami, work has proceeded on various measures including the erecting flood embankments, flood barriers, and switchyard flood barriers, as well as making reactor buildings and other structures water tight and preventing the inundation of heat exchanger buildings.

Flood embankment (reference: 15m tsunami): completed in June

Flood barrier: completed in March

Switchyard flood barrier: completed in March

Water tightening of reactor building, etc.: Units 1, 5-7 completed in May; Units 2-4 under design



Designed to resist wave force of 15m tsunami (3x hydrostatic pressure) and standard earthquake ground motion Ss

Flood embankment along Units 1-4

The following have been implemented to ensure function for cooling reactors:

(1)Securing power sources

・Deployment of air-cooled gas turbine power generating vehicles

・Deployment of emergency high-voltage power distribution panels

・Deployment of power supply trucks Etc.

(2)Securing cooling water function

・Installation of fresh water reservoirs (water sources)

・Deployment of fire engines Etc.

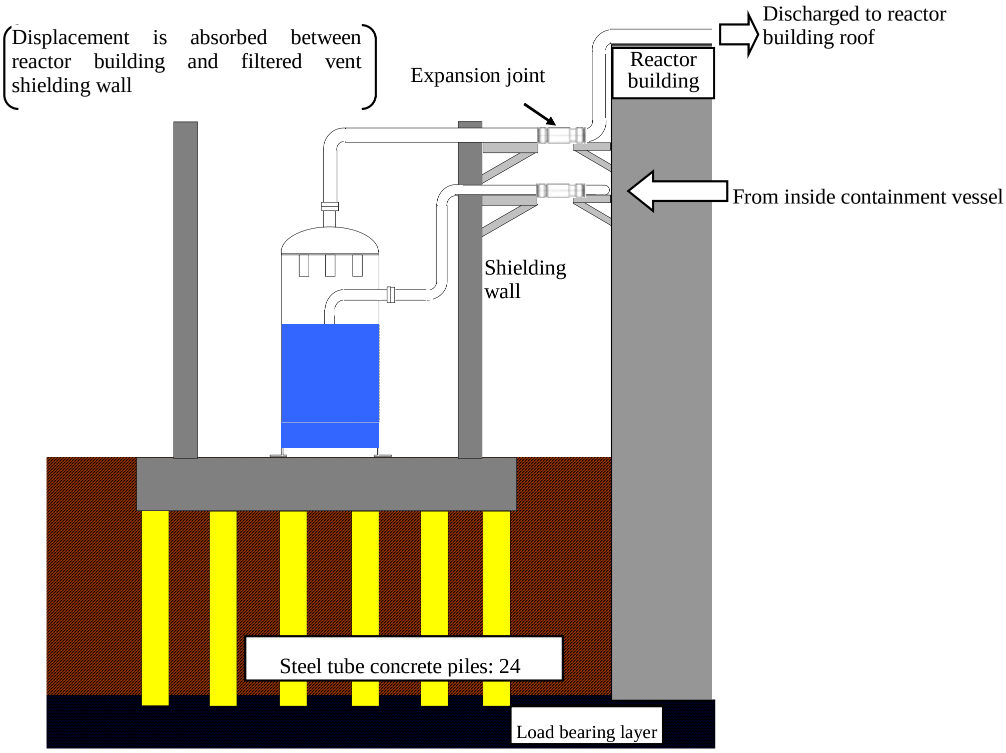
Training using emergency power-supply vehicle

In addition, the following have been implemented to ensure heat removal function:

・Alternate submersible pumps

・Deployment of alternate heat exchanging systems Etc.

Furthermore, foundation work is proceeding on filtered venting systems at Units 1, 5-7 (Units 2-4 are under review). The foundation of this filtered venting system is upheld by the supporting bedrock, just as with the reactor building, and is designed so that function will not be lost due to differential settlement between the reactor building and foundation of this system. Also, this system and the reactor building will be connected by means of expansion joints, and is designed so that function will not be lost due to displacement during an earthquake.



The filtered venting system is able to remove over 99.9% of particulate radioactive material, and the following results have been obtained when an assessment was conducted of the exposure level to the surrounding public when venting the containment vessel.

(1) Containment vessel venting to prevent core damage

From the results of an assessment of the dose on the public in the surrounding area from exposure to noble gases and iodine following venting of the containment vessel prior to core damage, it was verified that the dose at the site boundary was approximately 0.042mSv, which is below 5mSv as generally indicated in inspection guides of nuclear regulatory authorities.

(2) Containment vessel venting to prevent containment vessel damage after core damage

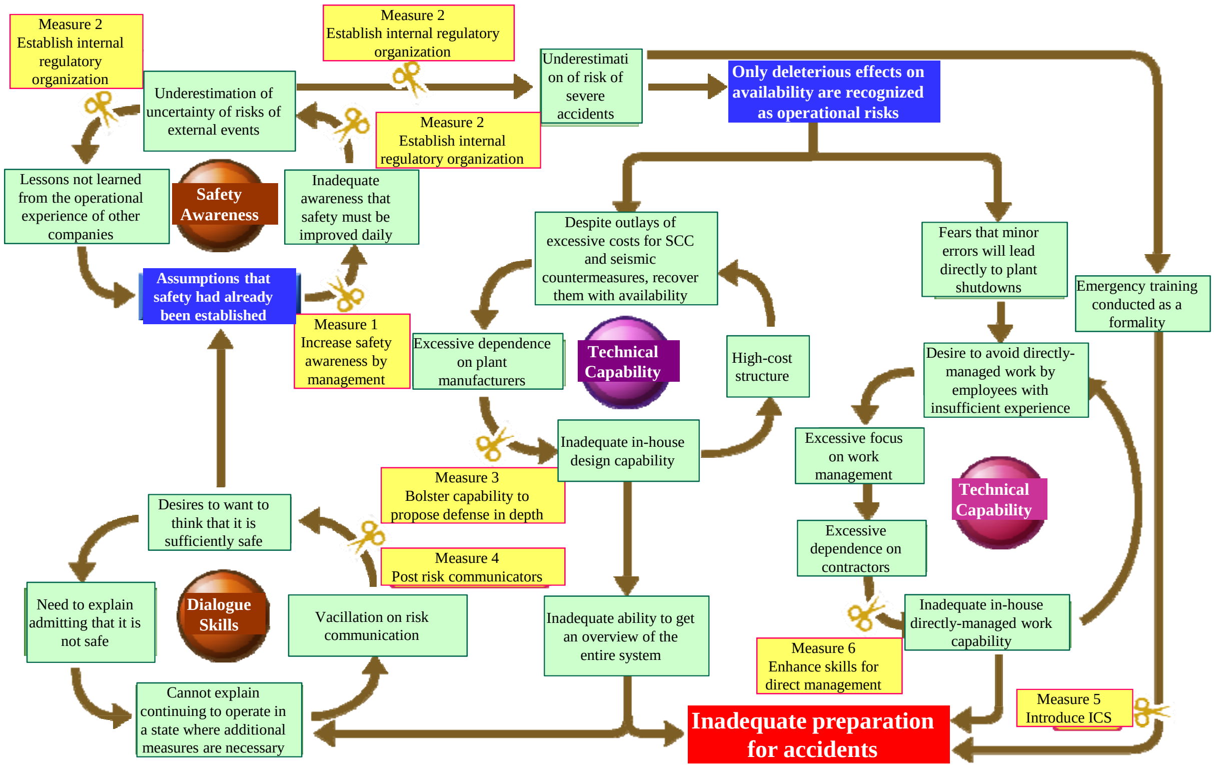
From the results of an assessment of the quantity of cesium-137 released from the standpoint of contamination of the environment due to radioactive material accompanying containment vessel venting after core damage, it was verified that the quantity of cesium-137 released was approximately 0.0025TBq[6] (TBq (terabecquerel) $=10^{12}$Bq), which is below the 100TBq as indicated in inspection guides of nuclear regulatory authorities.

[6] The quantity of cesium-137 released in the Fukushima Nuclear Accident (total for Units 1~3) was approximately 10,000TBq (TEPCO assessment), and the quantity of cesium-137 released in the accident at the Chernobyl Nuclear Power Station was approximately 85,000TBq.

2. Progress on Nuclear Safety Reform Plan (Management Reform)

Turning to progress on the Nuclear Safety Reform Plan (management), this report will describe two points, "items implemented" and "future plans" for each of the six measures to severe the so-called “negative spiral” which furthered the structural issues that nuclear power departments have faced.

Severing the negative spiral of insufficient accident preparation



2.1 Countermeasure 1: Reform of Top Management

<Items implemented>

- Training was conducted for corporate officers and prospective officers for the purpose of raising safety awareness of topics such as nuclear power station safety design, nuclear disaster prevention, as well as the development and lessons learned from the Fukushima Nuclear Accident (May 18 and 25).
- Nuclear power leaders [7] have been visiting companies in other industries working to improve safety awareness to exchange views (May 13).

Training for corporate officers (May 25)

[7] Executives and corporate offices responsible for nuclear power, power station directors and construction directors, Head Office nuclear power-related general managers and anyone equal to or above these ranks.

- As part of the effort to foster a safety culture, multifaceted discussions were held throughout the nuclear power departments on the subject of reports. Also, questionnaire surveys were conducted of the nuclear power departments (April 12-May 13), and the extent to which a safety culture is being created and penetrating the organization is currently being assessed.

<Future plans>

- In October, training will be held for corporate officers on safety culture, risk communication and other topics.
- For nuclear power leaders, training will be conducted that simulates a main control room during an accident and power plant walk-downs will be held (July-August). Also, "360-degree" assessments of behavioral indicators will be conducted in July.
- Initiatives on understanding how to foster safety culture in all workplaces will be continued, and discussions and self-assessments at each staff level and in each organizational unit will be conducted on a quarterly cycle. In particular, assessment methods will be reviewed and assessments (self-assessments) of the safety culture of individual organizations are scheduled to be conducted in July based on the results of questionnaires and discussions on safety culture in the first quarter.
- Specific issues pertaining to fostering a safety culture and its dissemination will take into account the views of the Nuclear Reform Monitoring Committee, Nuclear Safety Oversight Office and other third-party perspectives, and be reported next time.

Training for corporate officers (May 25)

Activities to foster safety culture
Discussion among nuclear power leaders
(March 30)

Activities to foster safety culture
Discussion among Fukushima Daiichi Nuclear Power Station managers (April 26)

Activities to foster safety culture
Discussion among nuclear power department managers at Head Office (April 11)

2.2 Countermeasure 2: Oversight and Support for Top Management

<Items implemented>

- The Nuclear Safety Oversight Office was established on May 15 as an internal regulatory organization, and Dr. John Crofts from the UK assumed the position of general manager of the office. The Office supervised training for corporate officers, visited Fukushima Daiichi, Fukushima Daini, and Kashiwazaki-Kariwa NPS and interviewed the station managers, deputy station managers, and chief reactor engineers. The office assessed their safety awareness and gave them advices.

Nuclear Safety Oversight Office General manager, Dr. John Crofts (right)

Deputy General Manager, Masuda on left (former Fukushima Daini Nuclear Power Station Director).

Discussions with General Manager Crofts

- At the Kashiwazaki-Kariwa Nuclear Power Station, the chief reactor engineer conducted nuclear safety training (nine sessions beginning in January with approximately 530 attendees (45% of power station personnel) (the training will be expanded laterally to Fukushima Daiichi and Daini Nuclear Power Stations)

<Future plans>

- The Nuclear Safety Oversight Office will continue to monitor and advise management and nuclear power departments from the perspective of a third-party
- At the Fukushima Daiichi NPS where decommissioning is being implemented which has no parallel anywhere in the world, the Nuclear Safety Oversight Office will strengthen monitoring and assistance for the stable management of facilities and approaches to improving safety because the state of the facilities and the environment differ from ordinary nuclear power stations.

- 360-degree assessments (once annually) will be conducted in October in order to evaluate how the thinking and behavior of middle management have changed as a result of activities to foster a safety culture

2.3 Countermeasure 3: Strengthening Ability to Improve Defense in Depth

<Items implemented>

- Preparations were made for a "Safety Improvement Competition," the objective of which is to propose very cost-effective safety measures and improve the technological capabilities for implementing such based a review of safety measures from multilateral perspectives. Solicitation of proposals for the first such competition began in June (for approximately three months). Aside from the competition, reviews are also underway on “installing an interlock system to stop pumps on ordinary systems in the event a tsunami (backwash) strikes” and on “adding depressurization means other than the main steam safety valves”.
- TEPCO reevaluated its screening process for selecting necessary safety information pertaining to operation experience (OE) data from Japan and overseas. We applied the process to approximately 330 items over a period from last December to June of this year, and selected approximately 20 for more detailed examination. Aside from the OE data, we surveyed and analyzed the ways in which regulatory authorities in Europe and America deduce lessons to be learned and adopt measures pertaining to the improvement of safety, and we began to study whether there was a need to provide feedback internally.
- Regarding external hazards for which systematic analysis has thus far been insufficient (natural phenomena, external artificial events), another reassessment was conducted from the perspective of preparing for cliff edge effects[8] on the safety functions of nuclear power facilities, and approximately 30 events, including meteorites, tornadoes, volcanoes, aircraft terrorism, forest fires and typhoons, were selected from among approximately 200 external hazards, and the analysis commenced.
- To provide for improvements in the periodic safety assessment process, systematic review methods were formulated and analysis of individual process issues was implemented. Along with commencing a review on “OE information-related activities” beforehand, a plan for improving issues is to be formulated by September.
- In improving operations which have become bogged down in a disproportionate emphasis on evidence[9], manuals, which form the basis for executing the work, are being reworked, but delays have arisen due to changes in the degree of priority given to operations. The plan for reworking manuals and other procedures that should be prioritized will be reassessed in June and implemented.

[8] The widespread loss of safety functions due to a common factor that occurs all at once when a load greater than a certain magnitude is added such as a tsunami that significantly exceeds design assumptions.

[9] An overemphasis on securing evidence from the results of operations implemented

- In the personnel rotations in July, employees were transferred among the departments with the objectives of "gaining awareness of operational improvements" and "acquiring an outside perspective" (nuclear power to other departments: 11 employees; other departments to nuclear power departments: 16). As of July 1, approximately 260 personnel from nuclear power departments were posted in other departments.

<Future plans>

- Proposals for the safety improvement competition are being solicited and the judging will take place by October to determine the superior proposals
- In the performance assessments, policies on drafting operating plans for the current fiscal year will include conducting assessments related to nuclear safety, which will be reflected in each employee's operating plan. The results will be checked at the time each individual’s performance is evaluated.
- Using the example of the introduction of information technology into the maintenance operation process, analyses will be conducted to identify issues to be addressed such as the weakness of the ability to resolve cross-organizational issues and poor project management, and countermeasures will be formulated and implemented by September.
- Verification will be conducted to determine whether or not a balance is being struck between the extent of the resources invested and results achieved through various initiatives such as the reworking of manuals based on awareness of solving the issue of whether improvements to operational quality are too few in comparison to the volume of rules and evidence (overemphasis on evidence), that is to say to the sense of how great the operational burden is

2.4 Countermeasure 4: Enhancement of Risk Communication

<Items implemented>

- The Social Communication Office was established on April 10, and since April 10, risk communicators have been appointed and stationed at posts (as of July 1: 31 risk communicators).
- The Social Communication Office collects mainly information on risks as concerns the nuclear power departments and has begun to make proposals on coping strategies to management and the nuclear power departments. In addition, the nuclear power departments have likewise started to provide the Social Communication Office with a variety of information.
- Risk Communicators have started communicating about risk with various stakeholders. Reviews have also been commenced on specific communications activities during emergencies by the Social Communication Office and nuclear power departments.
- Cases have arisen where sufficient communication has not been achieved, such as the response to the power outage accident due to mice which occurred at the Fukushima Daiichi NPS, and the work process of collecting and organizing information at the time of the accident or problem has been clarified.

Dialogue with local residents (May 28)

Reviewing risk communicator assignments roles during an emergency

<Future plans>

- General Manager of the Social Communication Office is to be recruited from external professionals (President Hirose is currently acting for the post)
- Improvement plan for Risk Communicators' communications ability such as simulation training for stakeholder communication will be developed. The training partially started in June.
- Public briefing on progress of the Nuclear Safety Reform Plan and other risk communication enforcement activities such as briefing paper quality improvement will serially start in July

2.5 Countermeasure 5: Reform of Emergency Response Team in Station and Head Office

<Items implemented>

- Development of a structure based on the Incident Command System (ICS)[10] began in January of this year on an emergency response organization at the Kashiwazaki-Kariwa NPS, and the organization has been administered in keeping generally with the ICS approach since March, while training has repeatedly been conducted (total of 9 comprehensive training sessions and 400 small-scale training sessions by the end of June)
- With the ICS structure, the emergency response organization is able to operate dispassionately and in an orderly manner, and a system of supervisory control has been established. Also, the Head Office has committed itself thoroughly to a support function, and it has reduced its dealings with power stations to allow the power station to concentrate on the disaster response. Thus, the effect by applying for ICS was confirmed.
- Through repeated training, response capabilities have been improved to a level where the significance and effectiveness of ICS can be actually sensed.

[10] Incident Command System (system for issuing field command during a disaster and has been adopted as the standard in the U.S. and elsewhere)

Training at Kashiwazaki-Kariwa Nuclear Power Station (March 8)

Training for the Emergency Response Office at the Head Office (May 22)

<Future plans>

- ICS will be adopted for the emergency response organizations at Fukushima Daiichi NPS and Fukushima Daini NPS, with training targeted to begin in August
- Based on past training results, there is room for devising ways to make the sharing of information among internal organization as well as governmental institutions, off-site centers and other entities outside the power station more expeditious, accurate and easier to understand, and the effects of the means devised are scheduled to be confirmed in the next comprehensive training to be conducted in September. Also, the framework for information sharing will be made more efficient (improving the usability of tools, reviewing operation rules).
- Based on the decision that "there is no end to training," work will be undertaken to maintain and improve the capability to respond during an emergency through a variety of training exercises, and items for improvement will repeatedly be deduced, reflected in the next training and the results of those improvements confirmed.
- Effective use will be made of ICS training programs systematized in the U.S., and the content for training will be prepared and expanded (preparations to be completed by September)

2.6 Reform of Station Organization and Enhancement of In-house Maintenance

<Items implemented>

- An application was filed on May 31 for authorization to revise the nuclear facility safety regulations in order to implement a review in August of the power plant organization under normal conditions at the Fukushima Daini NPS and Kashiwazaki-Kariwa NPS (implementation after authorization)
- It was clarified what is expected of the "system engineer[11]" position, which has been newly adopted,

[11] Engineers well versed in design, permits and licensing, operations, and maintenance of safety and other crucial systems.

and a training plan for the next two years was drafted (May)

- Training plan was drafted for power station personnel which includes drills on connecting power supply cars and fire engines, as well as on equipment diagnostic operations (data collection, simple diagnostics). A training curriculum has been drafted and preparations completed for the commencement of training on these areas to start in July. (June)
- In order to systematically bolster the direct-management capability of maintenance personnel, full-time personnel have been assigned to the maintenance departments, and preparations have been completed including the preparation of training plans and procedures as well as the posting of instructors along with training materials and equipment for the commencement of training on direct management of work to begin in July (June). Also, at each power station, preparations have been gradually carried out, including the drafting of procedures and the posting of instructors along with training materials and equipment, and direct management has actually been implemented based on the work for which preparations have been arranged.

Unloading work performed using vehicle equipped with a crane

Work to connect a replacement heat exchanger

<Future plans>

- Review will be undertaken of the power station organization under normal conditions and system engineers assigned (August).
- Review will begin on a framework for mid to long-term personnel rotations aimed at developing the human resources needed for organizational operations, and a specific schedule for such will be formulated.
- Training will begin in July for fostering the capability of operations and maintenance personnel to apply their skills, knowledge and experience to respond to an accident
- Regular maintenance work by operations personnel will be gradually expanded while coordinating operations with training in equipment diagnostic operations while, at the same time, increasing the number of personnel.

3. Review of the Reform Plan in Light of Exposed Problem in the 1st Quarter

TEPCO has initiated nuclear safety reforms, but several accidents or problems have occurred at the Fukushima Daiichi NPS in the ensuing period of time. Findings on the causes of each of these accidents or problems as well as recurrence prevention measures are available for viewing the company website. In regard to the following three events:

A) Power outage caused by mouse on March 18 and recurred on April 5 during corrective action
B) Contaminated water leakage from underground water storage confirmed on April 5
C) Groundwater contamination with tritium and other substances distributed east of Unit 1 and 2 turbine buildings announced on June 19

We looked back once again on these events in compiling this Progress Report so as to contribute to a verification of the appropriateness of the Nuclear Safety Reform Plan and to check for the presence of any insufficiency in implementation of the plan. In this “look back,” we categorized findings into the three perspectives of “safety awareness,” “technical capability,” and “dialogue skills” that were the key issues in our review on the Fukushima Nuclear Accident.

A) Power outage caused by mouse and recurred during corrective action

Safety awareness

There was risk consciousness for low reliability of temporary power source equipment. Such equipment was being replaced with permanent systems and scheduled to be completed by the end of March. Therefore, safety awareness was not paralyzed such that the vulnerabilities of power supply equipment would be neglected.

After the power outage occurred, managers at the station believed that there was a time margin of 4 days until the water temperature of the spent fuel pool would reach the limit value of 65^{o}C, and of tens of days until fuel tops appear on the surface of the pool water. They thought that it would be better to deal with the issue in a calm way rather than incurring a second accident by hastily performing night work. This decision was technically reasonable for safety of station.

However, 29 hours, the time spent for restoration of such an important power source, was too much even though the spent fuel pool temperature did not reach the limit value. We could have restored the source earlier if we had prepared the following hardware/software for sudden blackout

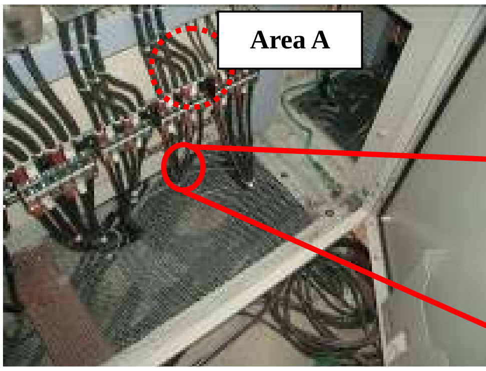
- Power source drawings were not updated with its improvement project progress.
- Connection procedure for emergency power-supply vehicle to power system should be established and well trained for improvement of restoration work
- Temporary lights and other working aids should be prepared to improve safety of troubleshooting work at night

We have to prevent from equipment failure by design and maintenance, and prepare for problems as a result of the failure simultaneously concerning defense-in-depth approach that is one of the essentials in nuclear safety. If the power outage was anticipated due to low reliability of temporary power source equipment, the necessity should have been even higher.

Preparedness for troubles such as power outage should be, therefore, strengthened further in terms of defense-in-depth approach by raising technical capability of station personnel sufficient for immediate response.

Technical capability

Although maintenance works were mostly outsourced before the Fukushima nuclear accident, in-house maintenance by TEPCO employees has expanded for rapid carryout in severe environments of the accident site. Installation of mouse-repellent wire net was one of those works. It was, however, an installation work inside a control panel comprising of live lines that we should have been more aware of the risks of electric shock and short-circuiting. Sufficient attention and proper measures were needed for the work.

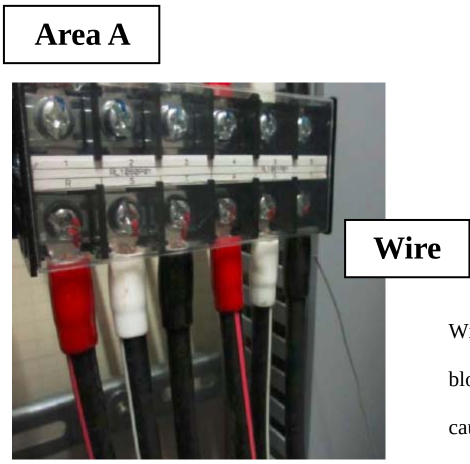


Wire installed inside control panel

Enlarged view of an opening in wire net

(Cut made in the wire net for a cable to pass through.

The excess opening is closed using wire string)



Wire tip slipping through the gap between the terminal block and the acrylic cover touched junction metal and caused short-circuiting

Our risk assessment process, which was designed for outsourced works where TEPCO personnel behave only as supervisors and inadequate for risk assessment of in-house maintenance, could neither find nor eliminate safety risks in our own works. Additionally, on-site general work management was not enough in light of a lack of collaboration between the mechanical maintenance group responsible for the fuel pool cooling facility including the control panel and the electrical maintenance group possessing expertise in electrical maintenance.

Furthermore, safety and quality supervisors, who have the role of providing guidance and support for work safety, could neither supervise all workers nor confirm all work sites due to dose limitation. Concerning TEPCO personnel performing in-house maintenance with insufficient work expertise, and the lack of adequate oversight and support by safety and quality supervisors, management effort to build a work process such as giving guidance and support by experienced professionals was necessary to reduce safety risks.

Dialogue skills

We could not have imagined that people in Fukushima would feel anxiety by associating the long power outage of important equipment with the Fukushima Nuclear Accident on March 11th of 2011.

In addition to ensuring technical safety, we should be, henceforth, aware of troubles making Fukushima citizens feel anxious, explain their status and importance, announce progress in restoration work, and show expectations for completion timing accurately from earliest possible moment..

The timeline of the trouble and the public announcements is given in the following table. Ad-hoc press conference was held four times including the first one at 10:00 on March 19, in addition to the announcements in the table.

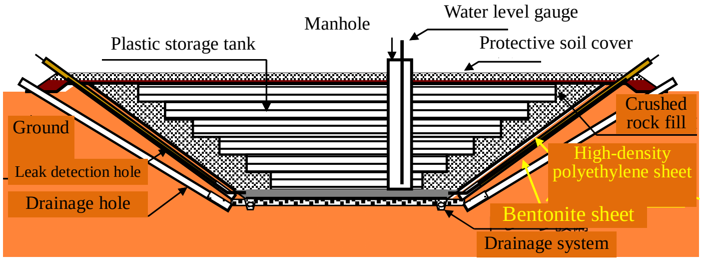
March 18	~18:57	Power outage occurred
	22:08	Announcement made that spent fuel pool cooling systems of Units 1, 3 and 4 had shut down.[12]
March 19	08:05	Announcement made that spent fuel pool cooling system of the common-use pool had shut down.
	13:42	Announcement made that the surveys for the systems' temporary power panels such as insulation resistance measurements had been continued since last night and that the panels were fixed at 9:03 and 10:01
	15:15	Announcement made that the Unit 1 spent fuel pool cooling system was restored at 14:20. Expectations for restorations of other cooling systems also announced.
	23:19	Announcement made that the Unit 3 and 4 spent fuel pool cooling systems were restored at 22:43 and 22:26.
March 20	00:56	Announcement made that the cooling system for the spent fuel common-use pool was restored at 0:12 (approximately 29 hours after the shut downs)
	13:48	Announcement made that soot was found at 12:36 covering terminals and walls of the Unit 3 & 4 temporary power panels, and TEPCO notified the firehouse at 12:45. (This was not fire according to the deliverance of firehouse)
	16:30	The fact that a carcass of a mouse was discovered at the bottom of the soot-covered power panel was explained at the press conference

[12] "Announcement" in this table means distribution of electronic mail to the media. The same contents have been posted on the TEPCO website since March 18.

B) Contaminated water leakage from underground water storage

Safety awareness

The specifications and location of the contaminated water storage are given depending on the various constraints such as project schedules and limitations on exposed worker dose and dose rate at the site boundary.



Structure of underground water storage tank

The leaked underground water storage was designed to use double layered high-density polyethylene sheet for water shielding with sheet joints carefully confirmed. It was, however, no experience of storing radioactive water in storage of such design.

The water to be stored was, therefore, limited by the original plan to the processed water using the multi-nuclide removal system. The only nuclide remaining in significant concentration in the processed water is tritium, which is easily diluted with groundwater even if leaked into underground soil. The leakage, thus, was thought to have no significant impact on the surrounding environment even if it had occurred.

However, completion of the multi-nuclide removal system was delayed while the storage capacity of steel tanks for the contaminated water was deficient, the plan was changed to store the water underground as the last resort. This decision was inevitable under unexpected delay of completion of the multi-nuclide removal system.

Nevertheless, we should have taken action since we had been aware of difficulty in early detection for the contaminated water leakage, and in retrievability of radioactive material that distributes into underground soil easily once released. We should have improved quality of oversight and swiftness of reporting consensually by defense-in-depth approach with high safety awareness, then, taken concrete risk reduction measures such as acceleration of the steel storage tank preparation project schedule for early transfer of the contaminated water from underground storage.

Technical capability

In preparation for leakage from the high-density polyethylene sheet, a bentonite sheet was bedded as a hazard for water penetration (though it does not have an ability to seal water), and a detection hole was created between the high-density polyethylene sheet and the bentonite sheet.

Nevertheless, since groundwater infiltration started from the outer surface of the bentonite sheet and it diffused into the detection hole, we could not find contaminated water leakage simply by the presence of water in the detection hole, but by concentrations of chlorine and other elements in the hole water, which was measured only weekly.

Water tightness of the underground water storage was confirmed prior to facility completion by the leak test that no significant variation in the readings of the water level gauge was found for the storage with clean water. Radioactive leakage, however, might trigger serious public reactions even if it is very small. We should have considered a probability that small leakage might not be detected by the gauge.

It was also pointed out that we were late in notification of variation in the gauge reading when it indicated a decline in the water level beginning in the middle of March. Though it was concluded later that the variation occurred due to gauge drift[13], we should have paid more attention to the gauge installed for leakage detection.

As mentioned above, taking into account the risk of unplanned storage of highly contaminated water and the difficulties arising in leakage detection from the underground water storage, we should promote the improvement of leakage detection measures and surveillance system, and enhancement of technical and organizational capability for performing countermeasures needed.

Dialogue skills

Since completion of the multi-nuclide removal system was delayed while the storage capacity of steel tanks for the contaminated water was deficient, the plan was changed to store the water underground as the last resort. The dose rate limitation of 1mSv/year at the site boundary due to additional radioactive releases also encouraged the use of the underground storage, which is a good distance from the boundary.

However, the dose rate at the site boundary was over 100mSv/year due to radioactive materials already widely emitted to the environments. It means that contribution of direct gamma ray suppression from the contaminated water and the debris stored on site to the dose at the site boundary is limited. On the other hand, the reduction of additional radioactive releases to the atmosphere and the ocean is important in order to prevent from further environmental contamination. Namely, restriction in allocation of the contaminated water storage facility contributed to the reduction of low-priority direct gamma ray from the tanks, but deteriorated the very highly prioritized reliability of contaminated water storage that resulted in radioactive leakage.

Based on the above reflection, we need to coordinate interests with the related stakeholders for matters with many constraints such as the contaminated water processing. For this purpose, it is important to share the idea of overall risk minimization and set a logical order of priority for the constraints through comprehensible and patient communication with regulatory authorities and people in Fukushima,

Similarly, implementing the investigation plan for the leakage and the retrieve plan for the contaminated ground soil, we should take into account the risks of secondary wastes and exposure dose of workers, and promote good communication with regulatory authorities and local governments.

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[13] Uncontrolled slow and continuous change of indication not by actual variations of measured objects. Observed under certain conditions.

C) Groundwater contamination with tritium and other substances distributed east of Unit 1 and 2 turbine buildings

Safety awareness

In April and May 2011, highly contaminated water flowed through the trench[14] and into the sea water intake of Units 2 and 3. The flow was stopped by filling waterglass in the water path. The contaminated water has been stored in the trench since then.

The contaminated water has been stored still and the radioactive concentration has been kept almost unchanged in contrast to the circulating water that is being decontaminated.

Presence of contaminated water in the trench, which was reported in detail in our accident investigation report published last June, was a publicly known risk. Comparing with the problems for which a special team was formed and assigned such as the leakage from horses and pipes of the circulating system, or the rush installment of storage tanks to compensate for the groundwater increase of approx. 400t per day, adequate efforts for concrete measures was not given for approx. 20,000 tons of contaminated water in the trench.

Although the risk of contaminated water in the trench was difficult to handle due to its large quantity and high radioactive level, the status of the circulating water gradually appeared so stable that we should have noticed that the chance came to prepare the concrete countermeasures by the ways like organizing priority reviews concerning the change of status and/or placing a manager generally taking charge of the matter in order not to keep neglecting the risk once regarded as low-priority just after the accident.

The Immediate Response Headquarters for Reliability Improvement at Fukushima Daiichi Nuclear Power Station was established in April. The headquarters examined potential risks of the station but didn’t care for the matter of highly contaminated water in the trench. The risk assessment aiming at systematic collection of all potential risks in the station, however, failed because there might be some weaknesses in the risk picking up processes.

Technical capability

The measure for the risk of contaminated water in the trench is the installation of the seaside groundwater shielding wall to be completed next year. The walls is made of steel pipe sheet-pile driven 780m in width located in front of water intakes of Units 1-4, and 30m in depth reaching the impermeable bed. The wall, which is designed to shield most of groundwater pouring into the sea, needs three years for construction.

For the contaminated water might leak into the sea before the wall construction completes, other measures such as the currently considered waterglass injection in the sea front areas between intakes or transfer and decontamination of the contaminated water in the trench should have been considered.

[14] Long narrow channel constructed underground for installing cables, pipes, etc.

Hereafter when we manage the difficult problems, we should not rely on only one absolute measure but consider second and third options flexibly even if they only mitigate the risk partially. There might be schedule delays and/or unexpected matters.

Dialogue skills

Though we primarily became aware that the concentration of tritium was high on May 31, the announcement was made on June 19 due to the following reasons:

・an unfamiliar nuclide, ruthenium, was detected and contamination of the sample was suspected
・it was necessary to assess as a set the results measured at high tide and low tide.
・there was a strong inclination toward prudently verifying the measured results due to fairly recent mistakes
・results measuring strontium-90 were identified on the morning of June 19
・we thought it necessary to provide an explanation accompanied by countermeasures,

There were weaknesses in inter-organizational collaboration, sharing of information on measurement and evaluation, and obsession with in-house ethical criteria. Moreover, attitudes to provide explanation proactively on one's own accord were not enough as a prerequisite for overcoming the above weaknesses.

For management of difficult issues such as highly contaminated water accumulated in the trench, expertise and competency in communication are inevitable to share risks and cooperate with regulatory authorities, local municipalities and other concerned organization.

[Conclusion]

In the aforementioned three cases involving an accident or problem, among the background factors, there are the three issues of "safety awareness," "technical capabilities" and "dialogue skills" which are derived from the root cause of insufficient advanced preparation for a severe accident or tsunami.

For safe decommissioning of severely damaged plants due to the Fukushima nuclear accident, we have to handle a variety of constraints. None of them are easy. Consequently, it is very important to raise safety awareness of the entire organization and to keep an eye on risks for their minimization. Top management and nuclear leaders keep trying to exercise even more leadership to raise safety awareness, and to relocate human resource and assign project managers to form cross-sectional projects for managing intractable risks.

We still find inadequacies in technical capability for on-site engineering. It is necessary to continue improving individual capabilities through in-house maintenance and emergency response training. Nuclear leaders will keep exercising leadership to accelerate further buildup of technical capability. Additionally, new technologies might be so unreliable at the time of introduction that technical capability is also required to gather knowledge of both internal and external parties and prepare for risks hiding behind them.

Furthermore, in circumstances where an order of priority must be given to multiple countermeasures, all TEPCO personnel from top management and nuclear leaders to site engineers have to have the ability to conduct a dialogue so as to sufficiently discuss the risks still retained within the station with regulatory authorities while at the same time sharing what people in Fukushima desire. Especially nuclear leaders and risk communicators take initiative and play important roles in this dialogue.

Therefore, "Countermeasure 1: Reform from Management," "Countermeasure 3: Enhancement of Ability to Propose Defense in Depth," "Countermeasure 4: Enhancement of Risk Communication Activities," and "Countermeasure 6: Reassessment of Non-Emergency Power Station Organization and Enhancement of Engineering Capability for Direct Management" will continue to be addressed in a prioritized manner and improvements made.

Based on the above situation as the accidents or problems have occurred, we need to further accelerate the nuclear reforms in addition to steadily implementing every part of the Nuclear Safety Reform Plan. We will also look back at the accidents and problems which have occurred during the period, confirm the appropriateness and degree of progress of the Nuclear Safety Reform Plan, and continue to make improvements.

Currently, under the Immediate Response Headquarters for Reliability Improvement at Fukushima Daiichi Nuclear Power Station (Headquarters Chief: President Hirose), risks involving equipment are being ascertained based on thorough field investigations and problems with operational management are being revealed so that countermeasures can be studied, the priority specified and adopted in a systematic manner. During this period, we have been able to prevent the actualization of risks related to equipment that should be handled in a prioritized manner, such as the risk of failure to inject cooling water into the reactor, and the risk management process is continuing to function effectively, and we will work to prevent the operational risks from being actualized as well as review the priority of the measures to counter each risk.

4. Status of Investigations into Unidentified or Unexplained Matters in the Fukushima Nuclear Accident

As part of the approach to unidentified and unexplained matters pertaining to the progression of the accident as well as the location, extent and cause of accompanying damage, additional analysis and reassessment of existing records, data and other evidence have been conducted along with field investigations, and it is the following results which have mainly been obtained.

- Estimation of status of core damage at Fukushima Daiichi NPS Units 1~3 (presented at a technical workshop held by the former Nuclear and Industrial Safety Agency on November 30, 2011)

  (The status of the containment vessels at Units 1~3 and the state of the dropped fuel which had been damaged and melt was estimated. (It was estimated that most of the fuel has dropped into the lower part of the containment vessel at Unit 1, and some of the fuel has dropped into the lower part of the containment vessel at Units 2 and 3.))

- Detailed analysis of the accident sequence at Units 1~3 using MAAP[15] (presented at a technical workshop held by the former Nuclear and Industrial Safety Agency on July 23 and 24, 2012)

  (An analysis was conducted based on estimates and information that had been revealed (operations performed by operators, estimates based on plant design data, etc.), and the plant behavior during the accident was recreated.)

- Various approaches to ascertaining plant status (presented at a technical workshop held by the former Nuclear and Industrial Safety Agency on July 23 and 24, 2012)

  (Based on the results of field investigations using robots and fiberscopes, the status of leaks from the pressure suppression chambers at Units 1~3 were estimated. (It was estimated that leaks have occurred from the pressure suppression chambers at Units 1 and 2, and that the pressure suppression chamber at Unit 3 is mostly sound.))

- Depressurization behavior of Fukushima Daiichi NPS Unit 3 (presented at meeting of the Atomic Energy Society of Japan on March 27, 2013)

  (Based on operational logic of reactor depressurization function and plant parameters at the time of the accident, it was estimated what sort of mechanism caused the rapid depressurization of the reactor at Unit 3 at the time of the accident (March 13, 2011).)

15 Modular Accident Analysis Program (an accident analysis code for severe accidents)

・ Status of investigations and reviews of the isolation condenser and loss of power at Fukushima Daiichi NPS Unit 1 (presented on May 10, 2013)

(When verification was made of the data remaining on the transient phenomena recording device which automatically detects the occurrence of abnormal events and collects data, it was confirmed that the Unit 1 emergency diesel generator had been operating until the function of the AC bus was lost due to tsunami (not damaged by earthquake).)

In addition, the presence of any damage to the Unit 1 isolation condenser has been confirmed in multiple field investigations and field investigations have also been conducted of the 4th floor of the Unit 4 reactor building (investigation into cause of Unit 4 explosion).

Investigating the side of isolation condenser unit at Unit 1 (October 18, 2011)

Investigation of condition of 4th floor of Unit 4 R/B
Floor surface has caved in, and it is estimated that the explosion occurred on the 4th floor.
(November 10, 2011)

In the future also, field investigations will be systematically conducted, including surveying the inside of the containment vessels using robots, industrial endoscopes and other tools, while attention is given so that important evidence is not lost in the decommissioning work.

The principal assessments and investigations concerning unidentified and unexplained matters examined by TEPCO are as follows.

・Quantity of cooling water injected into reactor pressure vessel by means of fire engines
・Assessment of extent of the interacting reaction between molten core and concrete
・Assessment of operating status of Unit 3 high-pressure cooling water injection system when reactor pressure fell
・Behavior of release of radioactive materials in responding to escalation of the accident
Etc.

Analyses and reassessments of existing records and other data as well as field investigations will continue to be used in an effort to clarify unidentified and unexplained matters, and these results will be announced. In addition, we will actively cooperate also with the Committee for the Accident Analysis on the Fukushima Daiichi NPS, which was established recently by the central government.

In Closing

As indicated in the Nuclear Safety Reform Plan, it is essential for us not only to severe the structural "negative chain[16]" that exists in our nuclear power departments, but also to push ahead more forcefully with efforts to overcome laxness in risk management among management as a whole and to correct the disparity between our overall corporate approach and standards for judgment and those of society.

At the first quarter, we have begun the implementation of countermeasures 1 and 2 for severing the "preconceived notion that safety has already been established," which is the starting point of the negative spiral, and for breaking away from insufficient safety awareness among management.

The resource for solving various subjects was supplied by the president's leadership, such as establishing "Immediate Response Headquarters for Reliability Improvement at Fukushima Daiichi Nuclear Power Station" promptly in response to the power outage caused by mice. The Nuclear Safety Oversight Office was established as an internal regulatory organization, and started to monitor and advise management and nuclear power departments. The Nuclear Safety Oversight Office will verify the changes in safety awareness against the situation in effect prior to and after the publication of our report and of our initiatives to increase nuclear safety by means of the nature of the discussions held in future by meetings of the Risk Management Committee and Nuclear Power Risk Management Committee.

On the other hand, accidents and problems have occurred indicating that our six measures are developing. We have rapidly conducted investigations in response to each individual incidents and made the necessary improvements, but in order to solve the factor which has led to such situations, we recognize that much more improvement of "technical capability" and "dialogue skills" is necessary for determination and review of the priority based on various constraints in our handling of the issues accompanying implementation of the Nuclear Safety Reform Plan and the risks faced by Fukushima Daiichi NPS.

Consequently management will exercise leadership on its own and reliably implement the nuclear safety reforms in order to accelerate further it. The Nuclear Reform Monitoring Committee will objectively assess the overall status of progress on the Nuclear Safety Reform Plan, and TEPCO will make improvements based on those results. In addition, we welcome any opinions or comments about these reforms and ask that you please visit our website to submit your views.

Lastly, as a nuclear power operator, we will continue to tackle nuclear safety reform based on our resolution that the "Fukushima nuclear accident will never be forgotten and we will be a nuclear operator that continues to create unparalleled safety and increase the level of safety to be higher today than yesterday and still higher tomorrow than today" so as to regain the trust of everyone in society and people in Fukushima.

[16] Refers to the fact that as a result of assuming that safety had already been ensured and identifying plant utilization rate and similar factors as the important management issues, we were insufficiently prepared for accidents, a sequence that we have expressed in the form of a chain. The Nuclear Safety Reform Plan specifies six measures ("scissors") which will enable us to cut this chain at multiple points simultaneously (see page 10).