November 2011

The Nuclear Safety and Quality Assurance Meeting's Accident Investigation Examination Committee's Opinion of the Tokyo Electric Power Company's "Fukushima Nuclear Accident Investigation Report (Midterm Report)"

1. Foreword

In order to investigate the accident that occurred at the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Daiichi NPS) as the result of the large earthquake and subsequent tsunami that struck eastern Japan on this past March 11, the Tokyo Electric Power Company (hereinafter referred to as, "TEPCO") established an internal Fukushima Nuclear Accident Investigation Committee as well as an Accident Investigation Examination Committee (hereinafter referred to as, "Examination Committee") for the purpose of providing opinions and advice from an objective standpoint as an expert third-party in regard to the aforementioned investigation.

We were asked by TEPCO to serve on this Examination Committee. Whereas it is important for TEPCO to refer to the opinions of third-parties while conducting their accident investigation and compiling their report, we all decided as individuals to cooperate with this effort.

This accident has affected the lives of a multitude of people as well as the society of not only Japan but the rest of the world, and it has yet to be resolved. All of the members of the Examination Committee would like to offer their sincerest sympathies for the victims of this tragedy. Moreover, members of the Examination Committee who are directly involved with nuclear energy, tsunami, and safety issues, would like to offer their deepest apologies for the events that occurred.

In addition to meeting several times as a Committee and also participating in smaller group discussions, committee members have also exchanged opinions in the field and conducted on-site investigations. From the initial stages of drafting this report, we have considered the positioning of this report as well as the importance and impact of that positioning. We are also aware that this document has historical significance and must bear the burden of time, and have therefore, adopted the following policy in regard to writing this report.

- Facts are to be presented straightforwardly, accurately, and in an easy-to-understand manner
- Predictions and presumption may be included in the course of analyzing the events that unfolded, but in these cases, background information and evidence that supports the conclusions shall also be mentioned.
- Arbitrary or intentional statements that are advantageous to TEPCO shall be avoided.

The reactor condition has yet to achieve total cold shutdown and the accident continues to this day. There is no telling how the reactor conditions may change in the days to come. Accordingly, the contents of this report may change as the situation develops in the future. We would also like to make it clear that the report that has been examined is only a midterm report and only covers a portion of the events that occurred during the accident.

2. The role of the Examination Committee and its point of view

The Examination Committee is comprised of the following members and its role is as follows:

(1) Examination Committee Members (field of expertise is in parentheses)

Chairman:	Genki Yagawa	Professor Emeritus, University of Tokyo (Nuclear Energy)
Members:	Yuriko Inubushi	Vice Chair, Consumption Science Federation (Consumption Science)
	Takeshi Kohno	Professor, Law Department, Keio University (Politics)
	Nobuo Shuto	Professor Emeritus, Tohoku University (Tsunami)
	Yoshihisa Takakura	Tohoku Radiological Science Center (Nuclear Energy)
	Hideki Nakagome	Attorney at Lawyer (Law)
	Masao Mukaidono	Professor, Science and Engineering Dept., Meiji University (Safety)

(2) Examination Committee Role

The Examination Committee was established on June 11, 2011, under the supervision of the "Nuclear Safety and Quality Assurance Meeting" that was established in December 2002.

The Examination Committee shall give opinions and advice from an objective perspective as an expert third-party in regard to the investigation conducted by the Fukushima Nuclear Accident Investigation Committee.

(3) Examination Viewpoint

The Examination Committee has examined all details of TEPCO's investigation from mainly the following four viewpoints:

1) Were the methods for investigation and examination appropriate?
2) Are the facts presented based on objective evidence?
3) Were the details of the investigation adequate?
4) Are explanations easy-to-understand for third parties?

(4) Scope of Examination

The Fukushima Nuclear Accident Investigation Report (midterm report) is separated into a main report (including attachments) and a separate report. We confirmed that the separate report focuses in on, and provides further details for, some items mentioned in the main report, but whereas it also includes items not directly related to equipment issues and recurrence prevention measures, the Examination Committee has limited the scope of its investigation to the main report excluding the separate report.

(5) Examination Method

In examining the accident investigation, explanations from the Fukushima Nuclear Accident Investigation Committee were heard during the first four meetings of the Examination Committee that discussed the investigation and the details of the examination. The Site Superintendents from Fukushima Daiichi NPS, Fukushima Daini Nuclear Power Station, and Kashiwazaki-Kariwa Nuclear Power Station attended all of the Examination Committee meetings.

Furthermore, in July an on-site investigation was conducted at the Fukushima Daiichi NPS.

The items discussed by the Examination Committee during each meeting and the details of the on-site investigation that was implemented are as follows:

1) Outline of Committee Meetings

・June 15, 2011: 1st Examination Committee Meeting

Discussion of Fukushima Nuclear Power Station outline, earthquake/tsunami status, damage caused by the earthquake/tsunami.

・August 3, 2011: 2nd Examination Committee Meeting

Discussion of initial response, accident response and plant behavior after the tsunami arrival.

・September 22, 2011: 3rd Examination Committee Meeting

Discussion of plant hydrogen explosion evaluation, accident analysis and issue extraction, future countermeasures based on accident causes.

・November 10, 2011: 4th Examination Committee Meeting

Discussion of Fukushima Nuclear Accident Investigation Draft Report (midterm report).

In addition, several separate meetings were held in order to explain details and engage in Q&A.

2) On-site Investigation

・July 8, 2011: Fukushima Daiichi NPS Investigation

The Emergency Operation Room within the seismic isolated building, the outer appearance of the reactor buildings for Units 1 to 4, yard equipment for Units 5 and 6, and the offsite power sources (fallen power transmission towers) were observed. Furthermore, opinions were exchanged with the Fukushima Daiichi Nuclear Power Site Superintendent (hereinafter referred to as, “Site Superintendent”) in the seismic isolated building.

3. Opinions of the Examination Committee

In examining the accident investigation, we particularly focused on the safety measures that were in place prior to the earthquake, and how the functions of “Shutting down,” “Cooling down,” and “Confining inside,” which are important for nuclear power station safety, were affected by the earthquake and tsunami. These two points have been separated into items (1) through (7) below, along with additional items (8) Recommendations for Future Countermeasures and (9) others, to which the following comments pertain.

(1) The Impact of the Earthquake on Power Station Facilities

TEPCO has stated that it "analyzed how equipment shook by using seismic observation records and evaluating various records, such as power station operation data from the occurrence of the Great East Japan Earthquake until the tsunami arrived, and performed a visual inspection of as much equipment as possible, including Units 5 and 6 that experienced seismic motion of the same magnitude as Units 1 to 4. Results showed that no abnormal activity was seen in the records. Furthermore, whereas some seismic observation values exceeded the maximum responsive acceleration for design-basis earthquake ground motion (Ss), it has been deemed that equipment important for reactor safety continued to function safely immediately after the earthquake since seismic observation values fell within the anti-quake evaluation standards for primary equipment with functions vital for safety."

The Examination Committee used photographs and video of facilities taken by TEPCO to confirm the above statement and confirmed that TEPCO conducted its investigation based on objective proof and analysis. As a result, at the current time, we deemed that there is no fact to support that important components were affected by the earthquake.

Furthermore, we believe that it is necessary to confirm the state of equipment that cannot be visually inspected at present due to the effects of radiation from the accident as well as contaminated water that has accumulated within the power station reactor building, and that such confirmation should be made as the environment improves.

(2) Operation Status of the Unit 1 Isolation Condenser (IC)

TEPCO has presented data for Unit 1 reactor pressure and the reactor water level and explained that "from between 14:52 and 15:30 on March 11, both pressure and water levels rose and fell three times. The reason for this is that operators were controlling and operating the IC in accordance with procedures that restrict temperature drops over one hour to within 55 degrees C in order to prevent compromising vessel soundness as the result of rapid temperature changes of the reactor pressure vessel."

The Examination Committee has deemed that the above operations conducted in accordance with procedures were adequate.

Furthermore, there are some that question why the IC was not continually operated in order to continue to cool the fuel. However, since the large tsunami warning that was issued for the Fukushima coast initially predicted that the tsunami would be no more than 3-meters high, no one could have imagined and predicted that water would flood the primary building area and render the IC inoperable.

Thereafter, based on TEPCO's evaluation of data and MAAP analysis, the function to cool the steam within the Unit 1 reactor was lost when the IC valve automatically closed as a result of loss of DC power immediately after the tsunami. TEPCO admits that as a result, the quick drop in water level caused by heat (decay heat) generated from the fuel was the cause of the fuel damage.

Furthermore, in regard to the IC operation status, the Site Superintendent who took command at the seismic isolated building when the accident occurred has conveyed to the Examination Committee that he was not able to communicate sufficiently with the main control room (MCR) where the operation was controlled. In a chaotic situation where the tsunami caused a loss of monitoring function at the plants and six plants needed to be dealt with simultaneously, the communication tools available for the MCR were limited to two telephone lines. A method for sharing information is a major issue to be resolved in the future.

(3) Primary Containment Vessel Venting

TEPCO has reported of the following in regards to the venting of Units 1 to 3.

"・While the Unit 1 water level gauge, which was restored at 21:19 on March 11, indicated that the water was above the top of the fuel, primary containment vessel pressure could not be confirmed until 23:50. The Site Superintendent ordered at 0:06 on March 12 that Unit 1 venting preparation begin after which venting preparation, such as confirming the order of operation of vent valves and assessing exposure dose in the surrounding area during venting, proceeded. At 9:02 on the same day, it was confirmed that surrounding residents had evacuated and at 9:04 operators headed to the area where the valve was installed and opened the motor operated valves in accordance with the procedures. After that, attempts in the area were made to open the air operated valves, but dose levels in the area made operation impossible so a temporary air compressor was procured, installed, and started up, and venting was implemented at 14:30 on the same day.

・The Site Superintendent ordered at 10:15 on March 13 that Unit 2 be vented, and even though a vent line had been configured, venting performance could not be confirmed. However, dry well pressure dropped for some reason at 11:25 on March 15.
・At Unit 3, after the high pressure coolant injection system stopped, the Site Superintendent ordered at 5:15 on March 13 that the vent line be completed. At 8:41 on the same day, the vent line was completed and venting began at 9:24."

The Examination Committee affirms that the Station General Manager was aware of primary containment vessel venting for Units 1 to 3, except Unit 4, which was in refueling outage, since Units 1 to 4 lost power, and has confirmed that the Site Superintendent gave detailed instructions to vent the primary containment vessels when the Unit 1 primary containment vessel pressure was identified as relatively high, and for Units 2 and 3 at the early stages.

In regard to the venting of Units 1 to 3, manual venting procedures and methods were examined in the MCR and emergency operation room, and various ingenuities were applied in the struggle to open the vent valves. Despite exhausting efforts at the site, the venting operation, in fact, took time. In light of the accident that occurred, we feel that there should have been detailed procedures and methods in place to handle the event of a total power loss.

(4) Depressurization and Cooling Water Injection

TEPCO has reported the following in regard to the depressurization and coolant injection of Units 1 to 3:

"・On March 11 at 17:12, the Site Superintendent ordered that the fire protection system and fire engine be used to examine/implement coolant injection methods for Units 1 and 2.
・At Unit 1 pressure decreased for some reason at 5:46 on March 12, so cooling water injection started into the reactor using a fire engine and the fire protection tank as a freshwater source, during which preparations were made to inject seawater, after which the injection of seawater using a fire engine commenced at 19:04 on the same day.
・At Unit 2, after the Site Superintendent ordered at 12:05 on March 13 that preparations be made to inject seawater, preparations continued; however, the seawater injection line's fire engine and hoses were damaged by the hydrogen

explosion that occurred at Unit 3 at around 11:00 on March 14, which forced all work to be done over.

- At Unit 3, whereas debris on the road that prevented movement of the fire engine was cleared and the fire engine was moved to a position that allowed injection of cooling water, the internal pressure of the reactor needed to be lowered below the output pressure of the fire engine. However, a power source needed to operate the valves could not be secured. Therefore, employees gathered car batteries from their personal vehicles to use as a drive power source for the valves, after which at around 9:08 on March 13, the valves were opened and rapid depressurization of the reactor ensued, thereby enabling the injection of coolant into the reactor at around 9:25. At 12:20 on March 13, the freshwater in the fire protection tank ran out, and seawater started to be injected into the reactor instead.
- As a result Units 1 to 3 suffered core damage.

The Examination Committee confirmed the status of the reactor buildings and the existence of countless debris during its inspection of the site in July and could easily imagine how work did not progress as easily as might have been anticipated. The Committee believes that the fuel damage that occurred at Units 2 and 3 was the result of time needed to prepare alternative cooling water injection due to various obstructions, such as a harsh working environment and loss of power.

The Site Superintendent's statement regarding the injection of seawater that “we thought our top priority was to get water into the reactor” conveys the sense of crisis at the site at that time that water needed to be injected into the reactor as quickly as possible. Taking into account the above facts that the orders to inject seawater were promptly issued together with such Site Superintendent’s statement, we find no evidence to suggest that there was any hesitation in injecting seawater.

However, in light of the accident that actually occurred, as mentioned in the section of venting procedures above, we feel that there should have been detailed procedures and methods in place to handle the event of a total loss of power.

(5) Cause of the Reactor Building Hydrogen Explosions

TEPCO has reported the following in regard to the cause of the hydrogen explosions:

“・Primary containment vessels are designed effectively to be injected with nitrogen and reduce the concentration of oxygen, thereby preventing hydrogen explosions. However, at Unit 1 hydrogen leaked into the reactor building that lies outside of the primary containment vessel and caused a hydrogen explosion. That was not foreseen.

・The cause of the hydrogen explosions in the Unit 1 and Unit 3 reactor buildings is assumed to be the leaking of hydrogen that generated from within the reactor due to fuel damage into the reactor building via some route.

・When investigating the state of contamination by radioactive materials attached to the filter for removing radioactive materials exhausting from the stack, it was found that gases, including hydrogen gas from the venting of the Unit 3 primary containment vessel, had infiltrated Unit 4 via the stack junction for Units 3 and 4, which in turn caused the hydrogen explosion at Unit 4.

・At Unit 2, since the pressure in the suppression chamber dropped around the time that a large shock was felt and heard, it had first been thought that an explosion occurred. However, according to the data from the temporary seismic instrument installed on power station’s ground, we do not believe that Unit 2 experienced an explosion. Incidentally, a reason that a hydrogen explosion did not occur at Unit 2 was that the blowout panel at the top floor of the Unit 2 reactor building was blown off by the explosion at Unit 1, thereby in effect ventilating the Unit 2 reactor building.

・In regard to Unit 3, various measures were deliberated and tools to open holes in the reactor building were being procured, but the explosion occurred before these tools arrived at the power station.”

The Examination Committee understands why the cause of the hydrogen leak at Units 1 and Unit 3 cannot be ascertained without inspecting the actual area.

Furthermore, the Examination Committee agreed that the assumptions made about the cause of the hydrogen explosion at Unit 4 and suspect of a hydrogen explosion occurred at Unit 2 are based on objective proof and are reasonable.

The Examination Committee has also confirmed that, after the hydrogen

explosion in the Unit 1 reactor building, TEPCO realized the possibility of a hydrogen explosion in Unit 3 and was procuring equipment to open holes, but was unable to do so in time, and the hydrogen explosion occurred in the Unit 3 reactor building.

Considering the fact that the impact of the hydrogen explosion was a major factor that made the subsequent countermeasures more difficult, although we can confirm that the measures to prevent the reactor containment vessel from exploding functioned, it is the Committee's opinion that the countermeasures were, as a result, insufficient.

(6) Tsunami Countermeasure Assessment

TEPCO stated that “in regard to tsunami countermeasure efforts, it had engaged in various tsunami countermeasures even after the establishing permit for the reactor was issued, such as assessing the estimated maximum size of a tsunami based on ‘Nuclear Power Station Tsunami Assessment Technology’ published by the Japan Society of Civil Engineers and implementing countermeasures.

Furthermore, even though TEPCO made an estimate regarding the tsunami assessment as a reference for deliberation based on the opinion of the Headquarters for Earthquake Research Promotion, a government research organization, and the proposals of researchers with respect to the Jogan Tsunami, this estimate was made in a situation where knowledge of wave source models, etc., had not been established, and TEPCO had asked experts to discuss the matter in order to establish wave source models for a tsunami that should be dealt with.”

The earthquake was an M9 and occurred by the linked movement of three areas, an area where an M8 earthquake was predicted as well as the areas to the north and south of this area. It is a fact that none of TEPCO, the government, or experts had predicted that such an earthquake could occur, and the tsunami that occurred was of a scale that transcended conventional knowledge.

The Examination Committee has deemed that TEPCO made every effort to be on the safe side when predicting tsunamis, such as examining the largest earthquake and tsunami possible based on the latest knowledge, comparing it with large tsunamis that occurred in the past, and choosing the larger of the two for tsunami countermeasure deliberation purposes. Compared with Japan's

Central Disaster Management Council, which uses earthquakes that have occurred repeatedly in the past as a basis for countermeasure deliberation, the efforts made by TEPCO were quite proactive.

However, as a result, damage from the tsunami this time was not prevented. In other words, more careful consideration should have been given to earthquakes and tsunamis, and, the country as a whole, including the government and experts must reflect deeply on this incident.

(7) Preparing Accident Management Measures

TEPCO reported the following in regard to the background of the accident management measures prepared between 1994 and 2002 as part of its effort to reduce the risk of nuclear disaster:

"・Accident Management was conducted based on "Accident Management as a Severe Accident Countermeasure for Light Water Reactor Facilities," which was decided by the Nuclear Safety Commission of Japan in May 1992, in response to the strong request of the Ministry of International Trade and Industry at that time that all business operators, including TEPCO, prepare such measures.

・During the planning stages and after preparation of the countermeasures, utilities reported the results to the Ministry of International Trade and Industry, which, in turn, reported them to the Nuclear Safety Commission of Japan.

・However, since this accident management did not assume a total and simultaneous loss of both AC and DC power, including that at neighboring units, most of the equipment and procedures that had been prepared were unusable, and the incident this time occurred."

The Examination Committee confirms that taking into account the background of the preparation of the aforementioned accident management measures, these measures were prepared substantively by the government together with utilities. However, the Committee has to evaluate the assumption made through accident management as being insufficient due to the fact that an accident, such as a total loss of power, had not been assumed.

The Committee would like to make an additional comment in regard to accident management, for example, that at Fukushima Daini Nuclear Power Station Unit 1, cooling water was able to be injected into the reactor using the make-up water system (condensed) that had been installed as an accident

management measure even though the reactor residual heat function had been lost when the seawater pump was rendered unusable due to flooding by the tsunami, because power was maintained. Therefore, in this instance, accident management functioned effectively.

(8) Recommendations for Future Countermeasures

TEPCO has stated that “the positioning of this report is being debated amidst the current deliberation on Japan’s nuclear power regulation, but it includes proposals for countermeasures necessary to contribute to improving the safety of existing nuclear power station's based on lessons learned from this event.”

In response to this, the Examination Committee offers the following opinions:

- During the deliberation of countermeasures as mentioned in the report, not only should countermeasures be devised for individual causes, but thought should also be given to worst-case scenarios, in other words, what to do in order to prevent the reactor from being damaged, and countermeasures should have greater applicability and mobility. However, in light of the lessons learned from this event, it is also important that equipment be designed to be automatically started for “shutdown” and “cooling” in the event of an accident.
- Much emphasis has been put on equipment countermeasures, but it is also important to imagine simultaneously occurring accidents at multiple units and engage in training under more harsh circumstances in an effort to improve worker response.

(9) Others

Opinions on other issues were exchanged as follows:

- Nuclear power station safety countermeasures placed much emphasis on equipment quality control and accident prevention and [the complexity of these measures] created a false sense of security. The question of “is this really safe?” was not sufficiently posed in regard to these countermeasures as a whole.
- The accident that occurred was of a scale of severity that no one had experienced. Even though problems for which there were no procedures had to be dealt with in the field immediately after the tsunami, and it took time to take

action as a result, when considering the harsh environment immediately following the disaster amidst which workers were forced to respond, the Committee feels that maximum effort was made. Work in the field continues within a harsh environment and the Committee would like TEPCO to continue to fulfill its responsibility with the support of the government and all involved.

- From the viewpoint of the rest of the world, what happened in Japan was inconceivable and the uneasiness that it has caused has led to a feeling of distrust. With this uneasiness the Examination Committee has reviewed this report from the points of view of whether the report is easy to understand, whether it has reported on all the facts without hiding anything, and whether it addresses the questions that people most want answered, in order to deepen the understanding of the rest of world in regard to this accident.

4. Conclusion

Needless to say, TEPCO must reflect seriously on the events of this large-scale accident. Particularly, while it has been pointed out from various quarters repeatedly that the time taken for the initial response is the factor of the accident and the expansion of the effects thereof, the Committee believes that such indication captures one aspect of the facts.

Through our inspection of the field and overall conclusion of the matter, the Committee deems it a fact that amidst a total power loss, pitch darkness, almost completely inoperable instrumentation, mountains of debris, loss of communications, aftershocks and the fear of death, there is no doubt that everyone was in the same position, regardless of who was giving orders and who was carrying them out. In particular, it is possible that without the almost literal, by-the-book response and decision-making carried out by the Fukushima Daiichi NPS Superintendent, TEPCO, and affiliated companies, the situation might have turned out much worse. We believe that respect is deserved.

The direct cause of this accident was an unprecedented tsunami. However, this Committee's conclusion is that, in light of the accident that occurred, the insufficiency of prior safety countermeasures that had been in place for the physical system and their management, including the accident management, caused the accident as well as its exacerbation.

In further looking back on this accident, we feel that an underlying cause of this incident was the creation of, and an inability to escape from, the “myth of

safety” among those involved in Japan’s nuclear power industry, including TEPCO, that a severe accident would not happen, which was the offspring of Japan’s self-confidence as a world leader in manufacturing.

End