Fukushima Nuclear Accident Investigation Report
(Interim Report – Supplementary Volume)

December 2, 2011

The Tokyo Electric Power Company, Inc.

Foreword

- As stated in the Fukushima Nuclear Accident Investigation Report (Interim Report) itself, our sympathies go out to all of the victims of the earthquake that occurred on March 11 of this year.

  We would also like to offer our deep apologies for the anxiety and inconveniences caused to the local residents around the power station, the citizens of Fukushima Prefecture, and the entire society due to the extremely serious accident at the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Daiichi NPS"), in which radioactive materials were released.

  We are continuing to put all of our effort into suppressing the discharge of radioactive materials and cooling the reactor at the Fukushima Daiichi NPS so as to enable evacuees to return to their homes as quickly as possible and to bring peace to the public.

- This Fukushima Nuclear Accident Analysis Report (Interim Report) organizes, evaluates, and analyzes the facts related to the damage to facilities caused by the tsunami, and the progression and development of the accident itself, while also deliberating mainly facilities countermeasures aimed at preventing a recurrence of such an accident.

  At the same time, in the process of investigating the series of accidents that occurred, many "independent factors" that are points of controversy were isolated.
  The items that are mentioned in the main report include details that focus on specific points of controversy. However, there are items that are not mentioned in the main report that should be made clear since they are attributing factors. These items have been organized and compiled in this separate interim report because they are important from the standpoint of accurately conveying all of the facts related to the accident.

- In particular, reference is made to "Preparation for Tsunami Countermeasures and Accident Management (AM) Procedures", "Plant Earthquake Impact Assessment", and "Organization of Independent Factors Based on the Timeline following the arrival of the Tsunami", etc., thereby indicating a different approach than that of the main report, which looks at the entire accident as a whole, in that each "independent factor" is looked out from a specific point of controversy.

- TEPCO has striven to reduce the risk of nuclear disasters from various points of view. However, as mentioned in the main report, the circumstances surrounding this accident far exceeded the existing framework of our efforts.

  In particular, almost all of the equipment and power sources that were expected to activate in response to an accident were rendered inoperable by the tsunami, which was one of the largest in the recorded history. Furthermore, since the systems and the procedures in place for responding to an accident were dependent upon the use of these equipment and power sources, it was extremely difficult to respond to the accident on site, with the workers being forced to respond flexibly to the changing situation. We regret that as a result we were unable to prevent the core damage.

- In this separate report we have compiled background information on the efforts that were engaged in for each item.

  While the interviews and discussions that were held at the Fukushima Daiichi NPS, the strenuous efforts of the workers at the power station became apparent. We have made mention of these efforts following the “Issues that became Clear during the Course of the Investigation”.

- We would also ask you to remember that this separate report is not something that the Fukushima Nuclear Accident Investigation Committee, which is a third-party consultation body, was consulted about, but rather a compilation of facts looked at from a point of view that differs from the main report.

  As with the main report, this report is based on the testimony of parties involved as well as information that could be gathered at the time. The investigation is ongoing and any new facts that come to light will be disclosed.

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[1]TEPCO's Tsunami Countermeasure Preparation and Tsunami Prediction Positioning

[Main Report 3.4 Tsunami evaluation (1) and (2)]

At 14:46 on March 11, 2011, the Tohoku-Chihou-Taiheiyo-Oki Earthquake with its epicenter at off-shore of Sanriku occurred, and the Fukushima Daiichi NPS was struck by a record-breaking tsunami.

TEPCO had tsunami countermeasures in place, but the scale of this tsunami far exceeded anything that had been predicted.

Some have commented that TEPCO had not taken appropriate tsunami countermeasures, even though TEPCO had envisioned the tsunami, pointing out that TEPCO had conducted a trial calculation, for the reference purpose of TEPCO's tsunami investigation, based on a supposition in reaction to assertions from earthquake research institutions.

However, even though TEPCO had deliberated various aspects of the investigations of tsunamis, the origins of these deliberations were simulations based only on hypothetical "wave sources," and there is no fact that suggests that these hypothetical tsunamis were regarded as an actual danger.

The following details the investigation into TEPCO's tsunami countermeasure preparation and confirmation of the positioning of such countermeasures.

[Tsunami Countermeasure Preparation]

- Each unit of the Fukushima Daiichi NPS obtained the establishing permit between 1966 and 1972. At the time there was no clear guideline for tsunamis so the units were designed based on past tsunami evidence. Therefore, the highest tidal level that had been observed at Onahama Port, which was observed following the Chile earthquake and tsunami of 1960, was used as a design condition. (O.P.* +3. 122m)

  * O.P.: Onahama Port construction standard level (0.727m below Tokyo-bay Mean Sea Level)

- Tsunamis were put forth as natural disasters that should be considered with the creation of the safety design review guidelines enacted in 1970 which referenced past records to require a design that could withstand the harshest of natural disasters. A government review was conducted based on these guidelines and the establishing permit was obtained as "the safe level is sufficient enough" to withstand a tidal level of the magnitude seen following the Chile earthquake and tsunami. The height of the tsunami that was written on the establishing permit remains unchanged to this day. However, as further discussed below, various opportunities were taken to assess tsunamis and the results of these assessments, including countermeasures, were reported to the government and ultimately used as actual design conditions.

- In February of 2002 the “Tsunami Assessment Methods for Nuclear Power Plants in Japan” which provided the first definitive tsunami assessment method in Japan was published by the Japan Society of Civil Engineers. This “Tsunami Assessment Method” has been used ever since in Japan by nuclear power stations to assess tsunamis.

  *1 According to the “Tsunami Assessment Methods”, a wave source model *2 is established for the largest tsunami that has been recorded in each tsunami region. Various numerical simulations that consider the uncertainty of position, direction, and angle, etc., of these wave source models are used to estimate the maximum size of the tsunami which is then in turn assessed.

  *2 Wave source model: Position, scale, displacement amount, etc., of an earthquake that generates a tsunami.

- Based on the assessment results of the height of a tsunami that may hit the Fukushima Daiichi NPS, tsunami level; O.P. + 5.4 to 5.7 m was delivered by “Tsunami Assessment Method”, and countermeasures, such as increasing the height of pump motors, were implemented in 2002. These assessment results were reported to, and confirmed by the government in March 2002.

- In June 2007, the tsunami estimate conducted by Fukushima Prefecture for disaster preparedness reasons was obtained, and it was confirmed that the tsunami height predicted by Fukushima Prefecture did not exceed TEPCO tsunami assessment results.

- In March 2008, tsunami wave sources were evaluated for disaster preparedness reasons in Ibaraki Prefecture, and it was confirmed that its tsunami height did not exceed TEPCO tsunami assessment results.

- In September 2006, the Seismic Design Review Guidelines were revised and instructions were given by the government to reconfirm anti-quake resistance based on the new guidelines (hereinafter referred to as, “Seismic Back Check”. During the seismic back check, geological surveys were conducted, and design-basis earthquake ground motion was created. After that anti-quake assessments were conducted on primary equipment all of which was reported to the government as the Interim report. In preparing a final report, tidal level observation data and the latest sea floor topography data were considered to reassess tsunami levels based on February 2009 “Tsunami Assessment Method” since it was deemed necessary to evaluate tsunamis as phenomena accompanying earthquakes in the final report.

  The tsunami level at Fukushima Daiichi NPS was calculated to be O.P. +5.4 to 6.1m and countermeasures for this tsunami height were implemented.

- As stated above, whereas tsunami assessment for Fukushima Daiichi is based on the “Tsunami Assessment Method” published by the Japan Society of Civil Engineers, independent action, such as confirmation based on the information regarding tsunamis compiled by the municipal government for disaster preparedness evaluations, had also been taken. In addition to this assessment, as knowledge and theories concerning tsunamis became available, independent action was taken to deliberate and investigate this information, including preparing estimates. As part of this action, the two estimations below were being deliberated, even though the knowledge, such as wave source models required for tsunami assessments, was still uncertain.

<1. Trial calculation based on the Meiji Sanriku-oki Earthquake (M8.3)>

- In July 2002, the Headquarters for Earthquake Research Promotion (hereinafter referred to as, “Earthquake Headquarters”), a government research institution, released a long-term earthquake assessment (hereinafter referred to as, “Earthquake Headquarters’ stance”) that said an earthquake could occur anywhere between the Sanriku Coast and the Bousou Coast. The earthquake headquarters’ stance was that an earthquake with a magnitude of approximately 8.2 could occur in regions that had not previously suffered a large earthquake in recorded history (namely, along the Japanese Coast from Fukushima to Bousou). However, even earthquake headquarters did not envision large-scale interlocking earthquakes like that which occurred. Furthermore, the wave source models, which are indispensable for evaluating earthquakes in regions that have not experienced large earthquakes in recorded history, were not indicated.

- Even the Japan Society of Civil Engineer’s “Tsunami Assessment Method” did not offer wave source models and did not consider the possibility of an earthquake occurring in this region.

- Meanwhile, the Japan Society of Civil Engineers had planned to deliberate on and assess methods based on probability theory as a new endeavor from FY2003. The Earthquake Headquarters’ stance was to be incorporated within this assessment method. Using the probabilistic method to assess tsunamis was a groundbreaking attempt, and TEPCO planned to watch the deliberations of the Japan Society of Civil Engineers closely. TEPCO had also performed an assessment in Fukushima as a case study for the purpose of applying this method and making improvements based on the deliberation results * of the Japan Society of Civil Engineer’s probabilistic assessment method. The results from a probabilistic assessment vary widely since the opinions of experts weighing in on the deliberation are also taken into account. Therefore, when actually conducting a probabilistic assessment, it is necessary to decide how to handle the results, including how to handle the assessment values (example: in the United States it is common to conduct the assessment of the probability over one year using the average value). TEPCO published a paper in 2006 that includes calculation examples.

* As mentioned in the conclusion of the paper on probabilistic assessment methods published by TEPCO, the probabilistic assessment method introduced at the time was still being developed and continued to be examined by the Japan Society of Civil Engineers between 2006 and 2008. However, at present time it has not been developed enough to be used for tsunami assessment, and has not passed the experimental analysis phase yet.

- Around April to May 2008, while it was being discussed internally how to handle the Earthquake Headquarters' stance in regard to future seismic safety evaluations (back checks), calculations were performed assuming a wave source model for the Meiji Sanriku-oki Earthquake (M8.3) as reference for deliberations. Since a large earthquake had never occurred along the Japan Trench off the coast of Fukushima. Therefore, the wave source from the Meiji Sanriku-oki Earthquake (M8.3) which is the most strict wave source for the Fukushima site when applied, was brought about along the Japan trench off the coast of Fukushima and used for the estimate to calculate the tsunami wave height. Estimate results for Fukushima Daiichi yielded a tsunami wave height of O.P. +8.4 to 10.2m and a flood height of 15.7m (* tsunami wave height on the south side of the site with the elevation being taken into consideration.)

- Around the summer of 2008, as a result of the deliberations on how to handle the Earthquake Headquarters' stance, TEPCO considered that the calculated estimates were mere assumptions with no actual basis for the reasons below and TEPCO decided to ask the Japan Society of Civil Engineers to examine the creation of actual wave source models for assessing tsunamis based on the Earthquake Headquarters' stance (The Japan Society of Civil Engineers has been examining this issue from FY2009, but has not established any wave source models for the Fukushima Coast yet):
  (1) The Japan Society of Civil Engineers' "Tsunami Assessment Method," which was adapted by electric company operators as the rule for assessing tsunamis, does not consider the generation of a tsunami along the sea trench off the coast of Fukushima; and
  (2) The wave source model to be assumed as a wave source of the tsunami has not been established.

- On March 7, 2011, (four days before the earthquake on March 11) the Nuclear Agency asked TEPCO to explain the recent actions to revamp the Earthquake Headquarters' long-term assessment, in response to which TEPCO submitted materials and offered an explanation on the above trail calculation results along with the status of tsunami assessment at TEPCO to the head of the Licensing Safety Review (of Nuclear Facilities) and investigators. During this meeting, TEPCO was not instructed to immediately implement countermeasures.

- Furthermore, the Central Disaster Preparedness Council, which is responsible for creating and promoting regional disaster preparedness plans and the country' basic disaster preparedness plan, had been examining past earthquakes but had not examined any earthquakes on the sea trench off the coast of Fukushima prefecture or Bousou since no large earthquakes had ever occurred in these areas. As a result, earthquake headquarters' stance had no relevance to actual disaster preparedness as far as the Central Disaster Preparedness Council was concerned. (The same goes for knowledge related to the Jogan Earthquake to be discussed later)

<2. Trail calculation based on the Jogan Earthquake (M8.4)>

- In October 2008, a thesis entitled "Numerical Simulations of the Jogan Tsunami of 869 A.D. for the Ishinomaki/Sendai Plains" by Prof. Satake of the National Institute of **A**dvanced **I**ndustrial **S**cience and **T**echnology (AIST) was received (prior to publication). The thesis stated that the scale and the generation point of the Jogan tsunami were uncertain (in other words, there were no wave source models) and proposed two wave source models, but to be certain it is necessary to conduct tsunami sediment survey of the coast of Fukushima prefecture.

- Even though the proposed wave source models were uncertain, the two wave source models proposed in the thesis were used for tsunami estimates in December of 2008. The result of the trial calculation for Fukushima Daiichi was a tsunami wave height of O.P. +8.6 to 8.9 m.

- In December 2008, a plan to implement tsunami sediment surveys was devised since tsunami sediment surveys of the Fukushima Prefecture caused were deemed necessary in the thesis by Professor Satake of the AIST.

- In April 2009, the thesis was officially published. As mentioned earlier, the aforementioned thesis include wave source models for the Jogan tsunami, but the wave source models were based on tsunami sediment survey results for Sendai plains and Ishinomaki plains, and the generation point and scale of the tsunami were uncertain. The thesis stated that to be certain it was necessary to conduct tsunami sediment surveys on the coast of Fukushima prefecture.

- In June 2009, the Japan Society of Civil Engineers was asked to examine the earthquake headquarters' stance and the wave models for the Jogan tsunami.

- In June 2009, it was pointed out by Okamura of the AIST, during the Earthquake/Tsunami, Geology/Soil Joint WG (a government council to examine anti-quake back checks) of the Anti-Quake/ Structural Design Subcommittee of the Advisory Committee on Energy and Natural Resources' Nuclear Safety/Security Task

Force, that it is necessary to examine the Jogan Earthquake (from the perspective of tsunami assessment).

- TEPCO's Interim report on seismic assessment was examined by this WG, but no mention of tsunamis was made in the Interim report since tsunami assessment was to be discussed in the final report. Furthermore, the Nuclear and Industrial Safety Agency (NISA) had responded to TEPCO that "this WG is for examining the Interim report related to seismic assessment, and tsunami assessment should be included in the final report".

- In July 2009, the NISA deemed that the Interim report's assessment of seismic safety for Fukushima Daiichi Unit 5 and Fukushima Daiichi Unit 4 was adequate. In the report from the NISA it stated that, "based on the fact that surveys and research on tsunami sediment and tsunami wave sources related to the 869 Jogan Earthquake are currently underway at research institutions, it is the position of the NISA that operators should take appropriate action as suitable based on the results of the aforementioned research institutions from the perspective of tsunami assessment and seismic movement assessment".

- The status of consideration of the Jogan tsunami was submitted and explained to investigators in August 2009, and the assessment results for tsunami height was submitted and explained to the head of the Licensing Safety Review (of Nuclear Facilities) and investigators in September of the same year, upon request from the NISA (on March 7, 2011, a tsunami wave height of O.P. +8.7~9.2 m obtained by changing methods for considering high tide levels was explained once again in conjunction with the Earthquake Headquarters' stance).

- In the winter of FY2009 (agricultural off-season), a tsunami sediment survey was conducted on the coast of Fukushima Prefecture and sediment deposited by the Jogan tsunami was found at an elevation of approximately 4m in the northern part of Fukushima Prefecture, however in the southern part of Fukushima Prefecture (Tomioka to Iwaki) tsunami sediment was not found. Furthermore, it was determined that further surveys and research would be necessary to create accurate wave sources since the results of the tsunami sediment surveys did not match the proposed wave source models.

- The sediment survey results were published in January 2011 and announced at the Japan Geoscience Union Conference 2011 held in May 2011.

- Furthermore, the epicenter and scale of the Jogan tsunami (wave source model) have still yet to be determined.

[2] TEPCO's Effort regarding Jogan Earthquake and Joint Working Group's (*) Opinion

[Main Report 3.4(2) Statements from related organizations regarding the tsunami and associated TEPCO's responses]

(*) Earthquake/Tsunami, Geology/Soil Joint WG, Anti-Quake/Structural Design Subcommittee, Nuclear Safety/Security Task Force, Advisory Committee on Energy and Natural Resources

In recent years new opinions have been made in regard to the Jogan Earthquake. Furthermore, in the government's deliberation council (joint working group) members pointed out various things related to the Jogan Earthquake in TEPCO's Interim report. It was pointed out after the March 11 earthquake that even though the Jogan tsunami was pointed out to TEPCO, TEPCO refused to take into account and did not deliberate countermeasures.

Therefore, we would like to mention of the results of investigations into the efforts regarding the Jogan tsunami in which TEPCO engaged.

<u>[Efforts regarding the Jogan Tsunami]</u>

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[3] Background Preparation of Accident Management Measures

[Main Report 4.4 Preparation for accident management;
4.5 Accident management measures and the Fukushima accident]

As mentioned in Chapter 4 Accident Management Preparation of the main report, TEPCO has continued to strive to improve safety through continual improvements, such as by reflecting accurate design, operation and progressively obtained knowledge [in accident management], in an effort to reduce the risk of nuclear disaster.

As part of these efforts, accident management measures were prepared to improve safety in the wake of the Three Mile Island (TMI) and Chernobyl accidents. It has been pointed out that since the accident management measures created between 1994 and 2002 were developed independently by TEPCO they lacked sufficient deliberation and development and were not suitable for handling the accident.

In the process of ascertaining the causes of the accident and the background behind development of these accident management measures were investigated. The following is a summary of the measures in which TEPCO engaged.

[Background Preparation of Accident Management Measures]

- TEPCO has been independently engaged in the deliberations and preparations of accident management, but as noted below, these deliberations and preparations have been made upon confirmation from and evaluation by the government.

<<Presentation of Policies related to Accident Management>>

- In May 1992, the Nuclear Safety Commission of Japan decided that “accident management be used as a severe accident countermeasure at light water reactors used for power generation”, and strongly encouraged utilities to prepare Accident Management (AM). It would also obtain reports from the government has needed in regard to actual plans and measures.

Fundamental thinking about AM preparation (as decided by the Nuclear Safety Commission of Japan)

- The safety of reactor facilities is sufficiently ensured by strict safety measures based on the idea of defense in depth, i.e., (1) preventing abnormalities from occurring, (2) preventing abnormalities and accidents from escalating, and (3) preventing abnormal discharge of radioactive materials during the design, construction and operation stages while abiding by current safety regulations.
- It has been deemed that these countermeasures have sufficiently lowered reactor facility risk and the possibility of an accident that could realistically occur from an engineering standpoint is so small that it’s unthinkable.
- Accident Management preparation is positioned to further alleviates this low risk.

- Therefore, the members of this Commission strongly recommend that reactor builders independently develop Accident Management so that they can precisely implement such measures in the slight chance that an accident occurs.
- The implementation of Accident Management is possible without largely altering reactor facility equipment, and its implementation is recommended and expected due to the effective reduction of risk that can be achieved.

- In July 1992, the former Ministry of International Trade & Industry (MITI) strongly urged utilities to prepare AM. Utilities would provide reports on the details of such AM which would be evaluated for adequacy by MITI.

<< Confirming the Suitability of Accident Management Plans>>

- In March 1994 TEPCO submitted reports on the deliberation results regarding AM development for each TEPCO nuclear power station unit to the former MITI.

  The following functions were selected for deliberation in order to further improvement of the safety:
  - Alternative cooling water injection methods (the make up water system (condensed) (MUWC)), mechanism for injecting cooling water into the reactor from a fire pump)
  - Residual heat removing methods from the PCV (pressure hardened vents)
  - Power supply methods (sharing power source from neighbor plants)

- In October 1994 the former MITI deemed that the functions selected by the utilities and the AM measures reported on were adequate, and reported such findings to the Nuclear Safety Commission of Japan. It urged that AM be prepared within six years and asked that the status of preparation be reported on when appropriate, including those items that did not require authorization.

<< Accident Management Preparation Result Report>>

- In December 1995 the Nuclear Safety Commission of Japan deemed that the report from the former MITI was suitable (that operator’s AM measures were suitable).

- Thereafter, utilities (including TEPCO) prepared AM, such as by renovating equipment, and submitted a report on the preparation status and effectiveness evaluation to NISA following installation (May 2002).

  NISA deemed the reports from operators to be adequate and reported the results to the Nuclear Safety Commission of Japan.

<< Accident Management Preparation Effectiveness>>

- The direct cause of the accident that occurred at the Fukushima Daiichi NPS was the tsunami, the scale of which greatly exceeded anything that TEPCO had envisioned, and the tsunami rendered almost all equipment that was expected to be used for an Accident Management response inoperable. Such conditions surrounding the accident greatly exceeded the existing framework for dealing with an accident, and as a result, workers were unable to keep up with the escalating emergency, leading to the core damage.

- However, while all the pumps that had been installed at the plant were inoperable, the fire engine, which had been deployed on site due to lessons learned from the Chuetsu-oki Earthquake, wound up being the only way to inject cooling water into the reactor and contribute to stabilizing the situation. Using a fire engine to inject cooling water into the reactor was in effect using an injection line from the fire protection system (FP), which was one of the AM measures implemented over the 14 years from 1994. Even though this accident greatly exceeded the assumptions of AM measures that had been prepared, the procedures and training that had been implemented as part of AM measure preparation led to an increase in knowledge which enabled action.

- Furthermore, the newly built seismic isolated building (Emergency Operation Room earthquake-proofing), which was born from the lessons learned from the Chuetsu-oki Earthquake, withstood the 6-strong earthquake and became the front line citadel while contamination was spilling into the atmosphere and surrounding radiation levels were rising.

- Furthermore, the tsunami that struck the Fukushima Daini Nuclear Power Station was much smaller than that of the tsunami at the Fukushima Daiichi NPS and did not cause the plant to lose power thereby enabling the aforementioned AM measures to function and prevent a serious accident, which contributed to plant stability.

[4] Concerned Issues and Improvement Measures of the Mark I Primary Containment Vessel

Since the Fukushima Daiichi NPS accident, some have been pointed out that the Mark I PCV had problems and this containment vessel was the cause of the accident. It is true that there have been issues in the past, but these issues have been dealt with in various ways. The facts related to these countermeasures are stated below.

[Facts found]

- PCV volume: It has been pointed out that the Mark I PCV is small and that if steam is leaked into the PCV due to incidents such as broken pipes, the pressure rises quickly, and a problem can occur easily.

  - BWR adapts PCV of pressure suppression type that suppresses pressure rises by forcing the steam (released into the vessel due to incidents such as broken pipes) through the water pool in the suppression chamber (S/C) [inside the PCV] and thereby condensing it, which itself is not an issue.
  - Both the Mark I and Mark II PCVs are the pressure suppression type and are designed to have a direct correlation between volume and output.
  - According to the volume-power ratio, as an appropriate index for comparing the relative sizes, the Mark I and Mark II vessels are almost the same, and hence, the Mark I is not particularly small.

Table: Primary containment vessel volume - reactor power ratio

Reactor	1F-1	1F-2~5	1F-6, 2F-1	2F-2~4	KK-6/7(reference)
Primary containment vessel	Mark I	Mark I	Mark II	Mark II advanced	RCCV
Volume-Power ratio *1, *2	Approx. 4.4	Approx. 3.1	Approx. 3.0	Approx. 4.3	Approx. 3.4

*1: Values are calculated as follows: primary containment vessel volume [m3]/reactor heat power [MWt].

*2: Reactor heat power values were taken from the application documents for the Establishing Permit. Primary containment vessel volume was taken from the sum of the volume of the dry well (D/W, including vent pipes) and the volume of S/C space as stated on the attachment 8 to the application documents for the Establishing Permit.

- Mark I PCV performance improvements (vents)

  - The US Nuclear Regulatory Agency (NRC) has stated that installing pressure hardened vents to the Mark I PCV is effective for reducing the risk of core damage. In Japan, probabilistic safety assessments were conducted to confirm the effectiveness of pressure hardened vents for preventing core damage and reducing impacts, and to examine the viability of actual installation, and such vents were installed on equipment including the Mark II PCV.

- Load on the S/C during an accident (a comment pointing out that the unexpected load would be placed when the steam from the reactor is quenched into the S/C for depressurization)

  - While the Mark III PCV was developed in the U.S, the load that is generated when the high pressure steam generated due to incidents such as broken pipes is quenched into the S/C became an issue, and therefore, the countermeasure was adopted (equipment that reduces the dynamic load from steam quenching: quencher direction, an installed device that disperses the steam equally in four directions instead of one.)
  - The same countermeasures were implemented in Japan based on the US countermeasures. The examination with respect to this load has been compiled in the guideline issued by the Nuclear Safety Commission of Japan, "Evaluation Guidelines for Dynamic Load on the BWR. Mark I PCV's Suppression System" (the guideline for Mark II that is equivalent to this guideline has also been compiled).

- Measures to prevent hydrogen explosions inside the PCV during an accident (a comment pointing out that the size of the Mark I PCV is small, and therefore, the concentration level causing the hydrogen explosion can be easily achieved inside the PCV)

  - The measures have been taken to prevent combustion and explosions inside the PCV, even in the event that a large amount of hydrogen is generated, by injecting Nitrogen into the PCV and thereby controlling the oxygen concentration below a certain level.
  - The Flammability Control System (FCS), which is designed to heat up and recombine hydrogen and oxygen to suppress concentration levels in the PCV after an accident, is installed in the reactor building.

[5] Plant Earthquake Impact Assessment

[Main Report 6.4 Assessment of the impact on facilities by the earthquake]

The Great East Japan Earthquake that occurred on March 11, 2011 was an inter-plate earthquake with a magnitude of 9.0, the largest to have ever struck Japan.

The seismic motion from this earthquake was approximately the same as that envisioned during the seismic assessment of equipment at the Fukushima Daiichi NPS, but it has been pointed out that it is likely that important safety-related equipment at the power station was damaged by the earthquake. Therefore, the actual scale of the impact that the earthquake had has been evaluated as mentioned below.

[Assessment using Plant Parameters]

- Plant parameters recorded an chart recorder, alarm logger, ,transient recorder in addition to operator records, are limited because devices lost power as a result of the tsunami, however many of these parameters indicate the status of the plant up until the tsunami and are therefore extremely important in evaluating the soundness of the facility.

- According to these parameters it has been deemed that major equipment, such as high pressure coolant injection equipment (isolation condenser (IC), reactor core isolation cooling system (RCIC), etc.) etc., was working immediately after the earthquake and not showing any particular abnormalities. In addition, as mentioned below, there were no abnormalities with piping soundness, etc.

  - In Units 1 to 3 an isolation signal caused by the rupture of main steam pipes was sent around the time that the main steam isolation valve (MSIV) was closed, but according to data from the transient recorder, closure of the MSIV resulted in a main steam flow of 0 (zero), and evidence to support that there was an increase in steam flow due to a pipe rupture was not found.
    Therefore, it is assumed that the isolation signal was sent not because the main steam pipe ruptured due to the earthquake but rather because instrumentation power was lost from the loss of an off-site power source.
  - Temperature changes on the ventilation system of the PCV after the reactor scrammed until the loss of instrumentation power, show small and a trend to saturate after rising several tens of degrees C. Therefore there was no indication that pipes ruptured within the PCV.
  - At Unit 3, after the high pressure coolant injection system (HPCI) started up, reactor pressure reduced from approximately 7 MPa to approximately 1 MPa, but interviews with operators revealed that no abnormalities were seen in the HPCI room. Therefore it is unlikely that a leak occurred from the steam pipes of the HPCI The reason that the reactor pressure change has been assumed that because the

HPCI (steam driven), which draws in and consumes a lot of steam from the reactor in order to drive the turbine, was operated continuously.

[Results of Seismic Response Analysis Using Observation Data]

- The seismic impact that the Tohoku-Chihou-Taiheiyou-Oki Earthquake had on the safety related equipment and piping systems was assessed by comparing response load and response acceleration obtained from seismic response analysis. The analysis couples the seismic response analysis of the reactor building with large components, such as the reactor building and the reactor, with seismic load obtained from seismic response analysis which utilizes design-basis of earthquake ground motion Ss.

- A seismic evaluation of the safety related equipment was implemented if the seismic load obtained from seismic response analysis during this examination exceeded the seismic load obtained from seismic response analysis that utilizes design basis of earthquake ground motion Ss.

- As a result, since all of the calculated seismic evaluation values for the major equipment responsible for the important safety functions with respect to “Shutting down” and “Cooling down” of the reactor and “Confining inside” for nuclear materials were below the evaluation standard values, it is concluded that the functionality of these equipment was not affected by the earthquake.

  Further, since these evaluation results match the current analysis results of plant behavior following the earthquake, it can be said that the major equipment responsible for the important safety functions was in the condition that allowed these equipment to maintain the safety functions required during and immediately following the earthquake.

[Results of a Visual Inspection of Power Station Facility]

- Equipment located in the field outside Units 1 to 4 that were categorized in low seismic class, might be impacted by the earthquake, such as leaking water, but the main cause of damage was the tsunami and hardly any evidence of damage from the earthquake that would affect functionality was found.

  Furthermore, a visual inspection was conducted in the turbine buildings of Units 1 to 3. (not in the reactor building due to highly radioactive area), and the equipment in the reactor building and turbine buildings of Units 5 and 6 revealed hardly any damage from the earthquake to low seismic class equipment that would affect functionality and no damage by the earthquake to major equipment that is safety related equipment.

- A visual inspection of the IC in the Unit 1 reactor building was conducted. Though some insulation had fallen off on the body due to most likely the hydrogen explosions, no damage that would cause a loss of cooling water to the unit body, major piping or major valves was found.

- In addition to equipment currently being used, the operability of some equipment for Units 5 and 6 has been confirmed through the surveillance and test runs. There were some events caused by the tsunami such as small diameter pipes connected to the motors were ruptured and the axle bearings were tainted with sand, but these items are now operational after replacing the motors and axle bearings. However, no evidence was identified that functionality was lost due to damage caused by the earthquake.

- In conclusion, no damage not only the safety related equipment, but low seismic class equipment was not of the magnitude to impact functionality.

[6] Details on the Workers' Deaths at Fukushima Daiichi Nuclear Power Station Unit 4

After the Tohoku-Chihou-Taiheiyou-Oki Earthquake occurred off the coast of Sanriku at 14:46 on March 11, 2011, the Fukushima Daiichi NPS was engulfed by a record-breaking tsunami.

Two TEPCO employees were swept up in the tsunami and perished in the line of duty.

On April 3, 2011, Chairman Katsumata released a statement regarding the loss of these venerable employees. This statement has been reproduced below along with the facts surrounding this incident that are known at present time.

[Chairman's Statement]

We feel deep remorse for the two young workers that sacrificed their lives trying to protect the safety of the power station even when engulfed by the earthquake and tsunami. I would like to offer my prayers for these victims and the deepest sympathies for the loved ones they left behind.

Tokyo Electric vows never to let a tragedy such as this happen again and is doing its best to bring the accident at the Fukushima Daiichi NPS under control. May you rest in peace.

[Facts found surrounding the incident that are currently known]

- Immediately after the earthquake struck (at 14:46 on March 11) the main control rooms (MCRs) for Units 3 and 4 paged auxiliary unit shift workers (six workers) and instructed them to evacuate to the operator waiting room near the entryway to the controlled area within the service building.

- During approximately 30 minutes following the earthquake, operators, including the two victims, helped to evacuate workers in the field from the controlled area.

- Eight operators evacuated to the operator waiting room. All operators, including the aforementioned two victims, contacted and confirmed their safety with the MCR.

- Emergency shutdown of Unit 3 (at 14:47)
  Surge tank level low signal of the turbine auxiliary cooling system is confirmed in the MCR

- The MCR ordered the operators to investigate.
  Three pairs of two operators (six operators in total) left the operator waiting room and headed to the basement, first floor, and second floor of the turbine building to investigate. The two victims headed to the basement of the turbine building in order to

check on the surge tank level of the turbine auxiliary cooling system.

While field investigations were conducted under the responsibility of the shift supervisor, the shift supervisor, at the time, was concentrating on handling the scram following the earthquake, and the fact that the employees headed for field investigations was reported to the shift supervisor after the employees had headed out to each site.

- The two victims contacted the MCR and reported that there was a leak in the EHC pump room.

- The assistant work manager who was watching for a tsunami confirmed that the tsunami was approaching and contacted the MCR verbally.
  * Japan Meteorological Agency issued large tsunami alert (at 14:49 over 3 meters in some places.)

- The MCR ordered all shift workers via pagers and PHS, regardless of whether they were inside or outside, and especially those workers close to the shore, to evacuate to the MCR. The two victims were unable to be reached at this time.

- The tsunami reached the service building of Unit 4 (at 15:35). It is assumed that the tsunami engulfed the basement at this time.

- Unit 4 emergency D/G (emergency diesel generator) tripped (shutdown) (at 15:39). The basement floors were flooded with water entering through the Unit 4 outlet, large equipment service door and emergency D/G room ceiling, and the water level was thought to have risen to the top of the basement ceiling (approximately7 meters).

[7]Details on Operation of the Isolation Condenser (IC)

[Main Report 10.1(1) 3) Speculations regarding the isolation condenser]

The IC draws steam from the reactor and condenses it to water thereby lowering the pressure in the reactor while reactor pressure rises. At the Fukushima Daiichi NPS, only Unit 1 is installed.

On March 11, 2011, the IC started up automatically immediately following the earthquake, however it has been pointed out that there was operator error involved with operation of this unit, and that the Headquarters and the Power Station Emergency Response Headquarters were not sufficiently able to ascertain of the operational status of the IC. The Station blackout affected multiple units, and how the IC was utilized at the Fukushima Daiichi NPS, and how it operated, amidst the harsh conditions of having to deal with multiple emergencies simultaneously will be investigated further, but for the time being the facts that are currently known are as follows:

[Response History]

- At around 14:52 on March 11, the 2 systems of IC automatically started up in response to “High Reactor Pressure (7.13 MPa[gage])”, and the reactor was depressurizing as the reactor depressurization and cooling commenced.

- At around 15:03, reactor pressure dropped quickly in conjunction with IC started up, and the IC’s return line’s isolation valves (MO-3A, 3B) were temporarily “fully closed” after it was determined that the pressure vessel temperature drop rate of 55 degree C/h as stipulated in the operating procedures could not be adhered to.
  Other valves were left open and on standby. After this it was determined that one IC system was sufficient for controlling reactor pressure at around 6 to 7MPa and the subsystem-A was assigned with this task. The reactor pressure was then control by opening and closing the return line’s isolation valve (MO-3A).

- Although the above shutdown procedural actions have been pointed out by some as an operation error, the operators conducted the operations as stipulated in the operating procedures.

- At around 15:37, all AC power and DC power was lost at Unit 1. As a result, all surveillance instruments, room lights and alarm lights in the MCR went out and it became impossible to confirm the open/closed status of the valves, or operate the IC.

- From around 16:40 until around 17:00 it became possible to temporarily confirm reactor water level (wideband) and confirmed that the water level was lower than prior to the tsunami.

- Since the MCR could not confirm the status of the IC, workers were sent to check the water level on the bilge side of the IC as retained the cooling water in the field where the IC is located and proceeded to do so at 17:19. However they were forced to turn back due to higher-than-normal dose levels in the field and inadequate equipment (reactor building entrance) (around 17:50).

- DC power became temporarily unstable as a result of the tsunami, but when it was partially restored thereafter an operator noticed that the green lights (using DC) that indicates that the IC (subsystem-A) feed containment isolation valve MO-2A and return containment isolation valve MO-3A as “Closed” were on. It is assumed that since the IC feed line containment isolation valve (MO-2A), which is normally open, was closed and DC power that is used for detecting “IC pipe rupture” was lost, the “IC pipe rupture” signal was issued to be on the safe side, and all IC containment isolation valves were closed. However, at 18:18 when an operator went to open the IC return line containment isolation valve (MO-3A) and feed line containment isolation valve (MO-2A) expecting that the containment isolation valves on the inside of the PCV (MO-1A, 4A) were open, the status indicator light switched from closed to open.

- With no power nor operable monitoring equipment, the operators had no means to confirm operating condition of the IC, and was forced to confirm that steam had been released from the IC vent pipes (this is steam released into the atmosphere from clean water that has been produced after cooling steam from the reactor) after the valves were opened by listening for the sound of released steam and by looking for steam out across the reactor building. After a while steam was not being released anymore, so at 18:25 the IC return line containment isolation valve (MO-3A) was closed and the IC was shutdown. Also, in the MCR action was taken to configure a reactor injection line using the FP, which was the only resort available at the time.

- While unforeseen events kept unfolding one after another, operators assumed that the reason why steam was not being generated was because the containment isolation valve (MO-1A, 4A) inside the PCV had been closed by an isolation signal, and feared that for some reason there was no water left on the bilge side (IC cooling water). Assuming that the IC was not functioning and knowing that a piping route to feed cooling water to the bilge side had not been completed yet, the operator decided to temporarily close the return containment isolation valve (MO-3A).

- At around 20:50, a reactor injection line using the FP was completed to set up, and the diesel driven fire extinguishing pump was activated. It was expected that this would allow cooling water to be replenished on the bilge side of the IC. Thereafter, when operators checked the status of IC operation, they noticed that the closed status light for the IC return containment isolation valve (MO-3A) had gone out.

- At 21:19, it became clear that reactor water level that until recently could not be seen was TAF (Top of Active Fuel) + 200mm.

- Even though reactor water level was above the fuel, the steam-driven HPCI pump could not be started up due to loss of power, which meant that at that point the IC was the only high-pressure system cooling device that was available. Normally, even without water feed to bilge side, the IC can be operated for approximately 10 hours, and since water was being fed to the IC bilge side using the diesel driven fire extinguishing pump, a lack of water on the bilge side was no longer feared. However, since uncertainty regarding when the IC would be functional remained, the return line containment isolation valve (MO-3A) that had been closed temporarily, was reopened at around 21:30 in hopes that the IC, which is a high-pressure system cooling device, would activate, and steam release was confirmed by listening for steam sounds and looking out across the reactor building for steam. Furthermore, the operations team from the Emergency Response Center members at the Power Station stepped outside the seismic isolated building to confirm that steam was being released.

<u>[Ascertaining the Situation]</u>

- The Emergency Response Center (hereinafter referred to as “ERC”) at the Headquarters and Power Station knew the following about the operating status of the IC:
  - Normally, the ERC at the Headquarters and Power Station can ascertain and monitor the status of the plant through the Safety Parameters Display System (hereinafter referred to as, “SPDS”). However, no data, such as plant monitoring data, which was lost as a result of the tsunami, was sent from this system to the ERC, which was not functioning.

  - Normally, PHS phones are used as communication measures within the power station, however, these could not be used due to the loss of power, and the communications between the MCR and the ERC at the power station were restricted to land lines and hotlines in the MCR. Amidst the lack of sufficient communication measures, the ERC at the power station was forced into the complicated situation where it had to simultaneously deal with emergencies at six plants. Under these circumstances, between around 16:40 and 17:00, the reactor water level was confirmed and it was discovered that the water level was above the top of the fuel. Based on this information, the time left until the reactor water level reached TAF (Top of Active Fuel) was estimated, and around the predicted time, at 18:18, part of the DC power to the IC (subsystem-A) had been restored, the green indicator lights, which indicated “Closed” position, for the IC (subsystem-A) feed containment isolation valve MO-2A and return line containment isolation valve MO-3A, were confirmed, and the valves were opened as previously mentioned.

・ At 18:25, as previously mentioned, the operation of the IC was temporarily shut down, but this fact was not recognized by the ERC.

・ Though the reactor water level became unavailable again, due to the information that the steam release, which indicates that the IC is operating, from the IC vent pipes was confirmed upon the activation of IC at 18:18, and the data that the reactor water level confirmed at 21:19 was slightly higher than TAF, which was, as a result, consistent with the fact that the IC was activated at 18:18, it was not seen by the ERC that the operation of the IC had stopped.

From the progression and analysis of the core damage of Unit 1 it is presumed that the IC had lost almost all function with the arrival of the tsunami. When the tsunami struck, the IC control signals were lost and as a result the IC was automatically isolated, which means that function to cool the reactor was almost completely lost. It is thought that this happened at a point in time when the decay heat (heat generated by the fuel) immediately after the reactor shutdown was at its highest so reactor water level dropped in a short period of time and lead quickly to core damage.

It was precisely at this moment that surveillance instrument power was lost so plant status and plant parameters, including the status of the IC, could not be ascertained. Power station worker gathered car batteries, brought them into the MCR and hooked them up to use as power for ascertaining data, such as reactor water level, which allowed some data to be confirmed after 21:19.

[8] Primary Containment Vessel Venting Preparation of the Fukushima Daiichi Nuclear Power Station Unit 1

[Main Report 8.1(3) Response Status Pertaining to Venting of PCV at Fukushima Daiichi Unit 1]

PCV venting is to prevent increasing pressure by allowing PCV pressure to vent into the atmosphere. If the core has been damaged, implementing this measure will temporarily discharge radioactive materials from the PCV, but by preventing the PCV from being damaged, an unlimited discharge into the atmosphere of radioactive materials kept inside the PCV can be prevented and as a result, contamination can be minimized.

There are two pipes used to vent the PCV, one from the D/W and the other from the S/C (wet-well), and each have large and small valves that operate by air (AO valve). After the two pipes converge, there is a motor operated valve (MO valve), a rupture disk that ruptures under a given amount of pressure, and then connecting to the stack.

When venting the PCV, fundamentally venting of the S/C is given priority, because the vented gases are passed through the water of the S/C which means that the amount of discharged radioactive materials is reduced in the same effect as if passing them through filter.

At the Fukushima Daiichi NPS Unit 1 at 12:06 on March 12, 2011, D/W pressure began to rise abnormally thereby increasing the necessity for venting.

Venting of Unit 1 was deemed successful at 14:30, however the facts confirmed in this incident that are known at this time, such as venting suitability, are as follows.

[Facts found]

- After the damage caused by the tsunami, the MCR and ERC at the power station was faced with the serious situation of loss of both power and cooling functions. As the situation evolved it became clear that venting was necessary and the following preparations were started to implement venting.
  - MCR: The shift manager was given the accident management procedures and s/he confirmed the details. Verification of necessary valves for venting and their location using the valve checklist were started.
  - ERC: Deliberate the way to vent under the loss of power condition with the accident management procedures. Even while continuing aftershocks, workers went into the main office building, which had been restricted to enter, to search for manual operating procedures for the valves required for venting.

- On March 11 at around 23:50, the generator that had been brought in for temporary lighting in the MCR was connected to the D/W pressure gauge enabling the indicator on the pressure gauge to be checked for the first time since power was lost. Upon discovering that the indicator read 600kPa, at around 0:06 on March 12th the Site superintendent ordered that venting preparation continue in fear that D/W pressure would exceed 600kPa.

- Venting is an serious measure, caused releasing the radioactive materials, therefore between around 1:00 and 1:30 the president's confirmation and authorization was received, and at around 1:30, Takekuro; Advisor of TEPCO, and Komori; Assistant Director of ERC at the Headquarters, Senior Executive Director of TEPCO, asked the Prime Minister, and the Minister of Economy, Trade, and Industry and the Nuclear and Industrial Safety Agency for permission to vent, respectively, after which at 3:00, the request to vent from the government was received following a press conference after 3:00.

- The following preparations were made between when the press conference ended and when operators headed to the field at around 9:00 to begin venting.
  - ・ Evaluation and conveyance of surrounding exposure doses during venting
  - ・ Field dose measurements
  - ・ In preparation for venting: Confirmation of valve operation order, route to the torus room where the air operated valves on the vent line from the S/C are located, and those valve locations
  - ・ Gathering of equipment necessary for work (fire resistant suits, self-contained air units, personal dosimeter (APD), survey meter, flashlights, full-face masks)
  - ・ Operating formation in the field was considered with the risk of one-man working in the total darkness, high radiation exposure, evacuation for aftershock.

- In consideration of the impact on the surrounding residents, it was necessary to confirm the status of resident evacuation in addition to confirming the status of the evacuation order from within a three kilometer radius [of the power station]. So, upon considering wind direction, and checking with the TEPCO employee who had been dispatched to the Okuma-machi city hall to confirm the status of resident evacuation from Okuma-machi, which located south of the power station, at around 9:04 operators headed to the field to begin venting procedures.

- Two operators (team 1) wore fire-resistant suits, self-contained air units, APD (personal dosimeter) and flashlights and headed to the field. At around 9:15, after opening the MO valve to 25% in accordance with predetermined procedures, they returned to the MCR.

- After that, team 2 headed to the field at around 9:24 in order to activate the small AO valve, however turned back due to the fear that dose limits may exceed 100mSv along the way.

- In response to this the ERC at the power station began deliberating the connection of a temporary compressor. In expectation of residual air pressure in the small AO valve (electromagnetic valve), this was opened from the MCR three times at 10:17, 10:23, and 10:24.

- At 10:40, a rise in radiation levels was confirmed at the front gate and monitoring posts, which the ERC at the power station deemed highly likely to be radioactive materials discharged when venting the PCV, however when radiation levels dropped at 11:15, it assumed that that the venting was insufficient.

- Therefore, preparing a temporary compressor and adapter were conducted at around 14:00, the temporary compressor was started up and vents lined up. After which at around 14:30 D/W pressure was confirmed to drop and the radioactive materials were deemed to have been discharged through venting.

[9] Arrangement for Prime Minister Kan’s Visit and the Impact upon the Restoration Work

On March 12, 2011 at around 7:10, the day following the disaster, Prime Minister Kan visited the Fukushima Daiichi NPS.

This is may be the impact on the recovery work, and it may be some confusion on the time line for this event. Therefore the investigation was conducted, and its results are as follows;

[Facts found]

- On March 12 at around 13:00, information was received that Prime Minister Kan was to visit to the Fukushima Power Station.

- At 6:14, Prime Minister Kan took off from the prime minister's residence (along with Madarame ; Chairman of the Nuclear Safety Commission in Japan)

- At around 6:33, evacuating routes from Okuma-machi to Miyakoji were deliberated in light of the evacuation status of surrounding residents.

- At around 6:50 the Minister of Economy, Trade, and Industry ordered to do manual venting based on law.

- At 7:11 Prime Minister Kan landed at the Fukushima Daiichi NPS.
  (Muto; Executive Vice President Muto of TEPCO joined this visit.)

- Yoshida; Site superintendent, explained in the status of the plant at the ERC at the power station.

- At 8:04 Prime Minister Kan took off from the power station.

- Furthermore, at around 8:03 the Site superintendent instructed that venting of Unit 1 commence at around 9 a.m. (the Site superintendent did not see Prime Minister Kan), and at around 9:03, TEPCO workers were sent to the field to manually operate the venting valves after confirming the evacuating completion of Okuma-machi residents.

- Venting preparations in the field continued during Prime Minister Kan’s visit. Therefore, the visit did not directly delay venting operations.

- On the other hand, as the Prime Minister Kan visited the site, the site superintendent provided an explanation of the current situation, while directors who were at the offsite center came to meet the prime minister as he landed and attended to him during his visit, in the midst of the recovery event.

[10] The Decision to Inject Seawater Which Would Lead to the Decommissioning of Fukushima Daiichi Nuclear Power Station Unit 1

[Main Report 8.1(2) Response Status Pertaining to Cooling Water Injection at Fukushima Daiichi Unit 1]

Injecting seawater into the reactor instead of freshwater can cause the reactor to become inoperable. Therefore, it has been pointed out that TEPCO hesitated to inject seawater in fear of leaving the reactor inoperable, thereby contributing to the accident.

However, cooling the reactor was an urgent issue, and if no freshwater was available, the only other conceivable choice was to inject seawater.

The following actions are that TEPCO made decide to inject seawater even though it might leave the reactor inoperable.

[Facts found]

- After the devastation of the tsunami, the ERC at the power station was aware that regardless of whether freshwater or seawater was used, cooling water had to be injected into the reactor in order to cool it.

- On March 11 at around 17:12, the Site superintendent ordered deliberation of methods to inject cooling water into the reactor using the FP and a fire engine.

  In response to this, the MCR confirmed an injection line to the reactor based on accident management procedures and decided to use the diesel driven fire extinguishing pump, which was the only means available since power had been lost, and at around 17:30 confirmed that the aforementioned pump was up and running and on standby.

  An injection line was configured via the core spray system, and at around 20:50 the diesel driven fire extinguishing pump was activated which enabled cooling water to be injected after depressurization of the reactor.

- However, high reactor pressure obstructed the injection of water, and at around 1:48 on March 12 the diesel driven fire extinguishing pump shutdown. The battery was changed, and operators refilled the fuel tank, but the pump could not be started again.

- At the same time, preparations were being made to configure a line from the FP using the fire engine, and at around 5:46 on March 12 the closest fire water tank on the Unit 1 was used to begin injecting freshwater into the reactor using the fire engine and a line from the FP.

- At around 12:00, while the injection of freshwater was still continuing, it was determined that there was a limit to the amount of freshwater that could be secured in the fire protection tank, and the site superintendent ordered that preparations be made to inject seawater, which was confirmed and approved by the president of TEPCO.

- As the fire engine was about to finish injecting approximately 80,000 liters of freshwater, at around 14:54 the Site superintendent gave the order to inject seawater into the reactor at which time work to switch injecting from freshwater to seawater was implemented.

- Preparations to configure a cooling water injection line using three fire engines and water from the tsunami that had accumulated in the Unit 3 back wash valve pit were made. However, at around 15:36 right before the line up was completed, the Unit 1 reactor building exploded.

- This explosion damaged the hoses that were to be used for injecting seawater. Furthermore, the explosion caused evacuation from the field and made injured workers that needed to be rescued and carried out. It was then necessary to take radiation measurements and conduct an investigation of the field in order to ensure safety and investigate the damages from the explosion. Hoses needed to be newly laid, so new hoses were gathered from the field’s fire hydrants and highly radioactive debris was cleared.

- A new seawater injection lineup was completed and the injection of seawater began at around 19:04.

[11] Fukushima Daiichi Nuclear Power Station Unit Seawater Injection Timeline and Discontinuance

The [Time Sequence (Facts)] regarding the injection of seawater into Fukushima Daiichi NPS Unit 1 and the decisions that were made by the Headquarters to terminate the injection of seawater, since the decision to terminate the injection of seawater was not made by the power station, are as follows.

[Facts found]

- While seawater was being injected into the reactor using the fire engine, at around 12:00 on March 12, the Site superintendent gave the order to make preparations to inject seawater into the reactor, which the president (Headquarters Countermeasures Division Director) confirmed and approved.

- As the fire engine was about to finish injecting approximately 80,000 liters of freshwater, at around 14:54 the Site superintendent gave the order to inject seawater into the reactor at which time work to switch injecting from freshwater to seawater was implemented.

- In response, at around 15:18, it was conveyed via fax to the Nuclear and Industrial Safety Agency and Cabinet Secretary’s Cabinet Information Gathering Center that “as soon as preparations were complete, the FP would be used to inject seawater into the reactor”.

- At around 15:36, right before the lineup was completed, the Unit 1 reactor building exploded and it caused damaging the hoses.

- While a new seawater injection lineup was being configured, at around 18:05, it was shared via teleconference that the Minister of the Economy, Trade and Industry had ordered the injection of seawater in abidance by law.

- At around 19:04 seawater injection commenced and at around 19:06. This fact was conveyed to the NISA.

- At around 19:25, the TEPCO liaison at the Prime Minister’s office contacted the Headquarters and power station and said that, “the Prime Minister’s office had yet to approve the injection of seawater”, after which the Headquarters and power station consulted and decided to temporarily suspend the injection of seawater.

- The Headquarters countermeasures headquarters assumed that the Prime Minister, who is the division director of the nuclear disaster countermeasures headquarters, and his staff were still debating the necessity to inject seawater while receiving advice from the Nuclear Safety Commission of Japan and felt that they could not inject seawater without the approval of the Prime Minister. The liaison to the Prime Minister's office at the time felt that he could negotiate and the injection would only be put on hold for a short period of time.

- However, the Site superintendent deemed that continuing the injection of seawater into the reactor was the most vital measure for preventing the further accident and made the decision to continue to inject seawater.

[12] PCV Venting and Alternative Cooling Water Injection Preparation for Fukushima Daiichi Nuclear Power Station Unit 2

[Main Report 8.2(2) Response Status for Cooling Water Injection at Fukushima Daiichi Unit 2;
8.2(3) Response Status for PCV Venting at Fukushima Daiichi Unit 2]

At the Fukushima Daiichi NPS Unit 2, the RCIC continued to operate immediately after the disaster and the injection of cooling water continued.

In order to determine whether PCV venting and alternative injection, for which preparations were being made in the interim, were carried out quickly and appropriately, the following facts that are currently known have been compiled below.

[Facts found regarding Primary Containment Vessel Venting]

- On March 12 at around 1:30, the Prime Minister, The Minister of Economy, Trade, and Industry, and the Nuclear and Industrial Safety Agency were informed about the plan to vent the PCVs of Unit 1 and Unit 2, which they approved.

- On March 12 at 2:55, it was determined that the RCIC was working through confirmation of the RCIC discharge pressure inside the reactor building, so venting of the Unit 1 PCV was given priority and the parameters for Unit 2 were to be continually monitored.

- While all efforts were being put into venting the Unit 1 PCV and injecting cooling water into the reactor, at around 15:36 on the 12th, a hydrogen explosion occurred in the Unit 1 reactor building. A reactor injection line was reconfigured and reactor cooling water injection resumed at around 19:00.

- On March 12 at 17:30, cooling water continued to be injected into the Unit 2 reactor using RCIC and PCV pressure was stabilizing at approximately between 200 and 300 kPa[abs], but it was still predicted that PCV would need to be vented, so the Site superintendent (Director of the ERC at Power Station) gave the order to begin preparations for PCV venting of Unit 2.

- Furthermore when actual preparations to vent the PCV of Unit 1 began, the same preparations, such as checking accident management procedures, valve diagrams, and piping and instrumentation drawings, were underway for Unit 2.

- On March 13 at 8:10, in accordance with procedures, the PCV venting line’s motor operated valve was switched to manual operation and opened to 25%.

- On March 13 at 10:15, the Site superintendent gave the order to start venting the Unit 2 PCV. At 11:00, in order to open the air operated valve (AO valve) in the vent line from the S/C, the portable generator being used for temporary lighting in the MCR was used as a power source to forcibly excite and open the electromagnetic valve installed in the air pipe for the AO valve drive mechanism. By doing this, when the rupture disk ruptures under a certain amount of pressure, the pressure from the PCV would be released into the atmosphere, and the vent line would be completed (workers were waiting for the rupture disk to rupture).

- However, at this time the pressure of the PCV (427kPa[gage]) was not high enough to cause the rupture disk to rupture, so the valves that comprise the vent line for the PCV were left open, and PCV pressure continued to be monitored.

- On March 14 at 11:01, an explosion occurred in the Unit 3 reactor building, and all workers, except the operators in the MCR, ceased working and evacuated to the seismic isolated building. Restoration work was put on hold temporarily while worker safety was confirmed, the status of the field was ascertained, and a safety check was made. PCV pressure fell to approximately 450 kPa[abs] (approx. 350 kPa[gage]), much lower than that required to rupture the rupture disk, and stabilized.

- The AO valve (isolation valve) on the vent line from the S/C closed because the electromagnetic excitation circuit was dislodged as a result of the explosion in the Unit 3 reactor building. After the evacuation order following the Unit 3 explosion was lifted, procedures to open the AO valve were conducted from around 16:00 on March 14, however at approximately 16:20 it became impossible to open as a result of insufficient drive mechanism air from the temporary air compressor.

- Since PCV pressure was not dropping at around 18:35 on March 14, not only the AO valve (isolation valve) in the vent line from the S/C, but also the AO valve (bypass valve) installed in parallel in the vent line from the S/C was focused on during continual work to restore the PCV vent line. It was thought that the large vent valve (AO valve) from the S/C could not be opened due to insufficient air from the temporary air compressor, but it is presumed that it could not be opened due to solenoid valve nonconformity).

- On March 14 at around 21:00, the AO valve in the vent line from the S/C was opened, and the vent line, with the exception of the rupture disk, was complete (workers were waiting for the rupture disk to rupture).

- In regard to PCV pressure, normally D/W and S/C pressures are approximately same, but while the pressure on the D/W side continued to increase, S/C pressure was stable at approximately 300 to 400 kPa[abs] resulting in unequal pressure. Since the pressure on the S/C side was too low to rupture the rupture disk, and D/W pressure side pressure continued increase, and at around 23:35 on March 14 it was decided to implement venting by opening the AO valve (bypass valve) in the vent line from the D/W.

- At 00:02 on March 15, the AO valve (bypass valve) on the vent line from the D/W was opened, and it was thought that the vent line, with the exception of the rupture disk, was completed, however several minutes later it was discovered that the AO valve (bypass valve) in the vent line from the D/W was closed. As a result it was not possible to determine whether venting was successful (ruptured status of the rupture disk ruptured).

[Facts found for alternative injection]

- On March 11 at 15:39, the RCIC was manually started.

- At 16:36, reactor water level could not be confirmed and cooling water injection status was unclear, so it was determined in accordance with Clause 15.1 of the Act on Special Measures concerning Nuclear Emergency Preparedness that a “specific event” (core cooling system injection failure) had occurred.

- At 17:12, the Site superintendent (director of the ERC at the power station) gave the order to deliberate accident management alternative injection (the FP, the MUWC, the residual heat removal system (RHR)) and alternative reactor cooling water injection methods using a fire engine.

- It was decided that an alternative injection line would be configured via the RHR as a result of these deliberations. However, whereas this line can be configured from the MCR if there is power, in the absence of power operation from the MCR was impossible, so in the pitch darkness the valves for the RHR in the reactor building, and turbine building were manually opened and a system was configured to enable injection after depressurization of the reactor (0.69MPa).

- At 21:50, as a result of restored instrumentation, it was discovered that reactor water level was 3400mm (TAF+3400mm) above the top of active fuel.

- On March 12 at 14:55, the ERC at the power station received a report from the MCR that had conducted a field inspection and deemed that the RCIC was working; it then decided to continue monitoring parameters and the operational state of the RCIC.

- On March 13 at 12:05, the Site superintendent (director of the ERC at the power station) gave the order to begin preparations for injecting seawater into the reactor in expectation that the RCIC would shut down. An injection line system was configured using the Unit 3 backwash valve pit as a water source, and a hose from the fire engine was laid.

- On March 14 at 11:01, workers, except the operators in the MCR, ceased work and evacuated to the seismic isolated building after the Unit 3 reactor building explosion. The seawater injection line that had been completed was rendered unusable as the fire engine and hoses were damaged in the explosion.

- From 13:05, field conditions were inspected and it was decided that seawater would be taken directly from the shallow draft quay to inject into the reactor instead of from the Unit 3 backwash valve pit.

- Since reactor water level was dropping it was thought that the RCIC might not be functioning, so at 13:25 on March 14 the incident was labeled as the aforementioned event (reactor cooling function loss) pursuant to Clause 15 of the Act on Special Measures concerning Nuclear Emergency Preparedness. Preparations to inject seawater into the reactor continued and at 14:43 connection to the fire engine FP was completed.

- In order to inject cooling water using the fire engine it was necessary to depressurize the reactor by manually opening the main steam safety relief valve (SRV), but since the temperature and pressure of the S/C were high, it was possible that steam would not be condensed in the S/C making it difficult to depressurize, so it was decided by the ERC at the power station that the SRV would be manually opened, the reactor depressurized, and seawater injected after preparations to inject seawater into the reactor and vent the S/C were made.

- However, at around 16:20 on March 14, it was deemed that manually opening the vent valve would take time, so the Site superintendent prioritized depressurization of the reactor using the SRV and ordered that the S/C be vented simultaneously.

- At around 16:30, the fire engine was started and preparations were made to start injecting seawater during reactor depressurization. At 16:34, the reactor started to depressurize, and seawater started to be injected into the reactor from the FP line.

- The SRV did not open due to insufficient battery voltage and workers continued to attempt to open multiple SRVs.

- At around 18:00, depressurization of the reactor was started using the SRV, but the temperature and pressure of the S/C were high thereby preventing condensation, so it took time for the S/C to depressurize.

- High radiation levels in the field prevented field monitoring, such as confirming the operational state of the fire engine, and workers were forced to work in shifts. It was then discovered at 19:20 on March 14 that the fire engine, which had been on standby to inject seawater into the reactor, had stopped due to lack of fuel.

- At 19:54, injection of seawater into the reactor was started using a FP line from the fire engine (two fire engines were started, one at 19:54, and the other at 19:57) began.

[13] PCV Venting and Alternative Cooling Water Injection Preparation for Fukushima Daiichi Nuclear Power Station Unit 3

[Main Report 8.2(2) Response Status for Cooling Water Injection
at Fukushima Daiichi Unit 2;
8.2(3) Response Status for PCV Venting
at Fukushima Daiichi Unit 2]

Similarly, at the Fukushima Daiichi NPS Unit 3, the RCIC, and the HPCI were working, and providing cooling water injection. At the same time preparations were made to vent the PCV and use alternative injection.

In order to determine whether PCV venting and alternative injection were carried out quickly and appropriately, the following facts that are currently known have been compiled below.

[Facts found for Venting]

- On March 12 at 17:30, while the HPCI had been started and reactor water level was being maintained, the Site superintendent (director of the ERC at the power station) gave the order to begin preparations for PCV venting. The MCR was working to restore monitoring instruments, At 21:00 procedures for venting the PCV, as well as the location of valves necessary for such operations, were reviewed and verified.

- Furthermore, the operations team and restoration team of the ERC at the power station verified the content of the Unit 1 PCV venting procedure (field procedure) after it was completed. Using the details of the Unit 3 accident management procedures the team deliberated on the Unit 3 PCV venting procedure, and conveyed the created procedures to the MCR.

- On March 13 at 14:42, the HPCI were shut down.

- On March 13 at around 4:50, in order to open the air operated valve (AO valve) on the vent line from the S/C the portable generator being used for temporary lighting in the MCR was used as a power source to manually open the AO valve solenoid valve.

- On March 13 at 5:15, the Site superintendent gave the order to complete the vent lineup with the exception of the rupture disk.

- It was thought that the reason why the solenoid valve for the AO valve (isolation valve) in the vent line from the S/C would not open even though it was energized was because of lack of pressure from the compressed air cylinder used to operate the aforementioned valve, so the compressed air cylinder was replaced. At 5:23 the aforementioned valve opened after the compressed air cylinder was replaced.

- At around 8:35, the MO valve on the vent line from the S/C was manually opened to 15%. Standard procedures call for the vent to be opened to 25%, but this was lowered in order to prevent to reduce PCV pressure drastically.

- At 8:41, alignment of the vent lineup, excluding the rupture disk, was completed. However PCV pressure was too low to rupture the rupture disk. (427 kPa[gage]) The system would not vent. (Workers were waiting for the rupture disk to rupture.) So the vent system alignment was kept open and PCV pressure was monitored.

- At 9:24, a drop in PCV pressure drop was verified so at approximately 9:20, it was determined that the S/C had been vented.

- At around 9:28, the pressure on the compressed air cylinder for the AO valve (isolation valve) on the vent line for the S/C decreased, Therefore workers headed to the field and found leakage from the tank connecting which they tightened.

- At 11:17, the AO valve (isolation valve) on the vent line from the S/C closed as a result of decreased compressed air cylinder pressure. The compressed air cylinder was replaced and an attempted to reopen the aforementioned valve. At 12:30 that the valve was open. Since the valve must be kept open, workers headed to the torus room where the S/C in which the aforementioned valve is installed is located. However no measures could be taken to keep the valve open due to high room temperature.

- Since the IA (instrument air system) [that is the other supply for operating the AO valve (isolation valve) in the vent line from the S/C] had shutdown, the restoration team of ERC at the power station set up a temporary compressor in the truck bay at the turbine building at around 17:52.This allowed the IA system to be used for opening the valve. The temporary compressor would be set up in a different location but high radiation levels forced the team to set up the compressor in the truck bay at the turbine building where radiation levels were lower.

- At around 21:10, PCV pressure dropped so it was deemed that the AO valve (isolation valve) in the vent line from the S/C opened.

<u>[Facts found for alternative injection]</u>

- On March 11 at 16:03, the RCIC was manually started up in order to maintain reactor water level, and reactor water level was maintained.

- After orders given by the Site superintendent (director of the ERC at the power Station) at 17:12 on March 11, the ERC at the power station deliberated on alternative injection to be considered as accident management measures (the FP, the MUWC, the

RHR) and alternative ways of injecting cooling water into the reactor using a fire engine.

- However, out of the three fire engines on located at the power station, only one was used to inject seawater into Unit 1. One fire engine was unusable due to the tsunami, and the other was located at the Units 5 and 6 side, so it was difficult to deliver due to damage of the road and debris left by the tsunami. After this, sandbags were used to level the roads and debris was removed in an effort to restore roads on site. The fire engine by Units 5 and 6 was delivered to the Units 1 to 4 side as soon as the road to Units 5 and 6 became usable. In addition, a fire engine that was on standby as an emergency backup at the Fukushima Daini Nuclear Power Station was delivered to the Fukushima Daiichi NPS.

- On March 12 at 11:36, the RCIC automatically shutdown. After the RCIC shutdown, reactor water level dropped, and at 12:35 on March 12 The HPCI was automatically started up as a result of low reactor water (L-2: Top of Active Fuel (TAF) +2950mm). As a result, reactor water level was restored but subsequently HPCI shutdown at 14:42 on March 13.

- With the HPCI was shut down, cooling water injection was attempted into the reactor using a diesel-driven fire pump that had already been started up as an alternative injection method. This was an accident management measure in order to maintain reactor water level and cool the reactor. However, reactor pressure, which had dropped temporarily, rose to approximately 4.1 MPa[gage] thereby unable to inject the water. After this, the RCIC and HPCI, which are turbine-driven, were attempted to be restarted as injecting cooling water into the reactor. However the HPCI would not been started up due to a depleted battery, and the RCIC could not be started up due to a valve malfunction.

- In order to inject cooling water into the reactor from the FP using a fire engine, it was necessary to reduce reactor pressure to below the discharge pressure of the fire engine. Therefore, it was attempted to reduce reactor pressure by manually opening the SRV. This was done immediately after batteries had been gathered in order to restore instruments and other purposes in Units 1 and 2. Therefore a power source to manually operate the SRV could not be established and the SRV could not be operated. At this time the workers of the ERC at the power station started removing the batteries from their personal vehicles and bringing them to the MCR to use as an SRV power source. At 9:08 on March 13 the SRV was finally manually opened and the reactor was depressurized promptly.

- As a result of this depressurized work, reactor pressure dropped below the discharge pressure of the fire engine pump so cooling water could be injected into the reactor. At 9:25, boric acid was dissolved into the fire protection tank (freshwater) and this cooling water was injected into the reactor.

- On March 13 at 10:30, the Site superintendent (director of the ERC at the power station) gave the order to start preparing for about the injection of seawater.

- At 12:20, the injection water source was started preparing to change from the backwash valve pit since the freshwater in the fire protection tank had been depleted.

- Soon after starting preparing to change the injecting water source, seawater injection configuration was completed. Therefore, on the same day at 13:12 seawater injection was started into the reactor, and at the same time, more freshwater had been procured.

[14] Prediction and Avoidance for the Fukushima Daiichi Nuclear Power Station Building Explosions

[Main Report 8.1 Response Status at Fukushima Daiichi Unit 1;
8.3 Response Satus at Fukushima Daiichi Unit 3]

Could the hydrogen explosion in the Unit 1 reactor building have been prevented?

Did the experience with the Unit 1 explosion make it possible to prevent the Unit 3 explosion?

The above two questions have been posed and the facts related to these events are as follows.

[Facts found]

- On March 12 at approximately 15:36, the Unit 1 reactor building exploded.

- It is widely known that if the core reaches high temperatures due to fuel exposure, the resulting water/metal oxidation will generate hydrogen that may accumulate in the PCV, which may cause a hydrogen explosion. The venting operations for the PCV were conducted under this recognition.

- When the Unit 1 reactor building exploded, it had not been predicted that hydrogen would accumulate in the reactor building leading to explosion.

- In response to the Unit 1 reactor building explosion, all the conceivable methods were considered in order to prevent an explosion at the Unit 3 reactor building, such as opening a hole in the roof, opening the blowout panels and using a water jet to open holes in the structure.

- It is conceivable that, during the time from the explosion at Unit 1 until the explosion at Unit 3, the measures to prevent hydrogen explosions, such as opening the blowout panels by entering into the reactor building, could have been implemented. However, in reality, amidst handling other multiple crises such as the explosion at Unit 1, it would have been difficult to engage in this work, as workers would have been forced to work at a high place in total darkness, wearing heavy equipment, such as air masks, etc.

- After the hydrogen had started being generated at Unit 3, even the slightest spark could have caused another explosion, and the radiation levels were extremely high, which prevented any handling of these problems. Therefore, the Unit 3 explosion could not be prevented. Water jets to open holes in the structure were in the process of being procured.

- At around 11:01 on March 14, the Unit 3 reactor building exploded.

[15] Evacuation of some Workers from Fukushima Daiichi Nuclear Power Station

[Main Report 8.2 Response Satus at Fukushima Daiichi Unit 2]

From March 14 to March 15, 2011 The Fukushima Daiichi NPS Unit 2 was in crisis. At around 6:10 on March 15, an explosive sound was occurred and the pressure in the S/C of Unit 2 indicated 0 MPa[abs] (vacuum). Due to this event, at around 6:30 the TEPCO president gave the order to "evacuate except worker who works for the recovery work." The Site superintendent ordered that "team leaders to designate necessary worker" after which all contractors and TEPCO employees not directly involved with the work at hand (approximately 650 people) took temporary refuge in a safe place while the workers that remained (approximately 70 people) continued with recovery work.

It has been widely reported by the mass media that TEPCO tried to force everyone to evacuate from the Fukushima Daiichi NPS in this event. The following, which includes testimony in the Diet, which should be the truth, are the facts about what actually happened.

[Facts found]

- TEPCO conveyed to the Prime Minister's office that, "the plant is in a serious situation and we would like to consider the temporary evacuation except worker who works for the recovery work", but never once spoke of, or considered, the total evacuation of all workers.

- On March 15 at around 4:30, TEPCO President Shimizu called to the Prime Minister's office and was asked by Prime Minister Kan whether or not they were to totally evacuate, to which Shimizu replied that they were not considering a total evacuation.

- Meanwhile, at around 5:35 Prime Minister Kan arrived at the ERC at TEPCO Headquarters countermeasures headquarters and stated that, "Total evacuation is not an option. If you totally evacuate, it will be the downfall of TEPCO".

- Furthermore, Prime Minister Kan made the following statements on April 18, April 25 and May 2 in front of the Upper House Budget Committee.

<<Statement by Prime Minister Kan on April 18>>

- "Very early time, we heard from TEPCO officials, and I personally heard from my ministers, that there was to be a total evacuation from the site which would have been a serious course of action. So I asked President Shimizu to come to my office, and I asked him directly about this matter. President Shimizu said to me that what I had heard, '<u>did not mean a total evacuation</u>'".

<< Statement by Prime Minister Kan on April 25>>

- “In other words, as of the 15th, I had been told by my ministers that TEPCO wanted to be evacuated totally due to various radiation dose-related matters. I asked President Shimizu to come to my office, and I said to him that we would be in a lot of trouble if they evacuated totally. He replied, “No, that’s not what we mean”.

<< Statement by Prime Minister Kan on May 2>>

- “At a certain point, I was told by Minister of the Economy Trade and Industry that TEPCO was considering a total evacuation based on circumstances. I asked the president to come to my office and asked him directly to which he replied, “We do not plan on doing that”.

[16] Public Announcement on Core Status

Increased interest the core damaged condition as meltdown (core melt) from the core damaged accident at the Fukushima Daiichi NPS, it has been pointed out that TEPCO continuously denied and hided the meltdown (core melt) even the core condition has been recognized.

However, there is no established definition for the term “core meltdown” (core melt) in respect of the specific status represented by such term, and each person understands this term differently. Therefore, TEPCO has used the terms “fuel damage” and “fuel breakage” to explain the status of the core, and never denied the possibility of a core meltdown.

Moreover, for each of its explanations, TEPCO has been using plain language, to the extent possible, which allows anyone to imagine the situation, based on the clarification of term definitions and the core status assessment through water level meter calibration and MAAP analysis.

The facts about what was actually disclosed are as follows;

[Facts found]

- Statements at TEPCO press conferences
  - By what we can confirm about the water level at present, we cannot deny the possibility that there is some damage at the top of the fuel. (March 12 press conference)
  - (In response to a question about whether TEPCO will admit the possibility that the fuel has been damaged) We believe that the fuel has been damaged because radioactivity at a higher-than-natural level has been released. (March 14 press conference)

<<Since March 20 iodine, cesium, tellurium, and ruthenium have been detected from the atmosphere within the power station site>>

  - We consider that these materials have probably been discharged as a result of fuel damage. (March 25 press conference)
  - (In regard to the level of fuel damage) It is not clear how much damage has actually occurred. (March 27 press conference)
  - (In response to the comment that the Nuclear Safety Commission of Japan has started using the word “meltdown,” but TEPCO has not) We do not have enough information to either confirm or deny this. (March 28 press conference)
  - (In response to the question about whether TEPCO considers that a fuel “melt” has not occurred based upon the current data) The data shows that there is a high possibility that the fuel has been damaged, but we do not have enough information to determine the volume or degree of that damage. (March 28 press conference)

<<March 28, plutonium detected>>

- Plutonium is a byproduct of atomic fission, so we cannot deny the possibility that the fuel has been damaged. (March 29 press conference)

- On April 10, TEPCO explained to the Minister of the Economy Trade and Industry that a core melt occurred at Units 1 to 3, but that the extent cannot be assessed at this time. At this time the Minister, NISA and TEPCO discussed the ambiguity of the term.
  - As a result, the minister ordered to use “fuel pellet melt” instead of “core melt”.

- Statements made at TEPCO press conferences

<< On April 18 the “Definition of Core Damage” and “Results of Presumption that the Fuel Pellets Melted and Serious Damage Occurred” was reported on at the Nuclear Safety Commission of Japan>>

- (In response to the question about whether a core melt is not being considered) We believe part of the pellets have melted and are exposed from the fuel sheath, but we have not been able to confirm this. TEPCO is consistently using the term “core damage” because the term “melt” conjures different images for different people. (April 20 press conference)
- It’s not that we’re saying “there wasn’t a core melt” while estimating that approximately 70% of the core has been damaged. What we’re saying is that, yet at this moment, since it has not been confirmed yet, there are cases where the fuel sheath have fractured or where pellets have melted due to high temperatures, and we have explained that the degree of damage itself is estimated to be approximately 70%. (April 20 press conference)
- (In response to the question: thus far, in response to the question “Was there a melt?”, the answer has been “There was damage,” so does this mean that TEPCO has not denied a melt?) That is correct. We do not know yet if a portion, or the entirety of the core, melted and fell down, so we are not denying that. However, with the situation being still unclear, we are explaining that we have found, from the results of measurements, as a level of damage, 70% of the core has been damaged, rather than whether there was a melt or not. (April 20 press conference)
- We believe there is the possibility that melted fuel has accumulated. (April 24 press conference)

<<On May 12 TEPCO announced that, “ inspection and calibration of the water level instrument of the reactor pressure vessel (RPV) of Unit 1 has shown that the water level was approximately 5m below the top of the fuel rods”>>

- We do not believe the fuel assembly is in its original position. However, we have not been able to confirm the extent of fuel damage, and do not know whether it is around the lower portion of the RPV, or have just slightly slipped down while maintaining approximately its original shape. (May 12 press conference)

・ We believe that the fuel assembly is either below its original position or possibly at the bottom of the RPV. However, we have not been able to confirm what condition the fuel assembly is in at the bottom of the pressure vessel. We believe that the fuel assembly melted, and is being cooled at the bottom. (May 12 press conference)

・ We believe that this is not a situation like the China Syndrome situation where the fuel has burned through the pressure vessel, PCV, and reactor building. Fuels are not in their original shape; however, those have remained, and have been cooled in the bottom of pressure vessel. (May 12 press conference)

<<On May 15 TEPCO announced its core assessment conducted through MAAP analysis>>

・The results of analysis showed that, in Unit 1, the fuel pellets melted to the bottom of the pressure vessel at a relatively early stage after the tsunami.

[17] Opinions of Workers and Working Conditions that indicate the Difficulty and Harshness of Working in the Field

On March 11, 2011, particularly after primarily the tsunami struck the power station and all AC power was lost, workers in the field were faced with very a difficult situation.

During the course of the investigation of this accident, interviews and discussions were held with workers that shed light on the difficulties and hardships that they endured.

These testimonials along with pictures have been attached as below.

[Handling by the Main Control Room Chief Operator]

- "On March 11, 2011 at 14:46, a large earthquake struck the Fukushima Daiichi NPS. When the earthquake struck, we took refuge under desks and I told operators to hold on.

  As soon as the earthquake subsided, I could see a green light from my position indicating that a scram had already begun.

  I confirmed that the emergency power (D/G) had started up and was running and parameters in the MCR were OK, so I thought that the worst was over."

- "After this (around when the tsunami arrived), power lights began to flick, and then I saw they all turned off.

  The emergency power was shut off, and all of the lights on the MCR panel started to turn off. I did not know what happened however I couldn't figure out that it was caused by a tsunami.

  My fears were confirmed when operator was running into the MCR and yelling we're being flooded with seawater".

- "As the tsunami engulfed us, the emergency power became unusable and lights in the MCR were reduced to one emergency light (making it possible to just barely see within the darkness)."

- **"We lost the power, and I felt that we could not do anything. The other operators looked nervous. They yelled, "we can't do anything, why are we still here!?" However I bowed my head and asked them to remain and they did."**

- "Radiation levels in the MCR rose therefore the Shift Supervisor ordered us to put on the charcoal filtered masks and protective suits. We moved closer to the Unit 2 side where radiation levels were lower and continued to monitor the situation."

[Confirming reactor building equipment in the darkness]

- "The ERC at the power station asked me in the MCR to confirm the operating of RCIC, **however that was not easy. Normally it only takes a few minutes, however it required 45 minutes to an hour, because fastening a self-contained air unit took 10 to 15 minutes. Performing in the field took 30 minutes, returning to the MCR, taking off all the equipment, and going back to the MCR for the report.**

  It would not have taken as long if we had **some communication measure.** Aftershocks were continued, and there was still the possibility of another tsunami would arrive."

<Self-contained air unit>

<Working in the darkness>

Taken the Service Building entrance from the inside.
The floor was cluttered with objects.

[The difficulty of venting]

- "Because the power was lost, we had to vent by manually opening the valves.

  However, due to high radiation exposure in the field we had to gather who could engage in venting work, and the Shift Supervisor allocated each team .

  Even though we had full protective gear, **the radiation levels were quite high therefore we did not let young operator go."**

- "We went into the field in order to open the vent valves. When we were at the near the torus room, we heard a large, weird popping sound. The valve is at up high, so I put my foot on the torus to lift myself up. Then**, my black rubber boot was melted like butter."**

Monitored by the Assistant Shift Supervisor

The Assistant Shift Supervisor at the desk monitored plant data and information wearing a full face mask in the total darkness.

Checking Instrument Gauges

Checking instrument gauges in the total darkness with only a flashlight to depend on.

[Others]

- "Some large aftershocks caused us to **flee to high level ground many times out of fear of dying while still wearing the full face mask."**

- "That was only way to restore the instruments at that time due to loss of time. Car batteries were begun to gather.

  However, carrying the batteries was difficult due to their weight. **It was the worst situation ever."**

- "Normally, laying cables requires one to two months; however, it was completed in only a couple of hours. **Also, we had to find the penetration seals in the darkness and splice the ends. With the puddles of water around, we thought we were going to get electrocuted."**

Temporary Instrument Power

Temporary batteries were connected to power control room instruments due to loss of power.

Installing Temporary Power

Workers who are not working for electrical system were called out to manually lay the power cables

Obstacles on access routes

Fire hoses caused detour for access. After the explosion, debris and damaged fire engines become additional obstacles.

End