The 4th Progress Report
on the Investigation and Examination of
Unconfirmed and Unresolved Issues
on the Development Mechanism
of the Fukushima Daiichi Nuclear Accident

December 17, 2015
Tokyo Electric Power Company, Inc.
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1. Overview of the Fukushima Nuclear Accident

To date, TEPCO has compiled the following documents to summarize the Fukushima Nuclear Accident:

**Fukushima Nuclear Accident Investigation Report**
(Provides details on the facts related to conditions before and after the Fukushima Nuclear Accident)

**Nuclear Safety Reform Plan**
(Analyzes organizational causes that served as a backdrop for the accident, as well technical causes of the accident)

- Elucidated the root causes of the Fukushima Nuclear Accident
  → Kashiwazai-Kariwa NPS: Implemented safety countermeasures to prevent the occurrence of a severe accident

- TEPCO compliance with new safety regulations
  → Nuclear Regulation Authority: Each measure discussed and confirmed at review meetings.
2. Positioning of this report

Accident investigations to date have made it clear that the accident occurred because of a widespread loss of safety function caused by the tsunami that occurred after all external power had been cut off by the earthquake, and that escalation of the accident thereafter was not able to be stopped due to the lack of advanced accident prevention preparation.

After reviewing the details of various accident investigations conducted by other agencies and organizations, including TEPCO, the Nuclear Regulatory Agency’s accident analysis review committee determined that the primary causes of the accident are the same as those above determined by TEPCO.

⇒ The Kashiwazaki-Kariwa NPS has implemented safety countermeasures based on these results.

This report compiles the results of investigations and deliberations conducted from the viewpoints mentioned above. This is the forth progress report following those given in December 2013, August 2014 and May 2015.
3. Investigation/Deliberation History

52 issues were identified as being unsolved events related to the detailed development of the incident following the accident.

Issues examined in the first report

Almost Completed. 10 issues*

High-priority issues to understand the development mechanism (priority high)
5

Issues that help to understand the development mechanism (priority not so high)
5

High-priority issues to understand the development mechanism (priority high)
10

Issues that help to understand the development mechanism (priority not so high)
34

Two of these issues are still being examined

Issues under examination related to the second report: 4
Issues under examination related to the third report: 2 (one of the issues is examined in field survey)
Issues under examination related to the fourth report: 4

Issues under examination related to the second, third and fourth reports: 9 (some cases in cooperation with external researchers)

The conclusions of 10 priority issues have been drawn. For continuous improvement in safety, we will keep on on-site investigations and new investigations.

*The ten issues include the issues the causes of which have been reexamined through additional investigations. The second report and the reports thereafter examine the development mechanism.
4. Progress made in the examination of ten high-priority issues

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<th>Issues reported on in the second progress report</th>
<th>Issues reported on in the third progress report</th>
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<td>Factors in the shutdown of the reactor core isolation cooling system at Unit 3</td>
<td>Success or failure of Unit 2 containment vessel venting (Rupture disk status of Unit 2)</td>
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<td>Evaluation of HPCI system operational state at Unit 3 and its impact on the accident’s progression</td>
<td>Cause investigation of dose increase around March 20th</td>
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<td>Rise in reactor pressure following forced depressurization at Unit 2</td>
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<td>Improving the accuracy of our estimate of the volume of cooling water injections from fire engines into the nuclear reactor</td>
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<tr>
<td>Issues covered in the current report</td>
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<tr>
<td>Investigation into safety relief valve (SRV) operations after reactor core damage</td>
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<tr>
<td>Behavior of molten fuel when dropping to the lower plenum (Dropping of melted reactor to the lower plenum)</td>
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<td>Thermal stratification in the suppression pool at Unit 3</td>
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<tr>
<td>High-dose contamination measured around the vicinity of particular pipes in Unit 1 Reactor Building (Identification of causes of the high-dose contamination of pipes of the reactor cooling water (RCW) system in Unit 1)</td>
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5. Major Points of the Fourth Progress Report

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<th>High-priority issues to understand the development mechanism</th>
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<tr>
<td>1. <em>Investigation into safety relief valve (SRV) operations after reactor core damage</em></td>
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<td>The SRVs at Units 2 &amp; 3 were opened to achieve and maintain the RPV pressure low. However, there were cases in which reduction in pressure was not confirmed. The investigation into the cause of it has revealed the importance of security of both power supply and nitrogen gas supply system.</td>
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<td>2. <em>Behavior of molten fuel relocation from the core region to the lower plenum</em></td>
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<td>The behavior of molten fuel relocation from the reactor core to the lower plenum at the BWR plant has not been identified due to the structural complexity of lower region in the reactor core. Thus, by analyzing previous experiments and the results of the latest research for enhancement of the severe accident analysis code, the behavior has been examined.</td>
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<td>3. <em>Thermal stratification in the suppression chamber at Unit 3</em></td>
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<td>The measurement results of the pressure in the PCV of Unit 3 on March 11 and 12, 2011 revealed that it elevated at a rate faster than that which could be estimated based on the decay heat. The analysis of the measurement data and related knowledge has reconfirmed the possibility that thermal stratification was developed in the suppression chamber.</td>
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<tr>
<td>4. <em>High-dose contamination measured around particular pipes in the Reactor Building of Unit 1</em></td>
</tr>
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<td>High dose rates of radiation have been observed in the vicinity of the RCW system of Unit 1. The examination of the radiation dose levels inside the Reactor Building and the like, and of the RCW piping has supported the presumption that the high level of contamination was caused as a result of the molten fuel falling down to the PCV and damaging the pipes of the system inside the PCV.</td>
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<td>5. <em>Leakage and release of a large amount of steam from the Unit 3 Reactor Building</em></td>
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<td>The PCVs of Units 2 &amp; 3 lost the airtightness in the end, which is confirmed by the fact that steam escaped from the Reactor Buildings. Analysis of the behavior of the pressure in the PCVs and the situation at the time of the accident has revealed that the environmental contamination from the night of March 14 to March 16 occurred by steam leakage together with radioactive materials directly from the PCVs not from the vent.</td>
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<td>6. <em>Presumption of behavior of radioactive materials based on measurement data of CAMS in Unit 2</em></td>
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<td>In the 3rd progress report, how the Fukushima Daiichi accident unfolded was presumed based on the measurement data of the CAMS in Unit 2. The presumption has been supported by the results of the quantitative assessment of the behavior and distribution of radioactive materials in circumstances where the measurement data could be reproduced.</td>
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6. Sharing insights and engaging in discussion with researchers from Japan and overseas

The Atomic Energy Society of Japan meetings/International meetings

We have given presentations on study results at academic and international meetings. We have been fortunate to receive awards for these presentations. We will continue our examination while considering comments that have been made and other achievements gained through these activities.

Presentation
AESJ meeting: Spring and Fall meeting 2014-2015
International meeting:
NURETH (Nuclear Reactor Thermal Hydraulics) 15th meeting, 2013
NUTHOS (Nuclear Thermal Hydraulics, Operation and Safety) 9th meeting, 2012 and 10th meeting, 2014
International Workshop on Severe Accident Research, Tokyo Univ.

OECD/NEA BSAF Project

We have shared our study results and accident information with BSAF project members. Comparing simulation results obtained from domestic and foreign researchers and exchanging opinions are helpful in our examination of unsolved issues.

 OECD/NEA: The Organization for Economic Co-operation and Development/The Nuclear Energy Agency
BSAF: “Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Station” has been established to improve severe accident codes and analyze accident progression and current core status in detail for presentation of fuel debris removal, as a part of the R&D projects for the mid-to-long term response for decommissioning of the Fukushima Daiichi. The first phase has been in completion in 2014 fiscal year, and the second phase has already begun.

Nuclear Regulation Authority, Japan
The Committee on Accident Analysis

We explained our evaluation of the tsunami arrival time and the cause of the loss of all power sources, which is mentioned in the interim report made by the NRA. We will continue our examination using the results from field investigations and the analysis results from the Committee.

Niigata Prefecture Technical Committee

We have explained the issues regarding questions and points of interest from the governor and committee members during the discussion at the Niigata Prefecture technical committee meeting on the verification of the Fukushima Daiichi accident and safety measures at Kashiwazaki-Kariwa NPS.

We are continuing our investigation while considering discussions and opinions with and from various organizations and researchers.