Current Status and Challenges at Fukushima Daiichi

@HOTLAB 2017, Mito, Japan

15 September, 2017
Noriyuki Saito
Today’s Topics

1. Current Status of Fukushima Daiichi NPS
2. Three Policies for Measures to Counter Contaminated Water
3. Fuel Removal from the Spent Fuel Pools
4. Toward Fuel Debris Removal
5. Waste Management
1. Current Status of Fukushima Daiichi NPS
(1) State of Units 1~4

- All reactors are in cold shutdown condition.
- Plant parameters including RPV and PCV temperatures are monitored continuously 24 hours/day.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Temperature at the bottom of the pressure vessel</th>
<th>Temperature inside the containment vessel</th>
<th>Fuel pool temperature</th>
<th>Reactor coolant volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>24°C</td>
<td>25°C</td>
<td>31°C</td>
<td>2.9 m³/hour</td>
</tr>
<tr>
<td>Unit 2</td>
<td>24°C</td>
<td>31°C</td>
<td>30°C</td>
<td>2.8 m³/hour</td>
</tr>
<tr>
<td>Unit 3</td>
<td>24°C</td>
<td>28°C</td>
<td>31°C</td>
<td>2.9 m³/hour</td>
</tr>
<tr>
<td>Unit 4</td>
<td>—</td>
<td>—</td>
<td>27°C</td>
<td>—</td>
</tr>
</tbody>
</table>

Values as of 11:00 am on June 14, 2017

Reactor coolant volumes were reduced from 4.5 m³/hour to 3.0 m³/hour in this year.
Compared to the situation just after the accident, the current level of radioactivity has been lowered to parts per hundred thousand, to per million.

The concentrations outside the port are substantially below regulation limits.

Concentration levels decreased further after closure of the sea-side impermeable wall.
(3) Airborne Radiation Level

- Estimated exposure dose at site boundary attributable to radioactive materials released from Units 1 to 4 has decreased to approx. 0.00034 mSv/y as of Feb. 2017 which is about one-5,000th compared to the estimated value in Jul. 2011 (approx. 1.7 mSv/y).

Amount of radioactive materials (cesium) released from Units 1 to 4 is estimated based on airborne radioactive material concentrations at top of reactor buildings.

- Estimated value of total release amount (As of Feb. 2017): approx. 77,000 Bq/hr

- Accordingly, estimated the exposure dose at site boundary at maximum 0.034 mrem/y (Excluding effect of already released radioactive materials)

![Graph showing exposure dose by radioactive materials (cesium) from Units 1 to 4]
(4) Decreasing Site Radiation Dose

As a result of radiation reduction measure, workers don’t have to wear full-face respirator or half-face respirator anymore in most parts of the site.

Decreasing radiation dose

<table>
<thead>
<tr>
<th>Area confirmed below 500μrem/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2013</td>
</tr>
<tr>
<td>FY2014</td>
</tr>
<tr>
<td>As of Dec. 2015</td>
</tr>
<tr>
<td>As of Mar. 2016</td>
</tr>
</tbody>
</table>

Personal protective equipment in each zone

- **R zone**: Area with anorak and full face mask
- **Y zone**: Area with coverall
- **G zone**: Area with general work uniform

- **Full-face Respirator**
- **Half-face Respirator**
- **General Uniform**

Workers in the G zone

Green zone equipment
(3) Worker Security

Currently about 6,000 persons/day are working on weekdays, which is twice as many as several years ago. Facilities such as Contractors’ Office Building have created the environment where TEPCO and contractors can address the decommissioning work closely in the vicinity of the decommissioning site.

Changes in number of workers

- Number of workers (TEPCO employees and contractors) per weekday engaged in work is 6,110 as of Feb. 2017.
- Percentage of workers from local area is approx. 55% as of Feb. 2017.

Radiation exposure regulation (Japan)
10rem/5years (100mSv/5years)
5rem/year (50mSv/year)
2. Three Policies for Measures to Counter Contaminated Water
(1) Three principles for Measures to Counter Contaminated Water

Three Principles

① Removing source of contamination
② Isolating fresh water from contaminated areas
③ Preventing leakage of contaminated water

① Purification with multi nuclide removal equipment (ALPS)
② Pump up of groundwater through groundwater bypass wells
③ Augmentation of tanks
③ Pump up of groundwater through subdrain
② Ice Wall (Frozen soil wall)

① Removal of contaminated water from trenches
② Paving to prevent rain water seepage into soil
③ Ground improvement with liquid glass
③ Sea-side Impermeable Wall

Water treatment facility for Subdrain & Groundwater drain

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved
Freezing pipes have been installed 1m apart (30 m deep).
As of July 2017, all but one place is in freezing mode.
Combined with subdrain system, Ice Wall blocks the flow of groundwater into the buildings by controlling the level of groundwater. It also helps remove the contaminated water in the buildings.
In order to prevent contaminated water in R/B and T/B from escaping, TEPCO constantly monitors the water level to ensure that groundwater always keeps higher than water level inside the buildings.

A place where freezing has not been undertaken

Seaside Impermeable Wall

Ice Wall (Seaside line)

Ice Wall (landside line)

Temperature Distribution

(Seaside)  (Landside)

As of 7 A.M. Jun. 27th, 2017
Many tanks are constructed everyday, but contaminated water also increases everyday. (Approx. 150m³ per day)
3. Fuel Removal from the Spent Fuel Pools
(1) Fuel Removal from the Spent Fuel Pool (Unit 1)

- Building cover was installed in Oct. 2011 to prevent dispersion of radioactive materials.
- Dismantling of the cover was completed in Nov. 2016 toward removal of spent fuel.
- Fuel removal will start in FY 2020.

### The status in 2011

- **Northwest side (Jun. 2011)**
- **Southeast Side (Jun. 2011)**

### The current status (Dismantling)

- **Complete installation of building cover (Oct. 2011)**
- **Removal of wall panels (Sep. 2016)**
- **Removal Completion (Nov. 2016)**

### Major Tasks in the Future

| 1. | Removal of Panels (Complete) |
| 2. | Removal of rubble |
| 3. | Decontamination |
| 4. | Shielding |
| 5. | Installing Cover & Fuel Handling Machine |
| 6. | Undertaking Fuel Removal |

※Currently investigation of rubble status on the refueling floor is underway.
(2) Fuel Removal from the Spent Fuel Pool (Unit 4)

- Fuel removal started on November 18, 2013.
- Removal of 1535 fuel bundles completed on December 22, 2014 as scheduled.
- No risk from fuel remains at unit 4. This gives confidence to proceed to fuel removal at units 1, 2 and 3.

September 22, 2011

Process of removing fuel rods at SFP Unit 4

July 5, 2012

November 12, 2013: Completion of fuel removal facility. (The volume of steel used is equivalent to those of Tokyo Tower.)
Removal of large pieces of rubble on the refueling floor and spent fuel pool was completed in 2015.
Decontamination work was completed in June 2016 and shielding was completed in December 2016.
In January 2017, the work for installing fuel removal cover started.
Fuel removal will take place in the middle of FY2018.

**Major Tasks in the Future**

1. **Shielding (complete)**
2. **Installing Cover & Fuel Handling Machine**
3. **Undertaking Fuel Removal (Middle of FY2018)**

燃料移出し用カバー

Fuel removal cover (Drill for installment at Onahama)

※Installing cover started in January 2017
5. Toward Fuel Debris Removal
It is assumed that at Unit 1, almost all fuel debris has dropped to the pedestal.

It is assumed that at Unit 2 and 3 that some of fuel debris has dropped to the bottom of RPV and the bottom of PCV, while others are likely to have remained in the reactor cores.

At Unit 3, underwater investigation is planned due to the high water level inside PCV.

Distribution of fuel debris is assumed comprehensively based on the analysis of accident development and the results of the investigation inside each PCV etc.

At the time of investigation, deposits have been found on the floor.

- Probe robot in Mar. 2017
- Probe robot in Feb. 2017
- Remotely operated vehicle in Jul. 2017
Investigation inside the PCV and at the bottom of the RPV was conducted. (from Jan. to Feb. 2017)

- X-6 through-hole was used as a path for devices to go inside.
- Equipment at the lower part of the RPV and the grating were observed.

Survey by a robot

<Obtained information on radiation level through robot exploration>

Pre-survey

<Photos taken inside the pedestal>

Places where fuel debris is presumed to exist

CRD

堆積物

Places where fuel debris is presumed to exist

Lower part of CRD

Grating

Distortion of grating

1m

1m

Approx. 210Sv/h

Opening of Pedestal

CRD replacement rail

X-6 through-hole

Pedestal

Guide Pipe

CRD Replacement Rail

X-6 through-hole

Deposits

Camera

Deposits

Lower Part of RPV

Lower Part of CRD

Pedestal

IRID

PCV

RPV

CRD
(2) Investigation inside the Primary Containment Vessel (Unit 2)②

- Deposits were too hard to remove completely.
- Self-propelled robot couldn’t run into pedestal because left crawler belt couldn’t move.

Investigation by self-propelled robot

Deviations from X-6 penetration direction:
- Deposits were too hard to remove completely.
- Self-propelled robot couldn’t run into pedestal because left crawler belt couldn’t move.

Pedestal direction

CRD rail (30mm)

Approx. 2m from X-6

X-6 penetration direction

21000rem/h

CRD rail

Opening of Pedestal

Pedestal

PCV
RPV
CRD

X-6 penetration
(3) Current Radioactive Impact on the Environment

- Radiation in the reactors is blocked by iron and reactor buildings.
- The measurement of 210Sv/h at the time of Unit 2 PCV investigation on Feb. 16 doesn’t mean that radiation had an impact on the environment.

No change in dose rate has been found after the work.

![Graph showing dose rate over time](image)

**Monitoring posts**
- Approx. 0.9〜1.2m
- Approx. 1.7m (PCV investigation)
- Approx. 2.6m
- Approx. 7.6m (reinforced concrete)

**Work area in the vicinity of the through-hole at Unit 2**: Approx. 0.003〜0.007Sv/h (3〜7mSv/h)

**Max value of monitoring posts**: Approx. 0.000002Sv/h (2μSv/h)

※The data regarding thickness is from Unit 1.
5. Waste Management
Without additional volume reduction, solid waste storage volume will reach about 750,000m³ on 2028.

- Mar 2016 Start of incineration of used protective clothing in Incinerator

Note: Not include the waste volume from fuel debris removal and demolition of reactor/turbine building.
By 2028, outdoor tentative storage areas eliminated except those for low contaminated rubble and contaminated soil.
(3) Blueprint in the future

Image of the establishment of systems and facilities

- Additional incineration facilities
- Incinerator pretreatment system
- Additional solid waste storages No. 10 through 13 buildings
- Tentative storage facilities for contaminated soil
- Miscellaneous solid waste incineration facility
- Large waste storage facility
- Volume reduction facility system

Current Status (June 20, 2017)
Thank you for your kind attention!
(1) Investigation inside the Primary Containment Vessel (Unit 2)

Step 1. Drilling

Drill machine

Hole saw

Step 2. Pre-investigation (CRD rail)

X-6 penetration

1/26/2017 Done

CRD rail

Step 3. Pre-investigation (Inside of Pedestal)

1/30/2017 Done Pedestal

X-6 penetration

CRD rail

Step 4. Remove deposits on CRD rail

Chamber Unit

2/9/2017 Done

Step 5. Internal investigation by self-propelled machine

Chamber Unit

2/16/2017 Done

Deposit Remover

Self-Propelled machine

Camera

Operation area maximum 48rem/hour
(1) Investigation inside the Primary Containment Vessel (Unit 2)

- Deposits on the RPV grating and CRD rail could be seen.
- Undamaged part of the RPV and distortion of the grating could be seen.

Pre-Investigation

- Pedestal
- Guide Pipe
- Lower Part of RPV
- X-6 opening
- CRD Rail
- Lower Part of CRD
- Deposits
- Camera
- Deposits

Green Area
The position of CRD contents could be confirmed

Yellow Area
The position of CRD contents couldn’t be confirmed

Red Area
Grating Distortion Area

Blue Area
Grating Remnant Area

Distortion of grating

©Tokyo Electric Power Company Holdings, Inc. All Rights Reserved
A robot inserted through X-100B penetration dropped a camera from the grating on the first floor using a cable and investigated the situation around the bottom of PCV. The deposits on the bottom of PCV were sampled and analyzed by simple fluorescent X-ray analysis.
Dose rate decreased upon submerging into the water, but then rise again as the floor was approached.

Uranium energy peaks were detected, but Pu energy peak wasn’t detected.