Current Status of Strategic Plan for Solid Waste Management of Fukushima Daiichi

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International safety principles on radioactive waste management

- All steps prior to disposal (predisposal) shall be managed safely and securely to ensure the safe disposal of waste.
- Processing shall be based on appropriate consideration of the characteristics of the waste and of the demands imposed by the different stages in its management (pretreatment, treatment, conditioning, transport, storage, and disposal).
- If waste processing is performed before the waste disposal requirements are set, it must be remaining possible to process the waste in a way which meets those requirements once they have been set.

Predisposal Management

- Segregation
- Storage
- Processing (Pretreatment, Treatment, Conditioning)
- Storage
- Disposal
Recent Advances in Solid Waste Management

- Reduction of solid waste generation is continued. Incineration of used protective clothing in Incinerator started to reduce storage volume.

- Waste management plan is reviewed regularly.

- Waste characterization based on collected analytical data.
Solid Waste arising from Accident at Fukushima Daiichi

- Waste Characteristics; Different from ordinary waste due to accident
  ⇒ Characterization is important
- Limited Data (especially for long-lived nuclides) is available because of contamination over wide area and high dose environment
- Forecast of waste generation is difficult because decommissioning activities will be clarified gradually

- [Debris/felled trees, etc.]
  - Debris
  - Fallen trees
  - Soil
  - Large quantity and spread over wide area
  - Insufficient past experience of processing and disposing of trees and soil

- [Secondary waste stemming from treatment of contaminated water]
  - Contaminated water
  - Secondary waste
  - Pipes for replacement, reservoir, etc.

- [Waste from Fuel debris Retrieval]
  - Large quantity and high dose
  - Access is difficult at present and collecting raw waste is difficult.
  - Insufficient past experience of processing and disposal
  - Collecting raw waste is difficult.
  - Quantity of some waste and nuclides can be estimated depending on the feature of equipment.
# Temporary storage volume of rubble etc.
## (As of April 30, 2017)

### Rubble

<table>
<thead>
<tr>
<th>Surface dose rate (mSv/h)/</th>
<th>Measure of store</th>
<th>Storage Volume (m³)</th>
<th>Storage Volume(m³) / Capacity (m³) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.1</td>
<td>Outdoor storage</td>
<td>147,900</td>
<td>147,900/214,300 (69%)</td>
</tr>
<tr>
<td>≤ 1</td>
<td>Outdoor Sheet covered storage</td>
<td>30,900</td>
<td>30,900/71,000 (44%)</td>
</tr>
<tr>
<td>1-30</td>
<td>Soil covered temporary storage facility, Temporary storage tent, Outdoor container storage</td>
<td>20,800</td>
<td>20,800/27,700 (75%)</td>
</tr>
<tr>
<td>&gt;30</td>
<td>Container (in Solid waste storage building)</td>
<td>8,300</td>
<td>8,300/12,000 (69%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>207,900</td>
<td>207,900/325,000 (64%)</td>
</tr>
</tbody>
</table>

### Felled tree

<table>
<thead>
<tr>
<th>Category</th>
<th>Measure of store</th>
<th>Storage Volume (m³)</th>
<th>Storage Volume(m³) / Capacity (m³) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root</td>
<td>Outdoor storage</td>
<td>79,500</td>
<td>79,500/144,500 (55%)</td>
</tr>
<tr>
<td>Branch/leaves</td>
<td>Temporary storage pool</td>
<td>19,600</td>
<td>19,600/24,900 (79%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>99,100</td>
<td>99,100/169,400 (59%)</td>
</tr>
</tbody>
</table>

### Used protective clothing

<table>
<thead>
<tr>
<th>Measure of store</th>
<th>Storage Volume (m³)</th>
<th>Storage Volume(m³) / Capacity (m³) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container</td>
<td>67,500</td>
<td>67,500/71,200 (95%)</td>
</tr>
</tbody>
</table>
### Temporary storage volume of Secondary Waste from Water Treatment (As of May 18, 2017)

#### Absorbent Columns

<table>
<thead>
<tr>
<th>Storage place</th>
<th>Storage Number</th>
<th>Storage Number / Capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor temporary storage area of used vessels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesium Absorption apparatus</td>
<td>758</td>
<td></td>
</tr>
<tr>
<td>2(^{nd}) Cesium absorption apparatus</td>
<td>188</td>
<td></td>
</tr>
<tr>
<td>HICs from multiple radio-nuclides removal system</td>
<td>1,365</td>
<td></td>
</tr>
<tr>
<td>HICs from improved multiple radio-nuclides removal system</td>
<td>1,044</td>
<td></td>
</tr>
<tr>
<td>Used vessels from high-performance multiple radio-nuclides removal system</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>Used column from multiple radio-nuclides removal system</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Used vessels and filters from mobile-type strontium system</td>
<td>191</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3628/6239 (58%)</td>
<td></td>
</tr>
</tbody>
</table>

#### Sludge and concentrated waste liquid

<table>
<thead>
<tr>
<th>Name of waste</th>
<th>Storage</th>
<th>Storage Volume (m³)</th>
<th>Storage Volume(m³) / Capacity (m³) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge</td>
<td>Sludge storage facility (Indoor)</td>
<td>597</td>
<td>597/700 (85%)</td>
</tr>
<tr>
<td>Concentrated waste liquid</td>
<td>Concentrated waste liquid storage tanks (Outdoor)</td>
<td>9,379</td>
<td>9,379/10,700 (88%)</td>
</tr>
</tbody>
</table>
Improvement of Waste Management Conditions

- TEPCO HD made plan for Improvement of Waste Management Conditions based on forecast of waste generation during next 10 years.
- In order to reduce risks during storage, the volume of rubbles will be reduced as much as possible, then the wastes will be transferred to inside storage buildings. Finally, outdoor tentative storage will be eliminated by around 2028.

Forecast of Waste Generation
Samples from R/B and T/B have taken (results)

- **Approximately 300 samples have taken**
- **Characterization is insufficient**

**Inside of Reactor Buildings**
- Analyzed rubble and boring cores sampled from 1st and 5th floor of Unit 1 and 2, and 1st floor of Unit 3 (47 Samples)

**Basement of Turbine Building**
- Analyzed sand and sludge sampled from the first basement of Unit 1 (5 samples)
- Analyzed sludge and water sampled from stagnant water in the basement of Unit 1 (8 samples)

**Inside of RPV**
- No sample so far

**Inside of PCVs**
- Analyzed stagnant water sampled from Unit 2 and 3 (4 samples)

**Spent Fuel Pool**
- Analyzed sand gravel sampled from Unit 4 (2 samples)

**Around Reactor Buildings and temporal storage facilities**
- Analyzed rubble around Unit 1, 3 and 4, and rubble from soil covered temporal storage (25 samples)

**Basement of Reactor Building**
- No sample so far
Tendencies of Contamination on R/Bs and T/B

**Inside of RPV**
(High level contamination is expected to be occurred with fuel debris and activation products. No sample so far.)

**Inside of PCVs**
- Tendency of higher radioactivity concentration ratio of $^{60}$Co and alpha emitters against $^{137}$Cs was observed for stagnant water of Unit 2 and 3 compare to that of downstream (Centralized Radiation Waste Treatment Facility).

**Spent Fuel Pool**
- Tendency of higher radioactivity concentration ratio of $^{60}$Co (activation product) against $^{137}$Cs was observed for Unit 4 compare to samples from inside of other R/Bs.

**Around Reactor Buildings**
- Tendency of similar nuclide composition of contamination was observed for rubble around Unit 1 and 3 with samples from inside of R/Bs.

**Inside of Reactor Buildings**
- Fission products (e.g. $^{137}$Cs, $^{90}$Sr), alpha emitters (e.g. Pu) and activation products (e.g. Co) were detected from samples from 1st and 5th floor of Unit 1 and 2, and 1st floor of Unit 3.

**Basement of Turbine Building**
- Tendency of higher radioactivity concentration ratio of $^{90}$Sr against $^{137}$Cs was observed compare to samples from inside of R/Bs.
- Tendency of containing Cs, Sr and alpha emitters was observed for sedimented sludge.

**Basement of Reactor Building**
(Contamination is expected to be occurred by stagnant water. No sample so far.)

*Tendencies of contamination were presumed based on results of radiological analysis of samples. It is necessary to keep on confirming the tendencies through sampling and analyzing data aftertime.*
Improvement of Predisposal Management

- Safe predisposal management is essential to ensure the safe disposal.
- Collection and storage of waste are basis.
- Stabilization of slurry, sludge etc. is favorable.
- Processing should be performed to meet waste disposal requirements.

Current status of 1F

Segregation → Storage

Processing Requirements

Processing
Pretreatment, Treatment, Conditioning

Storage

Disposal Requirements

Storage → Disposal

Complete Picture of 1F Waste

More stable or safer
Issues to clarify Complete Picture of 1F Waste

- Promotion of Characterization
  - Continuation of Sample Collection and Analysis (sampling from high dose area)
  - Optimization of Characterization
  - Representativeness of sample
  - R&D of Analytical Method
  - Consideration of Effect by Non-radioactive Material

- Clarification of Waste Amount
  - Confirmation of Decommissioning Plan
  - Selection of Processing Method
Improvement of Analytical Capability

➢ Radioactive Material Analysis & Research Facility
  ◆ Analysis facility for radioactive wastes, fuel debris, etc.
  ◆ Installed analysis devices to obtain data that can contribute to the appropriate processing of radioactive waste.
  ◆ Installed equipment that can obtain basic data of fuel debris, which are high level radioactive waste.

Source: TEPCO website and photo archive

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Action Policy for Solid Waste Management (draft)

- Thorough Containment and Isolation

- Processing is to ensure Safe Disposal
  → Focus on Predisposal Management because the Realization of Disposal is impossible at this time
    ◆ Reduction of amount of solid waste
    ◆ Promotion of characterization
    ◆ Through storage

- Preceding Processing Technologies in consideration of Disposal
  Stabilization & immobilization may be possibly required before the waste disposal requirements are set
  → Minimize the possibility which does not meet those requirements once they have been set.

Promotion of R&D based on Action Policy
Concluding Remarks

- Characteristics of contamination has partially estimated based on collected analytical data.

- Focus on characterization, safe storage, and preceding processing technologies until disposal would be realized.

- Propose to contribute to the basic concept of processing and disposal for radioactive solid wastes based on international safety principals and issues arising from R&D (Technical Strategic Plan 2017)
Thank you for your attention!