Development of technologies for the processing and disposal of radioactive waste

International Experts' Symposium on the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Plant Unit 1-4

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Outline

Feature of radioactive waste in Fukushima Daiichi NPP

- Highly contaminated debris by hydrogen explosions
- Secondary waste by treatment of contaminated water (zeolite waste, sludge, etc.)

We will need to

✓ study of properties
✓ evaluate for long-term storage
✓ develop new technologies for the processing and disposal

Introduction of the R&D plan and the its progress
1. Radioactive waste in Fukushima Daiichi Nuclear Power Station
Characteristics of the waste after the accident

● Influence of injected sea water
  ➢ Sea water affect disposal, corrosion
  ➢ Influence of injected chemicals to protect corrosion

● Influence of injected boron, etc.
  ➢ Boron affect the environment (consider when disposal)

● A great variety of radioactive waste
  ➢ Radioactive materials were carried by hydrogen explosions
  ➢ Non radioactive waste change into radioactive waste

● Influence of core melt down
  ➢ Nuclides originated fuel distributed various place in plant
  ➢ All waste is treated as trans-uranium waste ??

R&D consider these characteristics
# Example of radioactive waste

<table>
<thead>
<tr>
<th>Scene</th>
<th>Waste</th>
<th>Dose rate [mSv/h]</th>
<th>Volume of the waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment for contaminated water</td>
<td>Sludge</td>
<td>Approx $10^3$</td>
<td>581 m$^3$</td>
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<tr>
<td></td>
<td>Zeolite</td>
<td>Approx $10^1$</td>
<td>346 vessel</td>
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<td></td>
<td>Concentrated liquid waste</td>
<td>Approx $10^2$ beta ray</td>
<td>Approx 105,000 m$^3$</td>
</tr>
<tr>
<td>Actives for plant restoration</td>
<td>Debris</td>
<td>Approx $10^{-3}$ to $10^3$</td>
<td>Approx 34,000 m$^3$</td>
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<tr>
<td></td>
<td>Logged tree, Soil</td>
<td>Approx $10^{-3}$ to $10^{-1}$</td>
<td>Approx 59,000 m$^3$</td>
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<tr>
<td></td>
<td>Liquid waste from decontamination</td>
<td>Investigation from now on</td>
<td>—</td>
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<tr>
<td>Dismantling</td>
<td>Waste from decommissioning, decontamination</td>
<td>Investigation in the future</td>
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</table>

As in the second week of Feb., 2012
Secondary waste produced by the treatment of contaminated water (example)

Sludge (made by JAEA)

Cesium adsorption vessel

Tank for concentration liquid waste

Zeolite
Debris (example)

Between Unit 2 and 3

Area of accumulated debris

removal

Inside of tent
2. Outline of R&D roadmap – towards the disposal –
Framework for R&D

● Planning R&D and progress management
  “Research and Development Headquarters” will be planning and progress management overall of R&D
  • Working team for radioactive waste processing and disposal
    ➢ ANRE
    ➢ TEPCO
    ➢ JAEA
    ➢ Relevant knowledge and experience, etc.

● Performing R&D
  R&D and analysis are performed by JAEA
# Outline of R&D roadmap

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<td>Waste sampling and analysis</td>
<td>Waste sampling and analysis continued</td>
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<td>Revision of R&amp;D plan</td>
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<td><strong>R&amp;D</strong></td>
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<td>Holding points</td>
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<td>9</td>
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<td>Measures for long-term storage</td>
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<td>Applicability of existing disposal concepts</td>
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<td>Prospects for disposal</td>
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<tr>
<td>Perform and improve the safety of processing and disposal</td>
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<tr>
<td>Planning for storage container renewal</td>
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<tr>
<td>Establishment for laws, regulations, and technical standard</td>
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<td>Installation of equipment for production of waste packages</td>
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<td>Perform the disposal</td>
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<td><strong>Using results</strong></td>
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<td><strong>Holding points (HP):</strong></td>
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<tr>
<td>HP 8: Verification of applicability of existing concepts</td>
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<td>HP 9: Verification of prospects for safety</td>
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</table>
1. Goals in the near future (from 2012 on)
   - Verification of storage (hydrogen, heat generation)
   - Evaluation for container life
   - Measures for long-term storage
   - Planning for detail of R&D plan

2. Confirm the properties of actual wastes
   Analysis for few waste (planning)
   - Radioactive, Chemical component, etc.
   Because of difficulty for actual zeolite sampling, the properties evaluated from result of analysis for treated water.

3. Evaluate for applicability of existing concepts
   - Prospects for disposal for typical waste
   - Identification of problems for typical waste disposal
Until HP 9

1. **Confirm the properties of actual wastes**
   Expand number of results for waste analysis and kinds of waste, Perform actual waste (ex. Zeolite)

2. **Solution for problems**
   Problems regarding existing technologies

3. **Confirm of prospects for safety**
   Compared with the HP 8
   ✓ Condition of safety evaluation is more detailed
   ✓ Prospects for solution to major problems are verified
After HP 9

1. Establishment for laws, regulations, and technical standard

2. Installation of equipment for production of waste packages

3. R&D for dismantling wastes
   Confirm the properties of wastes from decommission, decontamination, etc. that produced after HP 9 and R&D for the waste

4. Perform the disposal
   - Site selection
   - Safety evaluation
   - Waste transportation, etc.
3. Goals in the near future and progress of R&D —Secondary waste produced by the treatment of contaminated water—
R&D for Secondary waste produced by the treatment of contaminated water

<table>
<thead>
<tr>
<th>Actives for plant restoration (Outline)</th>
<th>Phase 1</th>
<th>Phase 2</th>
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<tbody>
<tr>
<td>Installation of new system</td>
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<td>Sludge, Zeolite, etc.</td>
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Storage for secondary waste

Stability storage continued

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<th>Facility renewal plan</th>
<th>Long-term storage start about 2021 (as needed)</th>
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Development of technologies for processing and disposal of secondary waste produced by the treatment of contaminated water

Confirm the properties

Long-term storage

Produced waste package

Applicability of existing disposal concepts

Solution for problems

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Contaminated water treatment system / Sampling points for radioactive analysis

- Instead of actual waste sampling, the properties evaluated from result of analysis for treated water

- We are considering to sampling method for sludge
Selection for target nuclides on analysis

Selected important nuclides for safety evaluation: L1, L2, L3, High level waste, Trans-uranium waste

Low level waste
- Trench disposal (L3)
- Pit disposal (L2)
- Yoyusindo disposal (L1)

High level waste
- Geological disposal

Concrete, metal, etc.
- Asphalt- or Cement-solidified product
- Large-size metal
- Activated metal, resin, Trans-uranium waste, etc.
- Vitrification, Trans-uranium waste, etc.

Ground surface
- 20m
- 50m
- 100m
- 300m over

Figure of disposal concepts in Japan classified by radioactive level
Flow chart for verification of applicability of existing disposal concept

- Results of analysis for wastes
  - Radioactivity of waste, etc.
  - Property of waste package
  - Safety evaluation

- Results of analysis for contaminated waters
  - Evaluation for properties of secondary waste

- Existing property of waste package
- Existing property of disposal technology

Holding point

- Prospects for disposal
- Problems for processing and disposal
- Solution for problems
4. Goals in the near future and progress of R&D —other waste—
# R&D for other waste

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<tr>
<td>Removal of debris from Spent Fuel Pool and upper of Reactor Building (Unit 3)</td>
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<tr>
<td>Decontamination of the inside of the Reactor Building</td>
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<td>Stability storage continued for debris (Prepare storage area / Dose reduction)</td>
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<td>Stability storage continued for secondary waste produced by treated facility renewal</td>
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In 2012

★ Analysis for debris, logged trees, and soils (planning)
★ Planning for detail of R&D plan
5. Challenges for R&D
Challenges

1. **Sampling of debris, logged trees**
   Waste grouping method, Number of sample, Typical sample

2. **Influence and measure for chlorides**
   If we except chlorides in the waste, how treated with chloride isotopes.
   Reasonable disposal method for chloride

3. **Sampling of zeolite inside of cesium adsorption vessel**
   Because of strong structure and high dose rate, it is difficult to sampling and it is necessary for exclusive instrument to sampling

4. **Selection for important nuclides on safety evaluation**
   Especially in this accident, which nuclide we should consider

5. **Systematize and prioritize for processing and disposal of a great variety of waste**