Robot Technology for Nuclear Decommissioning of Fukushima Daiichi NPS

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Introduction

IRID is the Technology Research Association to develop technologies required for the decommissioning of the Fukushima Daiichi NPS

Organization

- R&D Management
  - R&D Management
  - R&D Strategy Planning
  - Administration

- R&D Implementation
  - Over 700 researchers participate in IRID and engage in the R&D projects at their facilities
  - Membership: National R&D Agencies(2) / Manufacturers(4) / Electric Utilities(12)

Scope of business

- Nuclear decommissioning technology R&D
  - Fuel Removal from Spent Fuel Pool
  - Preparation of Fuel Debris Retrieval
  - Treatment and Disposal of Radioactive Waste

- Promotion of cooperation on nuclear decommissioning with international and domestic organizations

- Human resource development

For more information >> http://www.irid.or.jp/en

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What has happened in the Fukushima Daiichi NPS (estimated)

Severe accident analysis code has estimated:

Unit 1:
- Almost all of melted fuel has been fallen down to the PCV pedestal.
- Little fuel has left in RPV.

Unit 2, 3:
- Some part of melted fuel has fallen down to the bottom of RPV plenum and PCV pedestal.
- The other part may has been left inside RPV.
# Fuel debris retrieval plan on Mid-and-Long-Term Roadmap (Unit 2)

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2012</td>
<td>FY2013</td>
<td>FY2014</td>
</tr>
<tr>
<td></td>
<td>FY2015</td>
<td>FY2016</td>
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<tr>
<td></td>
<td>FY2017</td>
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<td>FY2019</td>
<td>FY2020</td>
</tr>
<tr>
<td></td>
<td>FY2021</td>
<td>FY2022</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decontamination of the inside of the R/B</th>
<th>R&amp;D of remote decontamination equipment (1F)</th>
<th>Upper floors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair the part between PCV and R/B</td>
<td>PCV repair (lower part) equipment</td>
<td>Inspection of the lower part of the PCV</td>
</tr>
<tr>
<td>Water filling in the PCV</td>
<td>PCV repair (upper part) equipment</td>
<td>Repair / water filling</td>
</tr>
<tr>
<td>Inspection of the PCV internals/in-core inspection/sampling</td>
<td>R&amp;D of the equipment for inspecting the inside of the PCV</td>
<td>Inspection of the upper part of the PCV</td>
</tr>
<tr>
<td>R&amp;D of fuel debris removing techniques</td>
<td>R&amp;D of technologies for controlling fuel debris criticality</td>
<td></td>
</tr>
<tr>
<td>Fuel debris removal work</td>
<td>Grasping the property of fuel debris</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stable storage, processing/disposal of fuel debris after removal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R&amp;D for the processing of debris</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R&amp;D of safety evaluation technique, technologies for loading, transportation and storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R&amp;D of mock-up processing/disposal technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test &amp; evaluation of actual debris samples</td>
<td></td>
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<td>Establishment of nuclear material accountancy &amp; control measures for the fuel debris</td>
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## Technological Holding Point

1. Defining the repair method of the lower part of the PCV (stop leakage)
2. Defining the method of inspecting the inside of the PCV
3. Defining the repair method of the upper part of the PCV (stop leakage)
4. Completion of water filling of the upper part of the PCV
5. Defining the method for inspecting inside of the core
6. Completion of the preparation of fuel debris storage cans etc.
7. Decision on fuel debris processing/disposal methods
Fuel debris retrieval procedure

Current

Removal of fuel from Spent fuel pool

Submersion method

Investigation of RPV interior
• Location and configuration of fuel debris
• Damage of structural material

Investigation of PCV interior
• Location and configuration of fuel debris
• Damage of Pedestal and PCV

Stop whole water leakage on the PCV

Retrieve the fuel debris at 35m distance

Most favorable approach for minimizing the radioactive exposure of workers

Technology R&D

In-air method

Dose rate
*PCV 100 Gy/h
*RPV 1k Gy/h

*Requirement level for equipment R&D

Ensure boundaries

Operate and maintain the equipment in the PCV boundary

Decontamination of work area and walkway

Investigation and stop of water leakage from PCV

Fuel Debris Retrieval from 2021
Development of technology for remotely operated decontamination in reactor buildings

- For Low Places
  - Suction/blast
  - High pressure water jet
  - Dry ice blast

- For High Places
  - Expand
  - Swing arm

- Contamination condition is the combination of loose material and fixing material
- Dose comes from low place, high place, side wall and hot spot

Ground floor of Reactor Building

For Upper Floors

Each unit is lifted up to the upper floor with the Lifter in continuity

- Compressor Unit
- Decontamination Unit
- Work Unit
Development of technology to identify leakage points in the PCV

Equipment to investigate leakage from the PCV, etc., that take each environment, including elevated locations, high radiation dose areas, narrow spaces, and areas under water are developed.
Development of technology for investigation inside the PCV

Investigation methods and remotely operated devices are now under development to identify conditions inside the PCV and determine the situation regarding fuel debris.

Shape-changing crawler (Unit 1)
- Moving within pipes
- Shape changing
- Moving along flat surfaces
- Camera & Light
- Dosimeter

Small size crawler (Unit 2)
- Coming in the inside of the pedestal via CRD rail
- Camera & Light

【Unit 1】X-100B penetration (φ115mm)

【Unit 2】X-6 penetration

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Visualization method beyond camera

- Laser scan makes 3D picture of the Reactor building interior using a 3D laser scanner that provides 40,000,000 points data per 10 minutes.

- Gamma camera shows the radiation distribution, highlighting hot spots in the pipes.

- Reactor interior survey using the ‘Muon Permeation Method’ includes simulations and images showing equipment passage space from the 1st floor to the torus room.

- Space to pass the equipment from the 1st floor to the torus room can be found.

- Gamma camera shows radiation distribution, with hot spots in the pipes observed.

- Simulation image (90 days) illustrates the reactor interior with a focus on the gamma camera and muon detector placement.