Phase: **Preparation**

Decommissioning Process **"Fuel Debris Retrieval"**
Investigation Subject **"Understanding status inside PCV"**
Issue **"Understanding status of fuel debris"**

Needs

1. Obtaining information on fuel debris locations

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- In order to retrieve fuel debris safely and efficiently, it is desirable to understand where and how much fuel debris exists inside the PCV and where it does not exist. Among the various types of fuel debris, it is also desirable to be able to identify powdered fuel debris and fuel debris that has settled or deposited after dissolution (secondary debris).
- It is desirable that accident progression analysis (on fuel behavior, RPV rupture position, rupture timing, etc.) should be advanced with high accuracy to estimate factors that cannot be clarified by internal investigation.
- Since it is assumed that the initial fuel debris retrieval will be targeted at its surface or its vicinity, it is desirable to understand the debris distribution in three dimensions by combining with accident progression analysis.
- It should be noted that the location, amount, and composition of fuel debris vary among the units due to their different accident progress.
- Current measured values by thermometers or other instruments may also be used to evaluate the location and amount of fuel debris.

Current state against ideal

[Unit 1]

- It is known that almost none is inside the pressure vessel and most has melted down into the containment vessel. So far, investigations have been conducted inside the containment vessel (outside the pedestal, on the grating on the first floor, and in the basement). Comparatively little information on the status of debris is available for Unit 1.
- In the PCV interior survey conducted in 2022, thermal neutron flux and Eu-154 were detected at all survey points outside the pedestal, and no correlation between the distance from the pedestal aperture and the height of the deposit was confirmed for those values. From these results, it was presumed that material liberated from the fuel debris (fuel debris-derived material) was widely present in the survey area.

[Unit 2]

- It is known that there is more at the bottom of the pressure vessel, but less inside the containment vessel. So far, surveys have been conducted inside the containment vessel (inside and outside the pedestal). A relatively rich information is available for Unit 2.

[Unit 3]

- It is known that there is little in the pressure vessel, but some in the containment vessel. So far, surveys have been conducted inside the containment vessel (inside and outside the pedestal), and the survey results indicate that fuel debris leakage out of the pedestal cannot be ruled out.

Issues to be resolved

[Unit 1]

- In addition to the refinement of the existing investigations, the acquisition of new information on the location of fuel debris inside the pedestal and pressure vessel is a future issue. In the refinement of the existing investigation, it is particularly important to determine the thickness of the deposits and to confirm the extent of the fuel debris that extends to the bottom of the PCV and is hidden under the deposits.

[Unit 2]

- Further refinement of existing information and acquisition of new information on the location of fuel debris inside the pressure vessel are future tasks.

[Unit 3]

- Information on the location of fuel debris outside the pedestal as well as inside the pressure vessel, which is an uninvestigated area, will continue to need to be updated.

2. Understanding the properties of fuel debris (including predictions of its condition in each process)

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- The information on the properties of fuel debris should be utilized to elucidate the cause of the accident and improve the estimation of the in-core condition. It is desirable to utilize this information for the design of fuel debris retrieval methods, fuel debris retrieval operations, safe transport, storing, management and processing, and disposal.
- Three main methodologies are assumed for obtaining information on the properties of fuel debris: analysis, investigation with actual equipment and experiments.
- In order to reflect this information to the design of the fuel debris retrieval method and the fuel debris retrieval work, it is desirable to have information on the surface dose of fuel debris, mechanical properties of fuel debris, microstructure (porosity, etc.), properties of MCCI products, processability, dust generation behavior during retrieval and debris aging behavior. Since Fuel debris is found inside the RPV, CRD housing and in and out of the pedestal, it is desirable to identify the condition of fuel debris at each location.
- In order to ensure safe transport, storing, and management of fuel debris, it is desirable to have information on the composition, mineralogy, properties and aging behavior of fuel debris. Regarding aging behavior, it is desirable to elucidate the aging mechanism and take proactive measures by investigated method for predicting future changes. (For example, evaluation of the mechanism for its radiological, biological, chemical and physical dissolution to estimate the change of fuel debris caused by aging).
- For investigations on processing and disposal of fuel debris, it is desirable to have information on the stability of fuel debris (e.g., dissolution behavior of nuclides).
- For investigations on criticality control in each process, it is desirable to have information on the composition and properties of fuel debris and the properties of MCCI products. It is also desirable to understand the behavior of Gd and B and their volume in fuel debris to comprehensively understand the risk of criticality.
- It should be noted that the accident progress varies among different units and that properties of fuel debris and the environment in which the fuel debris placed differ greatly.

Current state against ideal

- So far, the properties of fuel debris have been estimated based on visual confirmation and sampling of deposits by the internal investigation, analytical method and experimental results using simulated debris.
- In the initial stage of fuel debris retrieval, the amount of fuel debris that can be retrieved will be very limited. Therefore, it is necessary to estimate the properties of fuel debris retrieved from different locations and from different depths, by using the limited amount of fuel debris. For this purpose, it is also necessary to set analysis items and analysis process of fuel debris.
- Sediments have also been successfully sampled during the PCV interior survey that has been underway since February 2022 and will be analyzed in the future.
- For the specific items for measurement and analysis of fuel debris, refer to [BST-3 : Measurement and Analysis Technology].
- Work has been underway since September 2024 for the test removal of fuel debris from Unit 2, and analysis will be conducted after the fuel debris has been successfully collected.

Issues to be resolved

- In the future, it is hoped that further investigation using actual equipment and analysis results of fuel debris obtained from actual fuel debris removal will be used to correct the results estimated by analysis and confirm their reproducibility through experiments and other means.

Relevant Issues

- FDR-105 “Collection of knowledge on conditions inside PCV”
- FDR-201 “Sorting fuel debris and radioactive waste”
- FDR-207 “Criticality control”
- FDR-210 “Understanding hydrogen generation behavior”
- FDR-213 “Fuel debris retrieval policy”
- FDR-214 “Establishing debris collection strategy”
- FDR-218 “Developing fuel debris retrieval equipment and devices”
- BST-001 “Remote control technology”
- BST-003 “Measurement and analysis technology”
- BST-004 “Radiation resistance”