Phase: **Preparation**

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

Needs

1. Characterizing FPs

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- In order to reduce the risk of exposure during work for decontamination for fuel debris retrieval as well as fuel debris retrieval, it is desirable to obtain information on the chemical behavior, basic physical properties, existence forms (free, permeable, etc.), vapor pressure change, and atmosphere dependence, of FP that is presumed to have been released from fuel during the accident and remain in the reactor.
- In order to prevent new accidents and protect the surrounding environment, it is desirable to understand the effects of difficult-to-measure nuclides that do not emit, or scarcely emit gamma rays among the nuclides released by the accident.
- For the chemical properties of FP, it is desirable to understand the depth dependence of FP from the top surface where it is exposed to air and water.

Current state against ideal

- In Unit 1, cesium particles of several tens to several hundreds of microns are scattered on the operation floor. Hydratable cesium compounds may have been penetrated the concrete inside from its surface in the form of cesium hydroxide. During the initial stage of core heating, insoluble cesium particles are formed by the solidification reaction between silicon oxide and cesium hydroxide in the gas phase. The amount of insoluble cesium particles produced is considered to be smaller than that of in Unit 2.
- In Unit 2, hydrated cesium compounds may have been penetrated the concrete inside from its surface in the form of cesium hydroxide. Insoluble cesium particles of a few micrometers in diameter have been confirmed as originating in the environment of Unit 2. Insoluble cesium particles were formed by the solidification reaction between silicon oxide and cesium hydroxide in the gas phase during the early stage of core heating. The amount produced is limited and estimated to be in the order of 10 kg, and some of the insoluble cesium particles may be remaining inside the PCV and reactor building.
- In Unit 3, hydrated cesium compounds may have penetrated inside from the concrete surface in the form of cesium hydroxide. Insoluble cesium particles are produced in the initial stage of core heating by the solidification reaction between silicon oxide and cesium hydroxide in the gas phase, but the amount produced is considered to be smaller than it in Unit 2.

Issues to be resolved

- Based on the assumed major chemical form and properties of cesium, the future issue is to understand the properties and amount of FP remaining inside the PCV. For example, free FPs are likely to have flowed into the stagnant water in the building due to the water injection that had been carried out so far. A future issue is to estimate the current state of FP penetrating the

concrete inside from its surface and insoluble FP existing in the furnace, as well as its properties during the upcoming retrieval period.
- For fuel debris retrieval, it is necessary to improve the work environment by decontamination. For this purpose, it is important to investigate the areas with large inventories, such as the Unit 1 RCW system (reactor auxiliary cooling system). It would be beneficial to have a technology that can estimate the amount of radioactivity. Even if it is not possible to understand the inventory, it would be beneficial just to be able to understand the nuclide composition ratio.
- If an evaluation method cannot be found, it would be necessary to treat it conservatively compared to the actual inventory. Therefore, an approach that combines analysis and actual measurement is particularly required (the ideal form is to be able to measure everything, but this is impractical and difficult, so an appropriate combination with analysis is required).

2. Determining the distribution of FPs

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- In order to perform fuel debris retrieval safely, it is desirable to estimate the distribution of FP in the reactor and to predict and detect the location of hot spots in the reactor.
- From the viewpoint of efficient decontamination and waste management, it is desirable to understand the distribution of FPs in the building by simulating the contamination diffusion mechanism and nuclide migration during an accident.
- It is desirable to elucidate the cause of the accident and estimate the reactor status, by correcting the estimated results by analysis based on the results of investigations using actual equipment, by confirming the reproducibility of the results by experiments, and by confirming the consistency of the results with the FP information obtained from investigations of the actual environment.

Current state against ideal

- In Unit 1, a hydrogen explosion occurred on the operation floor. It is presumed that FPs released during the accident mainly passed through the PCV, top head flange of the PCV, the reactor well, and the shield plug in this order, to reach the operation floor. It is therefore considered that FPs are unevenly distributed on this pathway. In addition, since the D／W pressure is considered to have been high due to the direct leakage from the RPV to the D／W right after the accident, it is assumed that a large amount of FP was deposited on the D／W as well. It is also estimated that the building wall, S／C wall, or water in the S／C is highly contaminated.
- In Unit 2, it is estimated that gas leakage from the RPV to the D／W occurred during the progression of the accident, and that FPs were easily transferred directly to the D／W side. At the operation floor of Unit 2, high dose was observed at the shield plug position. In addition, photographs taken during the accident show that a large amount of steam was released from the blowout panel. Therefore, the FPs are presumed to have passed through the RPV, the PCV, top head flange of the PCV, the reactor well, the shield plug in this order, to reach the operation floor. It is therefore considered that FPs are unevenly distributed on this pathway.
- In Unit 3, it is presumed that FPs released during the accident passed through the RPV, the PCV, the top head flange of the PCV, the reactor well, and the shield plug in this order, to reach the operation floor. It is therefore considered that FPs are unevenly distributed on this pathway.
- For example, in Unit 2, localized high doses were observed near the CRD rail, in the PCV internal investigation.

- In the process of decommissioning (operation floor decontamination) and an accident investigation of Unit 1 to Unit 3, it was confirmed that a large amount of cesium 137 existed in the lower part of the shield plug of each unit (Unit 2 and Unit 3). This amount is comparable to the amount of radioactive material presumed to remain in the PCV. Attention should be paid to this point in the future decommissioning work and accident analysis (mainly on the FP release pathway).

Issues to be resolved

- Events in which FPs are concentrated in specific locations have been observed. Elucidating the mechanism will be a future issue.
- Migration of water-soluble nuclides such as cesium is a problem in the condition where water is circulating.
- Since it is difficult to estimate the distribution of FPs by tracing the condition at the time of the accident through analysis alone, it is particularly desirable to obtain new knowledge by backfitting from the current condition. For example, removing water from the Unit 1RCW system due to its high dose is considered By examining FPs in this system, it is desirable to evaluate whether the same results can be obtained in other systems.
- If an evaluation method is not used, it is considered necessary to treat the inventory more conservatively than the actual inventory. For this purpose, an approach that combines analysis and actual measurement is particularly required (the ideal form is to be able to measure everything, but this is impractical and difficult, so an appropriate combination with analysis and actual measurement is required).

Relevant Issues

- FDR-104 “Understanding doses inside PCV and RPV”
- FDR-105 “Collection of knowledge on conditions inside PCV”
- FDR-201 “Sorting fuel debris and radioactive waste”
- FDR-202 “Shielding and decontamination measures”
- FDR-203 “Exposure control of workers inside buildings”
- FDR-205 “Establishing confinement function”
- BST-001 “Remote control technology”
- BST-004 “Radiation resistance”