Phase: **Design**

Decommissioning Process **"Fuel Debris Retrieval"**
Investigation Subject **"Retrieval method and system"**
Issue **"Establishing closed loop"**

Needs

1. Establishing a measure for controlling water levels

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- The goal is to reduce the amount of water retained in the reactor building by half from FY2022 to FY2024, compared to the level at the end of 2020. A circulating cooling system must be established to collect and purify the retained water and then reuse it as cooling water.
- During fuel debris retrieval, there is a possibility that the radioactivity concentration in the liquid phase will increase due to debris processing. In order to prevent the contaminated water from flowing out to the groundwater, it is desirable to consider to lower the water level in the reactor building and in the S／C. In particular, it is aimed to reduce the water contained in the S／C in Unit 1 and 3 to a level that will not flow out of the building in the event of a leak.
- Due to the low seismic margin of the S／C legs, it is desirable to lower the water level in the S／C. In addition, considering the damage status of the PCV in each Unit and the need to maintain the water level in the reactor building lower than the groundwater level to prevent cooling water from leaking into the groundwater, it is required that the water level in the PCV is appropriately set and managed, and also that it is confirmed safety is ensured from the perspective of cooling fuel debris and controlling dust dispersion.
- In order to carefully proceed while monitoring the status, it is necessary to prepare monitoring parameters, decision criteria, etc. for the existing circulating water cooling／purification system and how its cooling function is affected.
- In the long-term decommissioning process, various unexpected events and situations may occur. Thus, it is desirable to establish a system designed to respond to these events and situations.

Current state against ideal

- The construction of a PCV circulating cooling system is being investigated based on removal technology for dissolved nuclides that are thought to be leached from fuel debris into the circulating cooling water and treatment technology for solids collected in the filters of the circulating cooling water system.
- Development for a water stoppage technology by installing a stoppage plate in the Jetdiff or by installing a weir in the D／W, in addition to a water stoppage technology for the pipe was implemented.
- Water levels in Units 1 and 3 are higher than in normal operation due to the accident. The S／C is planned to be drained, and measures are being taken to install new water level gauges with a wider measurement range.

Investigation on the water level in the PCV of Unit 1

- The current water level in the PCV is estimated to be about 1.9 m. Most of the fuel debris at the bottom of the PCV is considered to be submerged. In addition, leakage of cooling water in the PCV into the torus chamber via the vacuum break line (approximately 1.1 m from the bottom of the PCV) and the sand cushion drain pipe has been confirmed. Therefore, it is necessary to apply a water sealing technique (vent pipe sealing or downcomer sealing) between the PCV and the S／C after lowering the PCV water level below the vacuum break line or, if water sealing is not implemented, to maintain the water level in the PCV below the vent pipe root. In both options, it is necessary to deal with the cooling water flowing into the torus room via the sand cushion drain pipe in order to retrieve the fuel debris in water or by pouring cooling water over it, which requires the installation of a drain catcher in the sand cushion drain section by remote technology.
- When vent pipe sealing or downcomer sealing is implemented, the water level in the PCV is maintained below the vacuum break line as described above, so the amount of cooling water retained in the PCV is not large. Even if the vent pipe attachment is damaged and cooling water in the PCV flows out into the torus chamber, the water level in the torus chamber can be kept lower than the groundwater level. In addition, as a countermeasure against cooling water flowing out from inside the PCV to the S／C due to damage at the down-comer attachment point, recovery by a pump installed in the S／C is being considered.
- When water stoppage is not performed, the water level in the PCV will be maintained below the base of the vent pipe. Fuel debris retrieval will be performed in the air with cooling water flowing. Since some of the fuel debris may be exposed to the air, it is necessary to consider in advance the decay heat of fuel debris and the required cooling water volume.

Investigation on the water level in the PCV of Unit 2

- The current water level in the PCV is estimated to be about 0.3 m. Most of the fuel debris at the bottom of the PCV is not submerged. In addition, the water level in the S／C and the torus chamber are at the same level. Therefore, it is assumed that there is leakage from the S／C to the torus room. In the case of water sealing of the vent pipe or down-comer, the water level in the PCV can be raised, and fuel debris removal from the bottom of the PCV can be performed underwater. In this case, the assumption of coolant leakage from the PCV is the same as in Unit 1.
- If water stoppage is not performed, the PCV water level will be maintained at the same level as the current status, and fuel debris retrieval will be performed in the air with cooling water flowing. In this case, it is necessary to identify damaged parts of the S／C and repair them in order to prevent the cooling water from flowing out of the PCV through the S／C into the torus room.

Investigation on the water level in the PCV of Unit 3.

- The current water level in the PCV is about 4.2 m, which is higher than in Unit 1 or Unit 2, and the fuel debris at the bottom of the PCV is already submerged.
- In October 2022, the PCV intake facility began operation, replacing reactor injection water by taking water from the bottom of the S／C and improving the quality of the S／C contained water to lower the PCV water level.
- In case of vent pipe water stoppage or downcomer water stoppage, the water level in the PCV needs to be lowered to the same level as the current water level in Unit 1 (about 1.9 m) for the reasons mentioned above. This will allow the fuel debris to be retrieved from the PCV

underwater. In this case, the assumption of the cooling water leakage from the PCV will be the same as in Unit 1.

- When water stoppage is not performed, the water level in the PCV will maintained below the base of the vent pipe, and fuel debris retrieval will be performed in the air with cooling water flowing. Since some fuel debris may be exposed to the air, it is necessary to investigate the decay heat of fuel debris and the required cooling water volume, in advance.

Issues to be resolved

- After the properties of α-nuclides in the stagnant water are grasped, it is necessary to design and install a removal system for the nuclides.
- It is necessary to establish a basic database to respond to unexpected situations and contingencies by consolidating knowledge about on-site information and its uncertainties, as well as efforts to resolve them. In addition, by disclosing such collective knowledge, it is necessary to gain a bird's eye view of the decommissioning progress in the related investigation issues, to optimize the decommissioning process as a whole and to promote research efficiently.

2. Identifying and repairing leakage part of the PCV

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- In order to secure multiple boundaries, it is desirable to consider water stoppage by repairing the lower part of the PCV. At that time, it is desirable, taking into account the PCV repair technology, to consider the nature of the confinement function, including a system that combines leak suppression and cooling water circulation／purification system by applying water stoppage technology.
- To prepare for a case where cooling water leaks from the PCV into the reactor building during water stoppage, it is also desirable to consider setting an appropriate water level difference between the groundwater and the stagnant water in the reactor building.

Current state against ideal

- For water sealing by burial in vent pipe, workability under flowing water and water sealing performance up to 0.4 MPa were confirmed by 1／1-scale simulated vent pipe test using self-compacting concrete.
- For water sealing by burial in S／C, water sealing of S／C damaged holes, quenchers, and strainers was confirmed by 1／1-scale tests, and the feasibility of installation was confirmed by S／C guide pipe installation tests necessary for water level control.
- Regarding water sealing by burying the vacuum break line, the constructability and water sealing performance were confirmed by 1／1 scale construction test, and no leakage was confirmed under water pressure of 0.45MPa.
- For waterproofing of torus chamber wall penetrations, a combination of high-pressure jet cleaning for rust removal and urethane rubber-based waterproofing material was confirmed to be applicable.
- For Unit 3, based on the results of the reactor water injection shutdown test conducted in June 2022, the leak area is estimated to be lower than the end of the new PCV thermometer／water level gauge.

Issues to be resolved

- It is necessary to clarify the concept of setting the water level in the PCV, the possibility of water stoppage, and a system for direct recovery of cooling water from the PCV (D／W section).
- In consideration of seismic resistance during fuel debris retrieval, it is desirable to keep the water level in the S／C low. If water stoppage is not implemented for each unit, the water level in the PCV should be lowered to the base of the vent pipe to reduce water flow into the S／C.

Relevant Issues