Phase: **Design**

Decommissioning Process **"Fuel Debris Retrieval"**
Investigation Subject **"Retrieval method and system"**
Issue **"Establishing access route to fuel debris"**

Needs

1. Removing interfering obstacles

Fuel Debris Retrieval：【Mid】

Desired state and reasons for it

- In order to load, install and unload of equipment and devices for fuel debris retrieval, it is desirable to reduce radiation dose in the environment to the extent that allow work and remove interfering obstacles safely.
- In order to safely remove interfering obstacles (in-building structures, in-core structures) for fuel debris retrieval, it is desirable to establish a method for removing interfering obstacles so that the release of radioactive materials from the PCV and the RPV is suppressed and that the integrity of the existing structure is maintained.
- In the long-term decommissioning process, various unexpected events and situations may occur. It is desirable to establish a system that can respond to such events and situations.

Current state against ideal

- In top entry method, structures on the upper part of the PCV and structures inside the RPV become interfering obstacles, while, in the side entry method, the equipment outside the pedestal becomes an interfering obstacle. Also, both entry method, the equipment in the pedestal and structures in the reactor building become interfering obstacles.
- Regarding the removal of interfering objects that are relatively difficult to remove, such as equipment and heavy objects at high locations, in FY2020 development of remote technology for environmental improvement and retrieval of interfering objects under high radiation dose was started. In FY2022, after selecting objects to be removed, specifications for remote control equipment based on required functions was proposed. In addition, the development of a remote monitoring and removal work system for removing PCV penetration piping, etc. has been underway since FY2024.
- In the sediment removal work inside the X-6 penetration of Unit 2, based on the dust diffusion caused by the abrasive water jet (AWJ) in the construction of the investigation access route inside the Unit 1 PCV, the following measures were prepared to suppress and control dust diffusion, sediment removal using low-pressure water washing equipment and spray curtains. For the removal of sediments and cables inside the X-6 penetration, after the sediments were pushed down with a dozer tool (push jig), the sediments were pushed in with low and high water pressure, the cables were removed with an abrasive water jet (AWJ), and the cables were pushed in with a push-in device, which was completed in May 2024.

Issues to be resolved

- It is necessary to develop technology to dismantle, remove, recover, and carry out interfering obstacles remotely. In particular, it is important to ensure the feasibility of processing in narrow areas and the workability of remote operation. Therefore, it is necessary to establish a function to

prevent contact with the surrounding environment during operation of a multi-degree-of-freedom robot.

- In order to maintain the integrity of existing structures, it is necessary to prevent damage to the equipment and surrounding structures caused by cutting.
- Compared to machining operations, other operations such as positioning the machining tool, grasping the object, and changing tools, require a great deal of time. In this respect, it is necessary to develop tools for supporting the operation of workers.
- Decontamination is necessary when equipment is carried out from the work cell to control the release of radioactive materials, so that it is necessary to improve decontamination by taking measures to prevent contamination by foreign substances.
- For remote work and monitoring, it is necessary to establish a method to construct work equipment, peripheral equipment, and monitoring equipment remotely including installing a camera in narrow areas remotely).
- Dust diffusion control measures are important in the retrieval of interfering objects associated with the construction of access routes. It has been confirmed that safety measures have been fully considered in the current work procedures, such as monitoring dust concentrations while gradually expanding the work. On the other hand, it is also required that the work process is not significantly extended, and it is necessary to set appropriate work control values for dust concentration.
- 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.
- In the future decommissioning work of the 1F, it is necessary to cut and remove many pipes, etc. However, it is often difficult to know what the conditions are like inside such pipes. For example, if the presence or absence of contents, presence or absence of liquid, radioactive material concentration, hydrogen concentration, etc. are not known, it is difficult to select appropriate cutting methods and measures (e.g., measures to prevent scattering of contents). In consideration of on-site application, it is desirable to be an easy-to-use method (short time understanding, handy type, etc.). In particular, it should be possible to determine the presence or absence of α-nuclides in the piping, and if α-nuclides are present, to what extent they are present.

2. Specifying how to build access routes with safety in min

Fuel Debris Retrieval：【Short】

Desired state and reasons for it

- It is desirable to develop a specific access route construction method for the safe delivery and installation (e.g., without exceeding the load-bearing capacity) of the equipment and devices for fuel debris retrieval.
- Considering systems sustaining an inevitable increase in high-dose waste and a significant increase in exposure, it is desirable to establish appropriate access routes to retrieve fuel debris that may exist in the lower part of the pedestal, at the bottom of the RPV, and at other locations.
- When new openings are made in PCV, etc. to construct access routes, it is required to control the release of radioactive materials from PCV and RPV from the viewpoint of confinement function, and to pay attention to maintaining the integrity of the existing structures.

Current state against ideal

- In Unit 1, access to the bottom of the drywell outside the pedestal from the top of the grating has been confirmed to be possible. In addition, information on the condition of the existing structures inside and outside the pedestal, as well as images and other information on the condition of deposits and fallen materials, were obtained through underwater ROV surveys in the PCV, as well as through surveys in the air-exposed parts of PCV, mainly in the first-floor area conducted through March 2024.
- In Unit 2, there are no large obstacles on the CRD rail or near the pedestal openings, and it has been confirmed that access to the inside bottom of the pedestal is possible through the openings. In addition, in the pilot retrieval which has been underway since September 2024, it has been successfully accessed to the interior of the pedestal from the X-6 penetration.
- In Unit 3, it has been confirmed that access to the inside bottom of the pedestal is possible from the pedestal openings.
- Currently, in order to further expand the scale of fuel debris and in-core structures retrieval, side access method is being investigated as access routes from the PCV side openings to the fuel debris, and the suspension bridge method, the method using lightweight cells and fixed rails, and the access tunnel method are being investigated.
- Investigation of a retrieval method from upper side including top entry is underway, and it is investigated a technology to remove and transfer the interfering obstacles to shorten the retrieval preparation process aiming to improve the throughput. In FY2020 and beyond, the feasibility of removing and transferring the interfering obstacles as one piece or cutting into large pieces while ensuring their confinement and shielding is being investigated.

Issues to be resolved

- Expanding confinement barriers in a high-dose environment is an extremely difficult task, and it is necessary that the work is carried out with a short rotation of heavily equipped workers. Given these circumstances, considering the imperfection and uncertainty of the confinement barriers, and the anticipated occurrence of earthquakes, etc., it is necessary to increase the safety and certainty of the work.
- In the construction of access routes, it is necessary to minimize the amount of secondary waste (additional amount of waste generated) generated by processing.
- In the side entry method, the confinement function of the connection structure between the new heavy structure and the PCV side opening, shielding, and response to seismic displacement are issues to be addressed.
- In constructing the access route for the top entry method, it is necessary to investigate it considering the results of additional surveys, such as the situation and dose survey in the reactor well below the shield plug and the dose survey in the excavation hole.

Relevant Issues

- FDR-102 “Understanding status of structures inside PCV and RPV”
- FDR-104 “Understanding doses inside PCV and RPV”
- FDR-105 “Collection of knowledge on conditions inside PCV”
- FDR-106 “Understanding contamination status inside buildings”
- FDR-211 “Ensuring structural integrity of PCV and buildings”
- FDR-301 “Fuel debris retrieval inside PCV”
- FDR-302 “Fuel debris retrieval inside RPV”