Phase: **Design**

Decommissioning Process **"Fuel Debris Retrieval"**
Investigation Subject **"Retrieval method and system"**
Issue **"Developing fuel debris retrieval equipment and devices"**

Needs

1. Developing tools for accessing, processing (cutting, crushing), and retrieving fuel debris, as well as tools necessary for dust collection

Desired state and reasons for it

- In selecting a method, while based on the five perspectives (safe, reliable, rational, prompt, and site-oriented), cost and process should also be used as decision indicators. To this end, evaluation items should be quantified as much as possible, and judgment indicators should be set from a comprehensive perspective.
- In selecting a method, it is necessary to develop retrieval scenarios and clarify requirements. The scenarios should be developed based on the preconditions for utilizing the outcomes obtained from the internal survey and technological investigation to be conducted in the future, assuming various outcomes could be obtained. In the clarification of requirements, it is important to investigate keeping in mind the entire Fukushima Daiichi Nuclear Power Plant while paying attention to the interrelationships among the requirements. Currently, a conceptual study is being conducted to select a method for further expansion of the retrieval scale, and by the end of FY2021, the methods are narrowed down for subsequent design investigation.
- In order to retrieve fuel debris safely, reliably and efficiently, considering radiation resistant, high corrosion resistance, simplicity of remote inspection and maintenance, have high reliability, high precision, and various troubles likely to occur, it is desirable to develop debris retrieval equipment and devices that meet specifications for a rescue mechanism that does not interfere with subsequent work when trouble had occurred, and can respond flexibly to on-site conditions.
- In order to retrieve fuel debris safely, reliably and efficiently, it is desirable to develop an access system corresponding to the debris location, a fuel debris collection system corresponding to the debris condition, and a cutting and dust collection system for fuel debris.
- In order to remove fuel debris safely, reliably and efficiently, it is desirable to understand the behavior of dust, fine particles and fumes generated in water and air, and to be able to prevent the expansion of contamination and the diffusion of radioactive material.
- In debris processing, it is essential to maintain the clarity of the images provided from the camera so that it is necessary to keep the turbidity of the stagnant water low. For this purpose, it is desirable to inhibit microbial growth without causing any corrosion or other problem.
- For fuel debris retrieval, it is necessary to cut, contain and transport in-core structures other than fuel debris to the outside of the reactor, and it is desirable to develop the technology and system for this purpose.
- Since in the cut, storage, and transfer of in-core structures other than fuel debris, larger (heavier) objects than fuel debris are handled, the cut, grasp, storage (container), and transfer capabilities are required accordingly.

Current state against ideal

- For the Unit 2, after the testing and training at the Naraha Remote Technology Development Center were implemented, a trial retrieval began in September 2024. Access from the X-6 penetration to the inside of the pedestal was successfully achieved in September 2024, and debris samples were successfully collected in November 2024 and April 2025.
- Conceptual studies are being conducted to select a method for further expansion of the scale of retrieval, and issues and risks of each method are being extracted. In addition, disc cutters, suction, chiseling, and core boring are being investigated as methods for processing structures and fuel debris.
- In order to develop a fuel debris collecting system, the properties of fuel debris (including a proportion of metal layer, stump fuel, powder, lump, pebble, and crust fuel debris) and the amount of fuel debris need to be set in detail. In addition, it is necessary to design a method for suction and collection of grain fuel debris (including a measure against piping blockage, a strainer shape for efficient suction, a pump maintenance method, detection and maintenance of clogged filter, and calculation of throughput).
- The development of fuel debris cutting and fabrication systems, dust collection and dispersion control systems, and methods for predicting dust behavior in the PCV have been conducted. Considering the results from such developments, it is necessary to select an optimal fabrication method, a dust collection method, and an equipment design and installation method.
- The design of the fuel debris retrieval enclosure, which will serve as a place for remote maintenance of the retrieval arm and packing of fuel debris, is underway. A prototype of the double-door system has been fabricated, and it is planned to be incorporated into the enclosure and tested in combination with the X-6 penetration connection structure to verify it as a system.
- The design of a remote transport cart for transporting the fuel debris storage container is underway. The prototype has been fabricated, and the feasibility of transporting work and maintaining the storage container has been verified through in-factory verification tests. In the future, it is necessary to conduct combination verification tests with enclosures.
- During the phase of gradually expanding the scale of fuel debris retrieval, the policy is to improve the equipment based on the enhancements identified through verification of the trial retrieval. Key issues include ensuring the confinement performance of the enclosure, securing the reliability of the manipulators, and maintaining equipment during the operational period.

Issues to be resolved

- For fuel debris retrieval gradually expanded its Scale, it is necessary to proceed with engineering to apply the results of research and development to the on-site, and to design, fabricate, and install fuel debris retrieval equipment, safety systems, storage facilities for fuel debris, and maintenance of retrieval facilities considering the knowledge obtained through test retrieval.
- After combining the developed equipment and devices into a system, a series of mock-up tests should be conducted to verify that the system can actually perform safely and reliably on site.
- The current processing speed in fuel debris retrieval is insufficient. Therefore, it is necessary to investigate the possibility of increasing the processing speed and seek a suitable application method for ultrasonic processing.
- 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, in order to optimize the decommissioning process as a whole, and to promote research efficiently.

2. Developing radiation-resistant materials (including electronic circuits)

Desired state and reasons for it

- In order to reduce the effects of radiation on the equipment and devices used in fuel debris retrieval, it is desirable to develop radiation-resistant materials (including electronic circuits) that can be applied to actual sites (Dose rates inside the PCV and RPV are on the order of several Sv／h to several hundred Sv／h, while dose rates inside the reactor building are on the order of several mSv／h to several tens of mSv／h.).
- It is desirable to develop a processing including surface processing technology that enable rapid decontamination even when exposed to high contamination conditions.

Current state against ideal

- For operation and maintenance of access equipment, the radiation resistance of the camera should be at least 100 kGy, while that the radiation resistance of the access equipment should be at least 1 MGy. Some cameras have achieved a radiation resistance of 100 kGy.
- The method and means of decontamination in the work cell that contains the fuel debris retrieval system are different for each retrieval method and have not yet been determined. Therefore, it is necessary to investigate a specific method in the future.
- TEPCO says that, as to the incident of camera image interruption that occurred during the trial retrieval conducted in October 2024, “Radiation passed through the semiconductor element of the camera, and a large amount of electric charge generated by the ionization effect is considered to have affected the image”.

Issues to be resolved

- In long hours of work under high dose, a large amount of spare parts are required, which result in a large amount of waste generation. Looking at not only advanced technology development but also application of existing technology, the materials are required considering waste generation.
- In order to improve the decontamination performance, measures for preventing foreign substances from entering the work cell are necessary.

Relevant Issues

- FDR-101 “Understanding status of fuel debris”
- FDR-102 “Understanding status of structures 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”
- BST-001 “Remote control technology”