Phase: **Preparation**

Decommissioning Process **"Fuel Debris Retrieval"**
Investigation Subject **"Understanding status inside PCV"**
Issue **"Understanding status of structures inside PCV and RPV"**

Needs

1. Checking for damage inside the PCV and RPV

Desired state and reasons for it

- Grasping the mechanical damage and deformation status of the reactor pressure vessel, in-core structures (RPV pedestal, CRD housing, shroud, RPV support skirt, etc.) and piping based on the perspective of the structural integrity, and constructing access routes for the internal investigation and fuel debris retrieval.
- Enabling to clarify the cause of the accident, estimate the in-core status and update the estimation of the in-core status by correcting the estimated results from analysis through actual equipment survey and confirming the reproducibility of the results by experiments, etc.
- Understanding the interaction between the constituent phases of the heat-affected concrete (condition that thermal alteration of some cement hydrate occurs at lower temperatures than the molten／sintered state) and the nuclides.
- It is desirable to understand the characteristics of the in-core structures and concrete exposed to the in-core environment from the time of the accident to the present, including aging degradation (e.g., changes in the void structure and hydrates in the concrete).
- Clarifying the aging mechanism of the structure caused by microorganisms in contaminated concrete as well as understand the deformation and fracture of the structure during operation.
- By achieving the above, fuel debris retrieval can be carried out safely and efficiently. In addition, it would be possible to continuously ensure the safety.

Current state against ideal

[Unit 1]

- For Unit 1, it was confirmed from the investigation conducted in March 2017 inside the PCV (first basement floor) that there was no significant deformation or damage to the existing structure (including valves, piping and steel) visible around the drain sump (X-100B side). In April 2015, an investigation was conducted on the grating on the first floor to confirm that there would be no interference with the B2 investigation. The investigation results showed no significant damage to the existing facilities on the access route (including HVH, PLR piping, and pedestal wall), except that leakage from the sand cushion drain pipe at the bottom of the PCV is presumed to have caused damage to the PCV.
- The PCV internal investigation using an underwater ROV started in February 2022. So far, visual inspection, sediment thickness measurement, etc. have been conducted sequentially. In the visual inspection, lumpy sediments were confirmed on the outside and inside of the pedestal around the worker access port, although they have not been identified whether it is the existing structure or fuel debris. In addition, rebar was found near the workers' access port, and part of the concrete in the pedestal was found to be missing. In March 2023, an underwater ROV survey was conducted to penetrate the pedestal interior, and it was confirmed that the concrete at the

bottom of the pedestal had disappeared near the worker access entrance and almost the entire interior wall of the pedestal. IRID conducted a seismic evaluation of the pedestal in a partially damaged condition in FY2016 under "Government-led R&D Program on Decommissioning and Contaminated Water Management" regarding this matter, and confirmed that the pedestal's support function is not to be significantly damaged. Also, TEPCO is examining the impact of pedestal damage on the plant based on the current information, assuming that TEPCO expand the knowledge and conduct the evaluation through internal investigations. According to the examination report, considering the confirmation status of the external surface of the pedestal, TEPCO assumes that there is little possibility of large-scale damage by movement, colliding and fall of supporting structures assumed by damage of the pedestal, and also presumes that it would not pose a significant risk of radiation exposure to the public in the vicinity as a result of consideration about the impact on cooling the fuel debris, dust dispersion and criticality among the safety impacts in case that the pedestal's support function were to deteriorate and the RPVs and other equipment were to tilt or sink.

- Following the loss of concrete at the bottom of the pedestal, a strength evaluation due to seismic motion was conducted. The evaluation determined that the inner skirt of the RPV pedestal foundation, the stabilizer and bulkhead of the pedestal superstructure were capable of supporting seismic loads, and therefore, it was concluded that no major damage would occur.
- In February 2024, the PCV internal investigation (the section kept in air) was conducted by a small wireless drone. The information obtained from the investigation is as follows: (1) No major damage was found on the outer wall of the pedestal. In addition, although there were some fallen objects outside the CRD replacement opening, it was confirmed that the existing structure generally maintained its shape and that there were no notable obstructions around the CRD replacement rail. (2) The CRD housing (including several CRD-related devices) that had fallen off was partially blocking a part of the CRD replacement opening in the pedestal, and a massive object (some parts of which looked like icicles) was observed attached to the top of the housing, which was presumed to have migrated from above. (3) No significant damage was observed on the inside wall of the pedestal, and existing facilities such as cable relay boxes and openings of existing TIPs (mobile in-core instrumentation) were also observed.
- Starting from March 2024, a program to reduce the water level in the PCV (by lowering the PCV water inventory) was conducted. Considering that some sediment could have been exposed to the air, internal PCV environmental surveys (dose rate, temperature, fogging／visibility measurements, laser scanning, etc.) were performed in the summer of 2024 and the winter of 2025. The collected data will be reflected in the design of future investigation equipment and mock-up conditions.

[Unit 2]

- The investigation in-pedestal conducted in January 2018 did not identify any major damage in the in-pedestal walls, the existing structure (CRD switchboard) in the pedestal and the CRD housing support, except that a part of the fuel assembly (upper tie plate) had fallen at the bottom of the pedestal. In the investigation in-pedestal conducted in January and February 2017, it was confirmed that the grating on the CRD rail side had fallen off and been warped. In addition, based on the measurement results using muon, the separator and dryer were thought to be remaining in the pedestal though inside the RPV must have been high temperatures caused by the fuel melting (it is unclear whether they maintain their original shape).
- On November 7, 2024, and April 23, 2025, experimental retrievals were conducted, and fuel debris samples were collected. The samples were transported to off-site analysis facility, where analyses such as visual inspection, elemental mapping, chemical composition, isotope ratios, and dose-rate measurements have already commenced.

- Internal investigation and retrieval using a robotic arm are expected to commence in fiscal year 2026, following mock-up verification at JAEA Naraha (including completion of the one-shot test with an enclosure integration and camera upgrade adjustments).

[Unit 3]

- An in-pedestal investigation conducted in July 2017 confirmed the existence of CRD housing and platforms. In the CRD housing, the support fittings were damaged／lost in several places, and the level and spacing of adjacent CRD flange faces were observed to be different. Near the CRD housing, there were structures presumed to be CR guide tubes and CRD index tubes. Near the platform, a part of the steel components of the platform was confirmed, indicating that the platform collapsed, while no grating was confirmed. Based on the measurement results using muon, the separator and the dryer were existing there (it is unclear whether they maintain their original shape).
- Preparations are underway for an investigation of the PCV interior outside the pedestal by deploying a micro drone from the X-53 penetration planned for FY2025. In addition, confirmation of leakage conditions on the outside of the pedestal near the worker access port using a fiber optic scope via the TIP guiding tube is under consideration.

Issues to be resolved

- Further refinement and validation of the information obtained so far
- Un-surveyed areas where in-core structures, such as the inside of the pressure vessel, are thought to be densely packed should be estimated and then, confirmed by actual equipment.
- Technology to construct radiation-resistant laser scanners, etc. and radiation-resistant wireless LAN access points, etc. for acquiring 3D point cloud data in RPVs. Currently, an internal investigation of PCV is being conducted, but an internal investigation of RPV where higher doses are expected will be conducted in the future. The situation inside the PCV is still unknown, so it is necessary to first understand what the situation inside the RPV is like (what is inside, where it is located, how far it has been damaged, etc.). In order to understand the situation inside the RPV in detail, it is useful to acquire 3D point cloud data in addition to camera images. For this purpose, a laser scanner with high radiation resistance is required. In the PCV internal investigation conducted in February 2024, it was confirmed that a wireless drone could be used inside the pedestal by installing a wireless repeater mounted on a snake-shaped robot, and that a considerable amount of video information could be obtained despite flight time limitations. This constraint is likely to become more significant in the RPV internal investigation. If wireless transmission becomes possible, the degree of freedom of access to the RPV can be increased. To this end, radiation-resistant wireless LAN access points need to be installed inside the PCV and RPV.
- In addition, as a source of power for wireless LAN, transmission technologies such as wireless and laser that transmit and receive energy without the need for wiring, as well as technologies that deliver that energy to specific locations while avoiding the influence of structures, need to be developed. In addition to wireless LAN, the power obtained from wireless power supply has the potential to be used for lighting, which, if realized, would contribute to more efficient surveying of dark areas.
- Common challenges include areas across units where direct video footage has not yet been obtained. Continuous updating of the investigation plan is required, incorporating new investigation technologies (e.g., underwater ROVs and further use of drones) and clearly identifying priority survey areas.
- In addition to remote-operation equipment in high-radiation environments, it is necessary to implement planned measures to reduce worker exposure and dose dispersion, secure long-term

personnel, establish an exposure assessment system, and ensure proficiency through mock-up training.

- The methods must be robust to uncertainties in field conditions and external events. For risks that cannot be eliminated, pre-event response measures should be prepared in advance.

Relevant Issues

- FDR-105 “Collection of knowledge on conditions inside PCV”
- FDR-201 “Sorting fuel debris and radioactive waste”
- FDR-205 “Establishing confinement function”
- FDR-211 “Ensuring structural integrity of PCV and buildings”
- FDR-213 “Fuel debris retrieval policy”
- FDR-217 “Establishing access route to fuel debris”
- FDR-218 “Developing fuel debris retrieval equipment and devices”
- FDR-219 “Ensuring safety in processing fuel debris”
- BST-001 “Remote control technology”
- BST-004 “Radiation resistance”