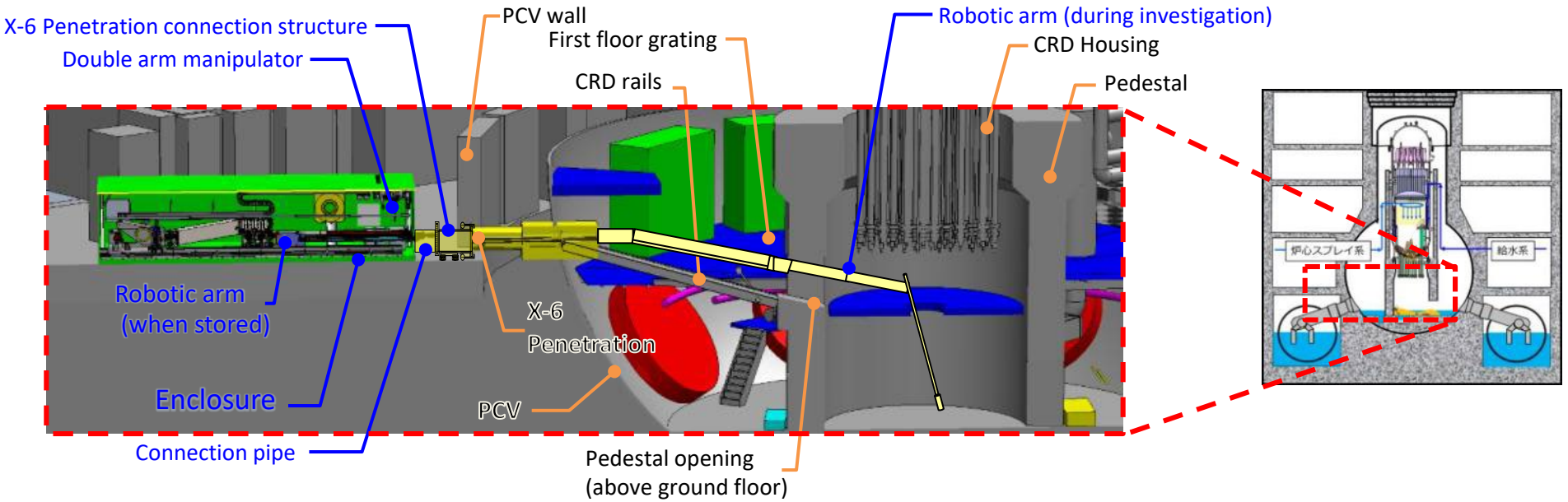
Fukushima Daiichi Nuclear Power Station
Unit 2 PCV Internal Investigation/
Preparation Status of Fuel Debris Trial Retrieval

March 28, 2024

International Research Institute for Nuclear Decommissioning
Tokyo Electric Power Company Holdings, Inc.

1. PCV internal investigation and trial retrieval plan overview

- In order to guarantee work safety and prevent the spread of contamination, the following equipment will be installed at the penetration to the Unit 2 primary containment vessel (hereinafter referred to as, "X-6 penetration") that will be used for the PCV internal investigation and also as a preparatory stage of trial retrieval.
  - A work room (isolation chamber) isolates the PCV when opening the X-6 penetration hatch
  - The X-6 Penetration connection structure isolates the inside of the PCV from the outside
  - The connection pipe shields radiation
  - A metal box that contains the robotic arm (enclosure)
- After installation of the aforementioned equipment, the robotic arm shall be fed into the PCV through the X-6 penetration to remove obstacles inside the PCV while also conducting internal investigations and moving forward with the trial retrieval of fuel debris.



Unit 2 internal investigation/trial retrieval plan overview

2-1. Status of Testing of Unit 2 Fuel Debris Trial Retrieval Equipment [Performance Tests]

- Tests are being performed on a mockup of the X-6 penetration at the Naraha mockup facility.
- The robotic arm has been installed inside the enclosure, and forced arm withdrawal test by double arm manipulator and run-through test are underway. Since the arm will have to repeatedly pass through confined spaces, we will continue even after the run-through test to optimize the control program in order to reduce risks of hitting obstacles, by improving positioning accuracy and the coordination between hardware and software.
- Furthermore, in addition to robotic arm testing, we are also developing this technology while confirming applicability to the actual worksite by looking at procedures that simulate actual work tasks, operator operability, and equipment reliability.

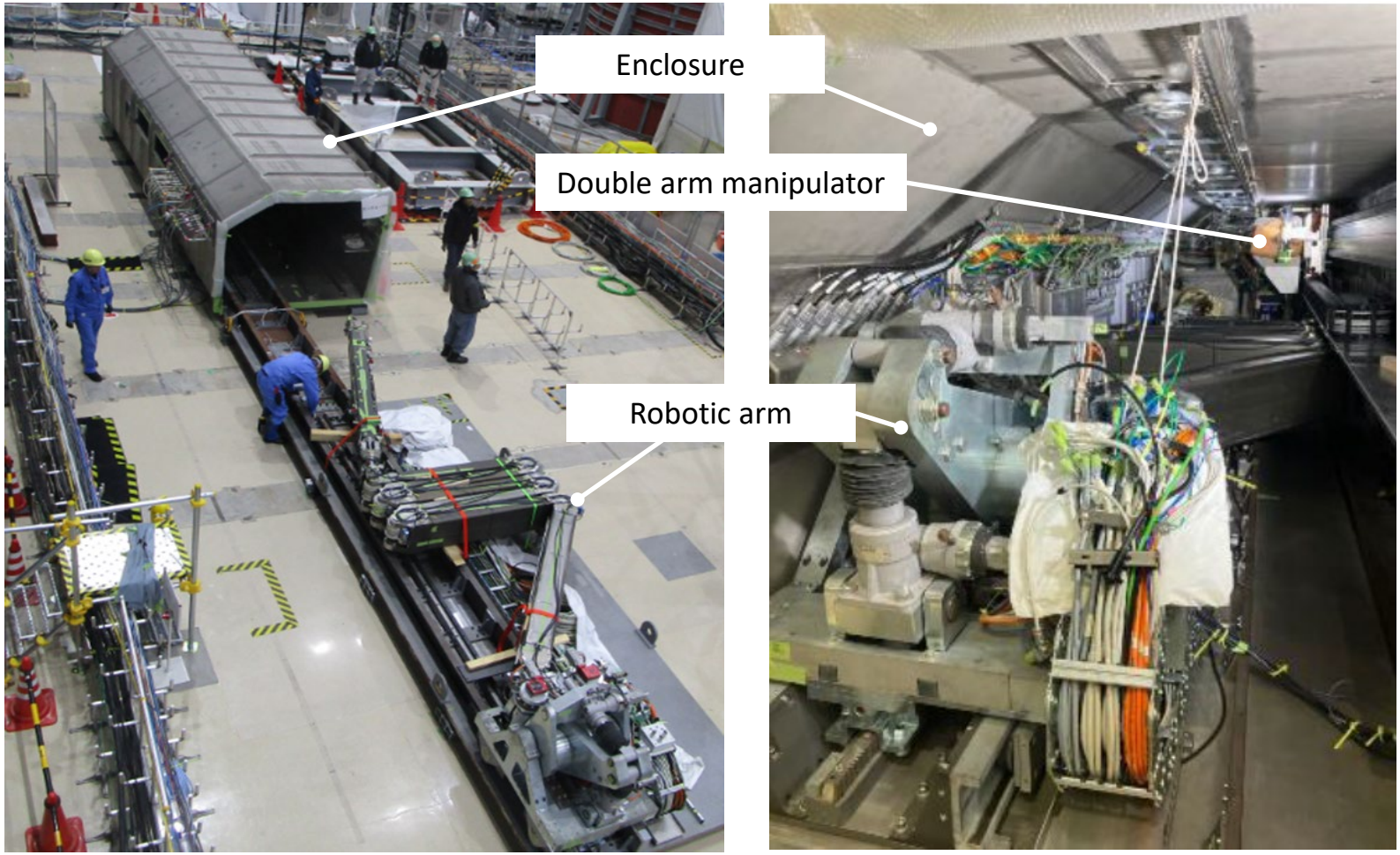
Performance tests

Covered in this report

Test category	Test details	Naraha
Robotic arm-related tests	Ability to pass through the X-6 penetration	Completed
	Removing obstacles at the exit for the X-6 penetration using the AWJ	Completed (work efficiency being examined)
	Function tests (deflection management, etc.)	Completed
	Ability to access the inside of the PCV ・Accessing the top of the pedestal ・Accessing the bottom of the pedestal	Completed
	Removing obstacles inside of the PCV ・Cutting obstacles inside the PCV after passing through the X-6 penetration	Completed (work efficiency being examined)
Double arm manipulator-related tests	Connecting sensor tools to the arms	Completed
	Connecting/removing the external cables to/from the arms	Completed
	Bringing in and removing sensor tools	Completed
	Removing the fixed arm jig	Completed
	Replacing arm cameras/lighting	Completed
	Changing the position of the enclosure camera	Completed
	Forced withdrawal of the arm	Underway
Run-through tests (robotic arm + double arm manipulator	Installing sensors, tools and external cables at the arm	Underway
	Constructing an access route (removing obstacles using the AWJ)	To be performed going forward
	Investigation of the top of the pedestal (sensors and wand are installed)	
	Investigation of the bottom of the pedestal (sensors and wand are installed)	

2-2. Status of Testing of Unit 2 Fuel Debris Trial Retrieval Equipment [Run-through Test]

- The arm has been assembled inside the enclosure.
- Currently, operational tests of the double arm manipulator inside the enclosure are underway.



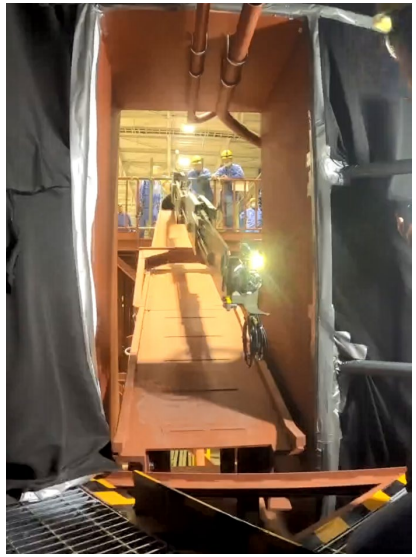
The robotic arm being installed inside the enclosure

3. Status of Mockup of the Telescopic Trial Retrieval Equipment

- Manufacturing of primary components has been completed, and mockup testing is currently underway at the manufacturer's factory.

Telescopic trial retrieval equipment (photo taken from above the equipment)

Inserting the guide pipe



Inserting the equipment into the pedestal opening

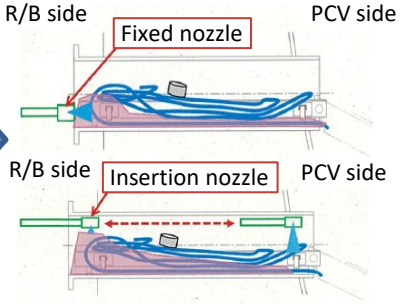
Suspending and lowering the end jig through the grating opening

4-1. Deposit Removal Status

- During the removal of deposits from inside the X-6 penetration, deposit removal equipment will be set up inside an isolation chamber that serves as a boundary with PCV so that we can safely and carefully continue to remove deposits while preventing the gases inside the PCV from leaking out and impacting the surrounding environment.
- As with all tasks performed to date, we shall take dust measurements during this task using dust monitors and continually monitor dust concentrations in order to confirm that gases inside the PCV are not leaking out and impact on the surrounding environment.

Installation of deposit removal equipment (low pressure water)

Spray jig installation
※Connected to X-53 penetration



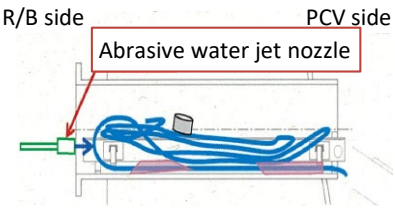
Deposit removal equipment (low pressure water)

※Remotely operated
Deposits are pushed with the dozer rod after which low pressure water is sprayed to remove the deposits

Removal of deposit removal equipment (low pressure water)

Red outline indicates current progress;
X-6 penetration deposit removal
(high-pressure water, abrasive water jet) are underway

Installation of deposit removal equipment (high pressure water, abrasive water jet)



Deposit removal equipment (high pressure water, abrasive water jet)

※ Remotely operated
Deposits are pushed with the dozer rod after which high pressure water/abrasive water jet is sprayed to remove the deposits

Removal of deposit removal equipment (high pressure water, abrasive water jet)

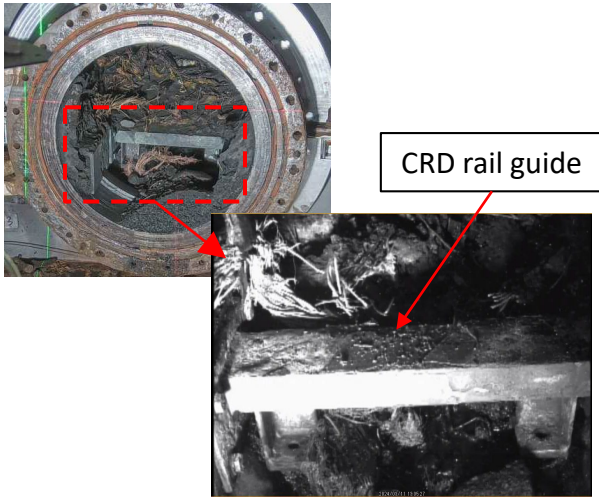
On to next step
Installation of X-6 penetration connection structure

※Photos were taken using the mockup

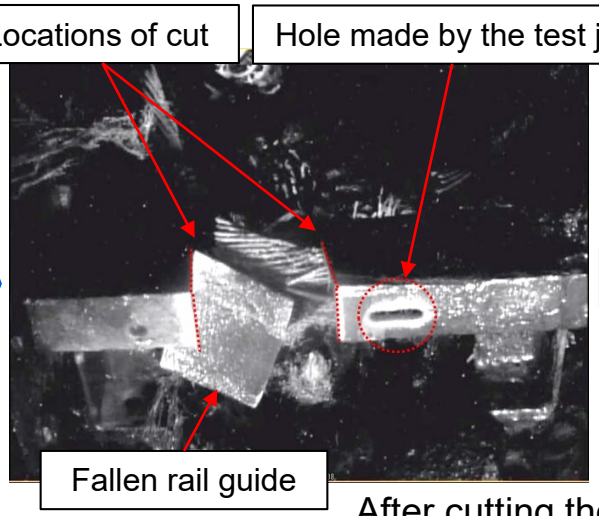
4-2. Field work Progress Status

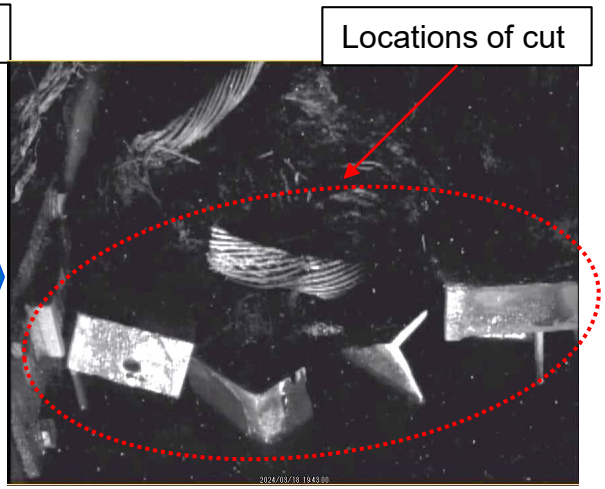
(Removing Deposits from within the X-6 Penetration) (High-pressure water/AWJ): AWJ work

- We started to use the AWJ on March 18, and removed the CRD rail guides that are in front of the X-6 penetration. Since March 22, we have been pushing and cutting the cables using AWJ. Following that, we will remove the CRD rail guides at the back of the X-6 penetration.



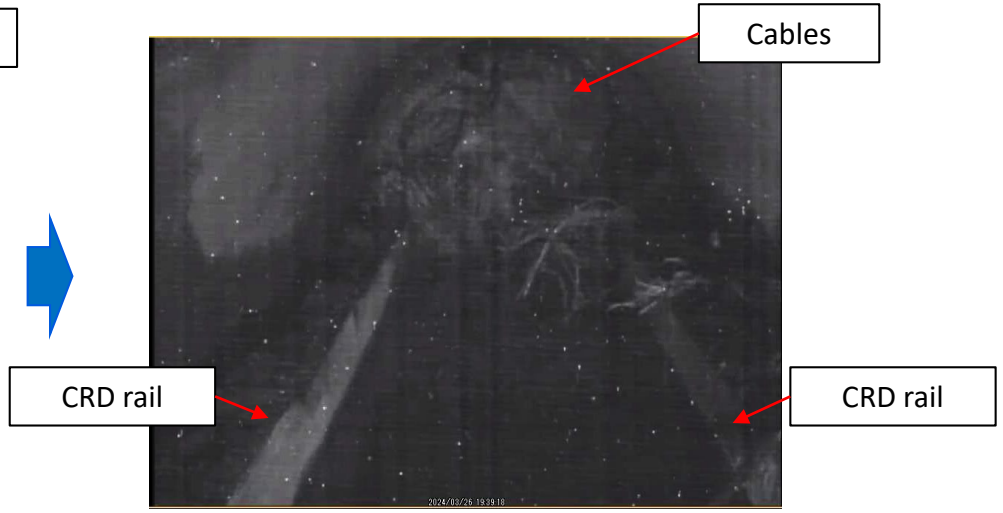
Before cutting the CRD rail guides





After cutting the CRD rail guides

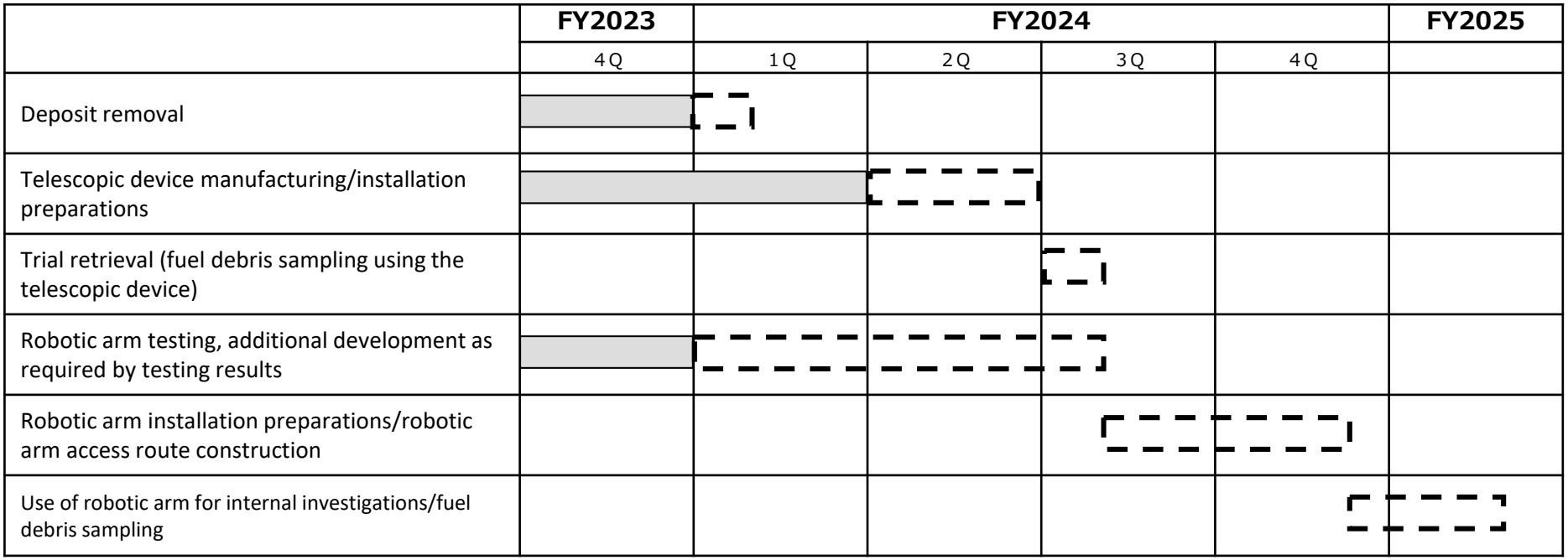
Bringing the CRD rail guide into the PCV



Pushing the cables towards the back of the X-6 penetration

5. Schedule

- We began the deposit removal work using the AWI and have cut away the CRD rail guides that are in front of the X-6 penetration. Currently, we are continuing the deposit removal work with the high-pressure water/AWJ.
- There are uncertainties of removing deposits with low pressure water, high pressure water and AWJ. In addition, we know through tests using the mockup that it will take time to construct an access route for the robotic arm. Furthermore, we must conduct additional tests to confirm the reliability of the robotic arm that will be used for the first time inside the primary containment vessel of a reactor that has suffered an accident. In light of these situations, to ascertain the attributes of fuel debris quickly and steadily, we will use the telescoping device that was successful during past internal investigations and can be inserted into the PCV without completely removing all of the deposits, to sample fuel debris. Thereafter, we will perform internal investigations and sample fuel debris with the robotic arm as we continue initiatives pertaining to trial retrieval.
- Prior to constructing an access route for the robotic arm, we will use the telescopic device to confirm conditions after the removal of deposits from inside the PCV thereby improving the certainty that robotic arm tasks can be performed.
- We plan to begin the trial retrieval of fuel debris by October 2024 at the latest.
- We will continue to steadily move forward and prioritize safety during the removal of deposits and the trial retrieval of fuel debris.



[Reference] Field Work Progress
Primary Steps of the Fuel Debris Trial Retrieval (Internal Investigations/Debris Sampling)

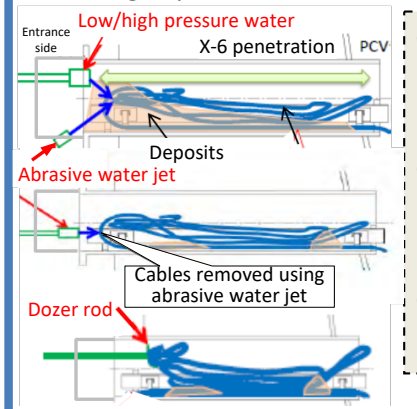
Approved

1. Isolation chamber installation

2. Opening of the X-6 penetration hatch

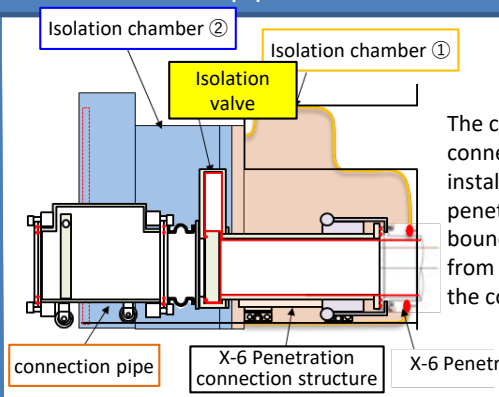
3. Removal of deposits from inside the X-6 penetration

Removing deposits/cables from inside the X-6 penetration



- Deposits pushed with low/high-pressure water
- Cables removed with Abrasive water jet
- Cables pushed with dozer rod

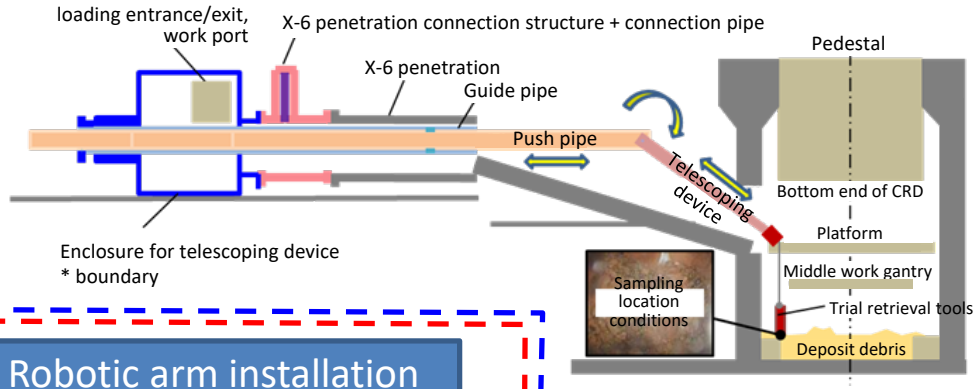
4. Installation of X-6 penetration connection structure and connection pipe



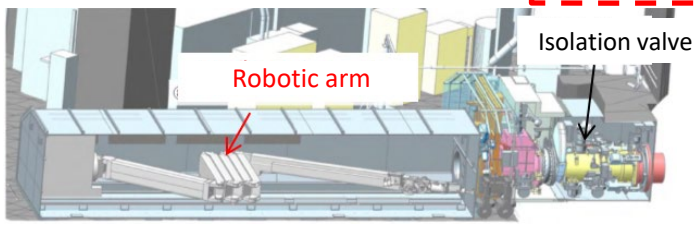
The connecting structure and connection pipe will be installed at the X-6 penetration and the boundary will be changed from the isolation chamber to the connection structure.

Approval application pending

5. Installation of telescopic device
6. Trial retrieval (debris sampling using telescopic device)

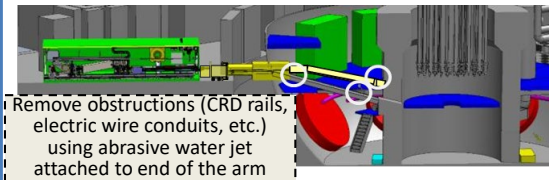


7. Robotic arm installation



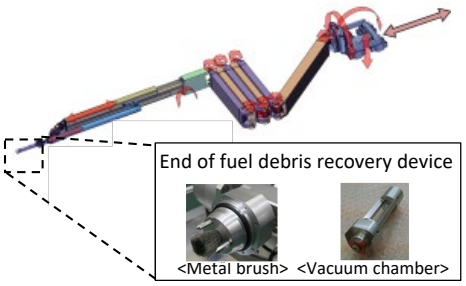
8. Internal investigation/debris sampling using robotic arm

① Internal investigation



Remove obstructions (CRD rails, electric wire conduits, etc.) using abrasive water jet attached to end of the arm

② debris sampling using robotic arm



(Note)

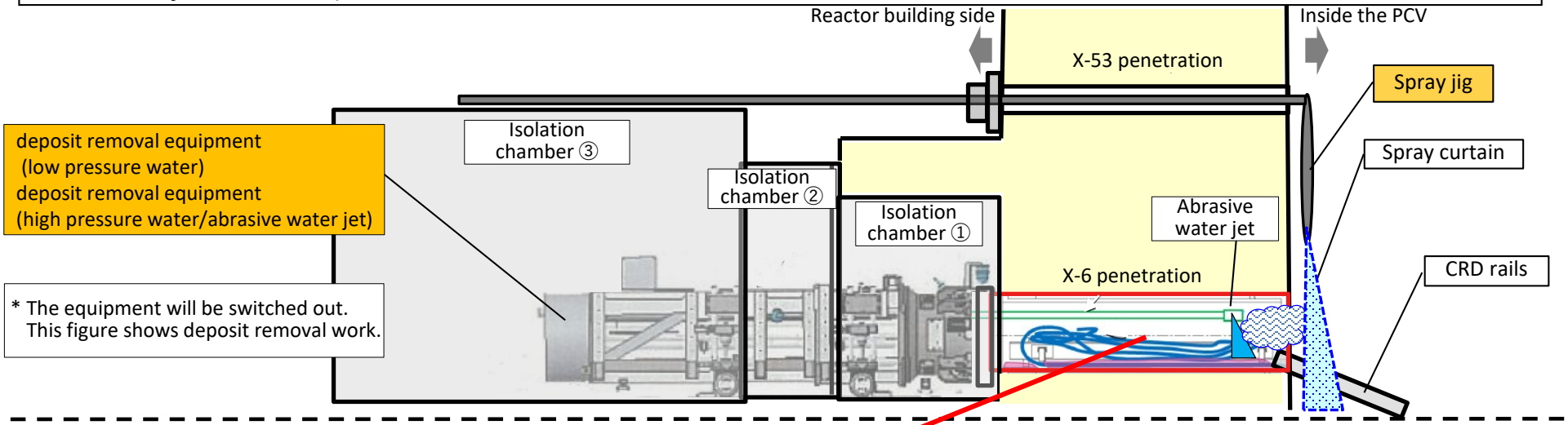
Isolation valve: Valve installed to separate the inside of the PCV from the outside

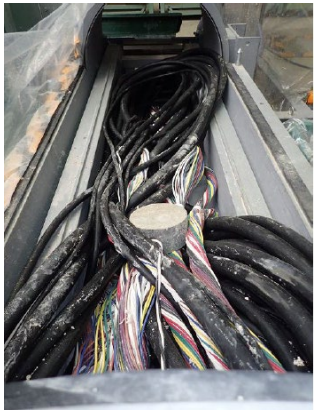
Abrasive Water Jet: Combines high pressure water with an abrasive to improve cutting ability

[Reference] Overview of Deposit Removal Work

In order to construct an access route for the trial retrieval of fuel debris, the following preparations will be made:

- Suppression of dust dispersion inside the PCV using a spray jig
- Removal of deposits inside the X-6 penetration using a deposit removal equipment (low pressure water/dozer rod)
- Removal of deposits inside the X-6 penetration using a deposit removal equipment (high pressure water/abrasive water jet/dozer rod)

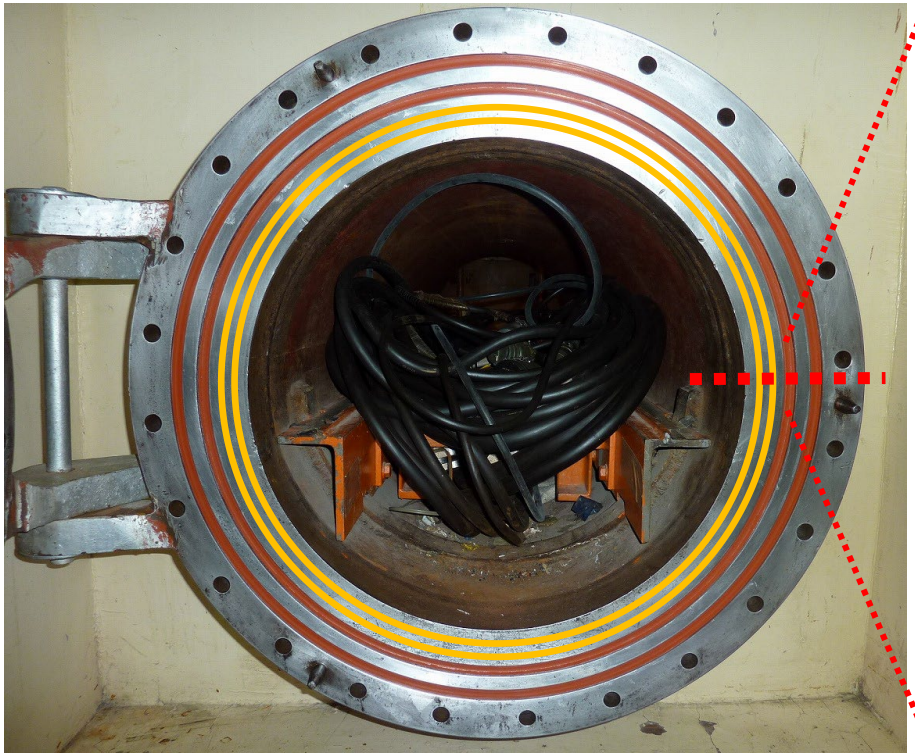




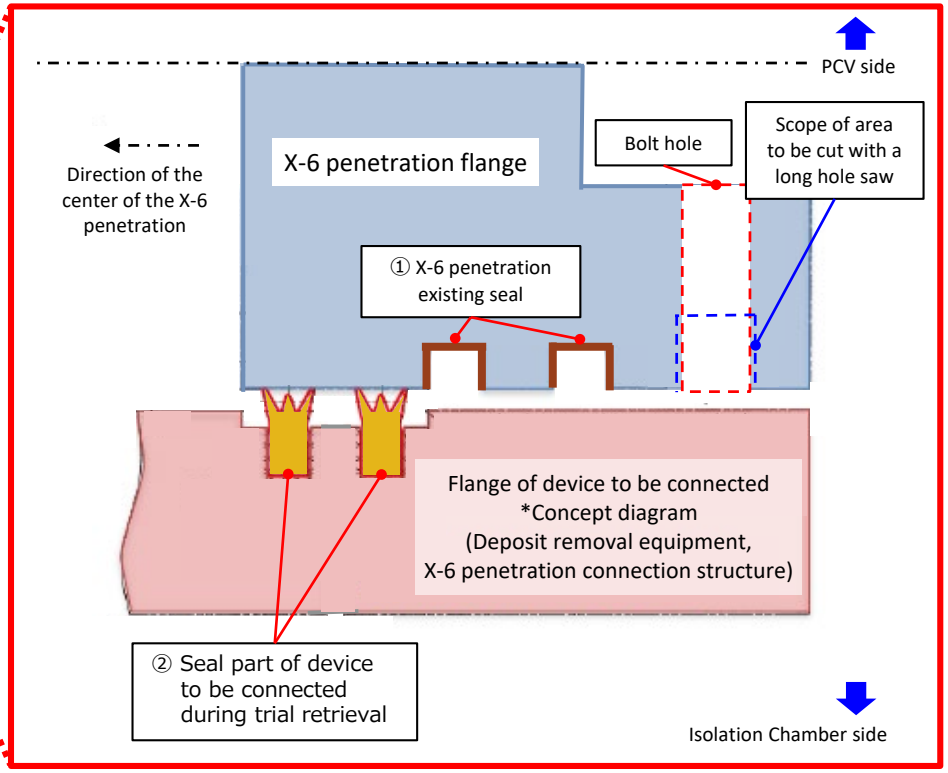
Conditions inside the X-6 penetration (mockup)

[Reference] Sealing of the Device Connected to the X-6 Penetration

- A deposit removal equipment and X-6 penetration connection structure will be connected to the hatch flange after it is opened



X-6 penetration hatch prior to the accident (open)

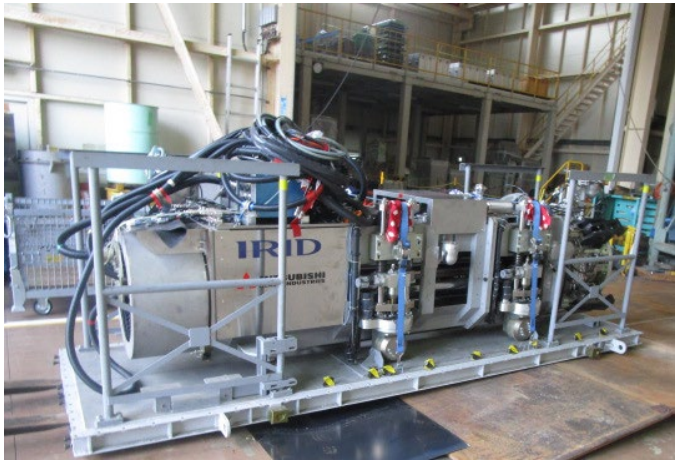


Location of seals when connecting devices to the X-6 penetration (as seen from above)

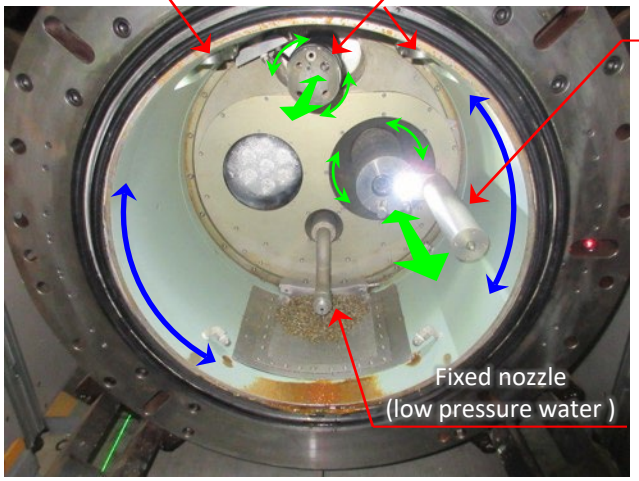
: ① X-6 penetration existing seal
: ② Seal of the devices connected to during trial retrieval
* Deposit removal equipment, X-6 penetration connection structure

[Reference] Deposit removal equipment (low pressure water, high pressure water and abrasive water jet)

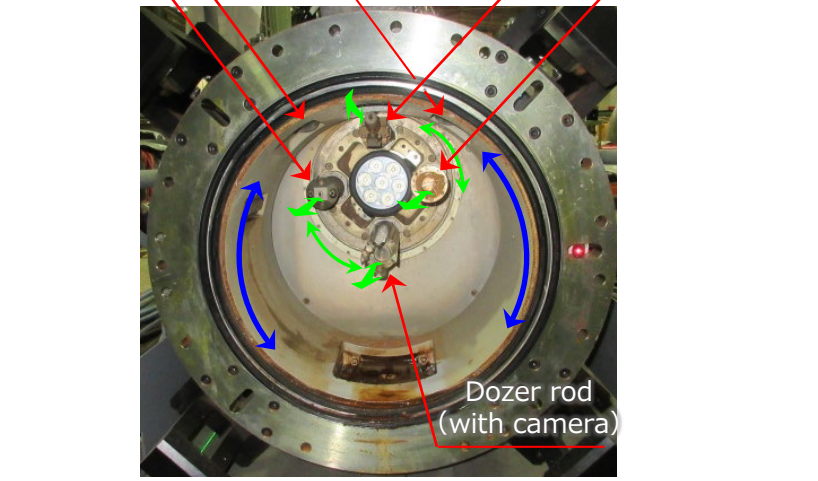
Exterior view of the deposit removal equipment (low pressure water)



Exterior view of the deposit removal equipment (high pressure water/abrasive water jet)



Cross-sectional view of the deposit removal equipment (low pressure water) connection to X-6 penetration



Cross-sectional view of the deposit removal equipment (high pressure water/abrasive water jet) connection to X-6 penetration

[Reference] Environmental Impact (1/2)

- The removal of deposits from inside the Unit 2 X-6 penetration has been ongoing since January 10, and we have not seen any radiological impact on the surrounding environment.
- During investigations, gases from inside the primary containment vessel have been prevented from leaking to the outside environment through the construction of a boundary.
- There have been no significant fluctuations in data from monitoring posts or dust monitors neither prior to or after work.
- Data from monitoring posts/dust monitors near site borders can be found on TEPCO's website
  Reference URL: https://www.tepco.co.jp/en/hd/decommission/data/monitoring/monitoring_post/index-e.html
  https://www.tepco.co.jp/en/hd/decommission/data/monitoring/dustmonitor/index-e.html

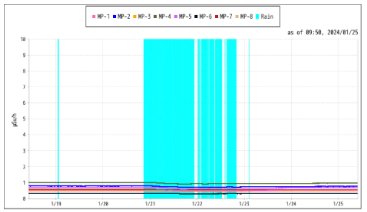
Radiation Dose measured at Monitoring Post of Fukushima Daiichi Nuclear Power Station

The following is the radiation doses of the air measured by the monitoring posts (MP1-8) at Fukushima Daiichi Nuclear Power Station.

Monitoring post (MP1 - MP8)

Monitoring points

Radiation dose



MP Unit : μSv/h Wind Velocity Unit : m/s

=Measurement value (2024/01/25 09:50)

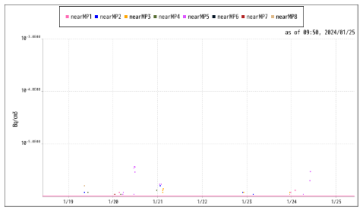
MP-1	MP-2	MP-3	MP-4	MP-5	MP-6	MP-7	MP-8	Wind Direction	Wind Velocity	Rain
0.502	0.758	0.478	0.959	0.670	0.309	0.554	0.522	west-northwest	12.4	No

Radioactive Concentration measured at Dust Monitors near the Site Boundary of Fukushima Daiichi Nuclear Power Station

The following are radioactive concentrations in the air measured near the monitoring posts (MP1-8) at the site boundary of Fukushima Daiichi Nuclear Power Station.

Monitoring points

Radiation concentration



Radioactive Particles Monitor Unit : Bq/cm³ Wind Velocity Unit : m/s

=Measurement value (2024/01/25 09:50)

nearMP1	nearMP2	nearMP3	nearMP4	nearMP5	nearMP6	nearMP7	nearMP8	Wind Direction	Wind Velocity
1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	1.0E-06	northwest	4.4

[Reference] Environmental Impact (2/2)

- The removal of deposits from inside the Unit 2 X-6 penetration has been ongoing since January 10, and during investigations plant parameters are continuously monitored. We have seen no significant fluctuations in primary containment vessel temperature neither prior to or after work, and there's been no change in the status of cold shutdown state.
- Primary containment vessel temperature data can be found on TEPCO's website.
  Reference URL: https://www.tepco.co.jp/en/hd/decommission/data/plant_data/unit2/pcv_index-e.html

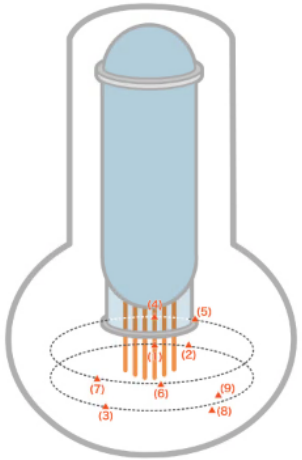
[Reference] Screen image of our website

Temperatures measured inside the Unit 2 Primary Containment Vessel at Fukushima Daiichi Nuclear Power Station

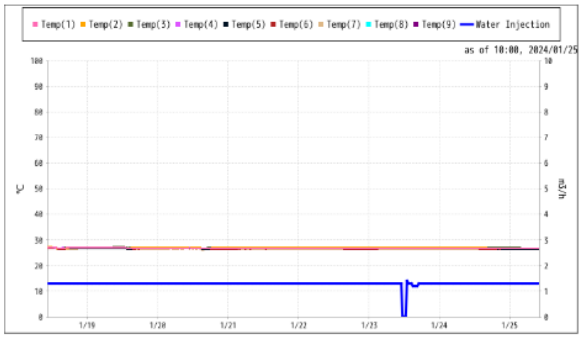
Here are the measurement results of temperatures inside the Unit 2 Primary Containment Vessel at Fukushima Daiichi Nuclear Power Station.

Monitoring points

Unit 2 reactor containment vessel



Temperature



Temperature Unit:℃, Water Injection Unit : m^3/h
=Measurement value (2024/01/25 10:00)

Temp(1)	Temp(2)	Temp(3)	Temp(4)	Temp(5)	Temp(6)	Temp(7)	Temp(8)	Temp(9)	Water Injection
26.6	26.8	26.8	26.7	26.5	26.4	26.3	-	-	1.3