

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

December 26, 2024

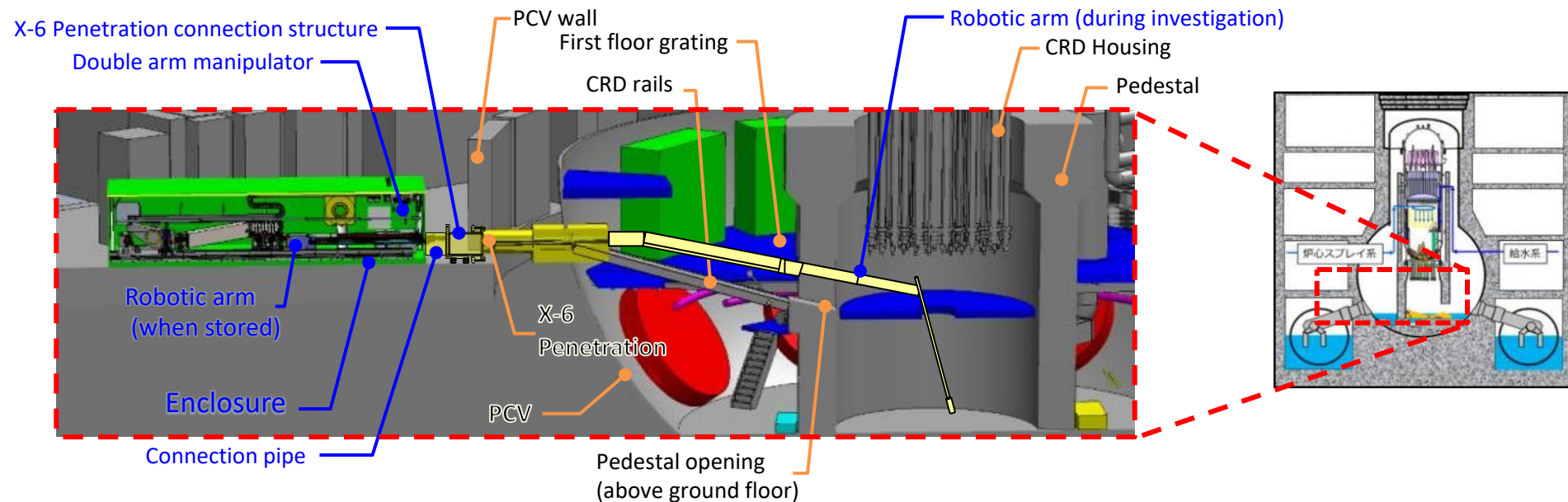
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International Research Institute for Nuclear Decommissioning  
Tokyo Electric Power Company Holdings, Inc.

# 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.
  - 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 telescopic device and 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. Field Preparation Work Progress

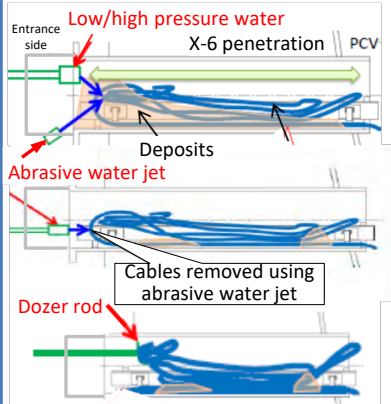
## Primary Steps of the Fuel Debris Trial Retrieval (Internal Investigations/Debris Sampling)

1. Isolation chamber installation

2. Opening of the X-6 penetration hatch

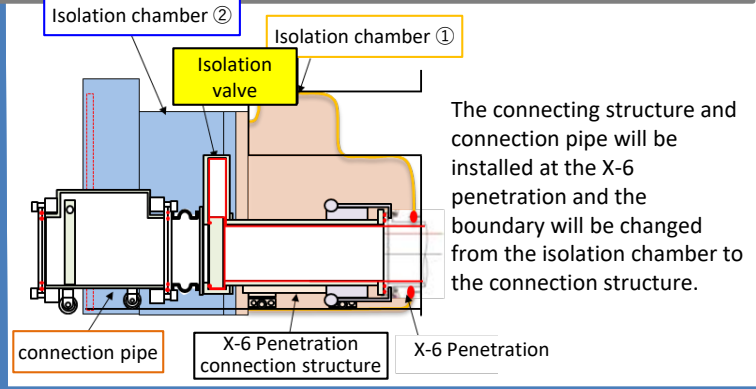
3. Removal of deposits from inside the X-6 penetration

Removing deposits/cables from inside the X-6 penetration

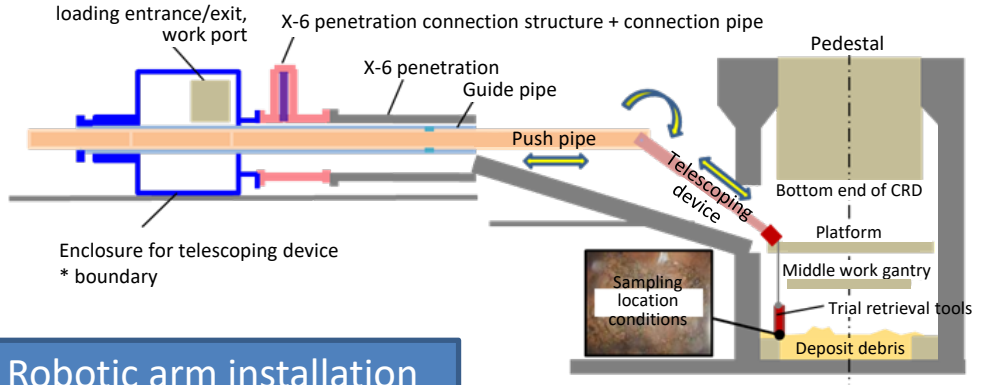


- Deposits pushed with low/high-pressure water
- Cables removed with Abrasive water jet
- Cables pushed with dozer rod

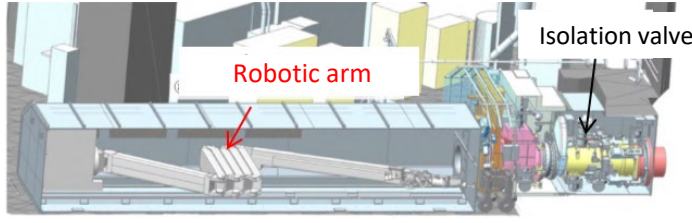
4. Installation of X-6 penetration connection structure and connection pipe



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

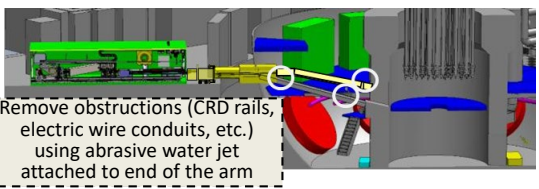


7. Robotic arm installation

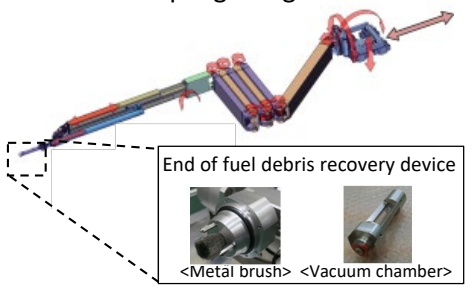


8. Internal investigation/debris sampling using robotic arm

① Internal investigation



② debris sampling using robotic arm



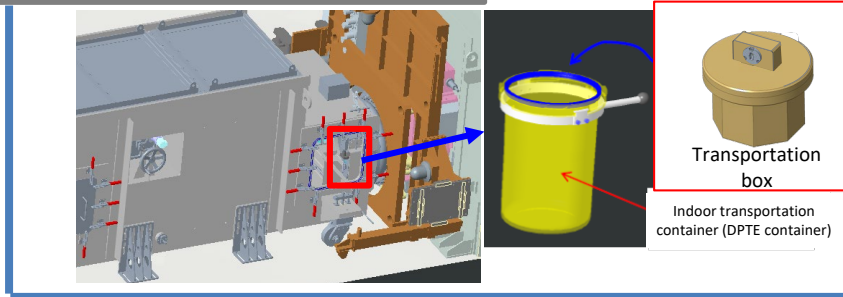
(Note)  
Isolation valve: Valve installed to separate the inside of the PCV from the outside  
Abrasive Water Jet: Combines high pressure water with an abrasive to improve cutting ability

## 2-2. Field Preparation Work Progress

### Primary Steps of the Fuel Debris Trial Retrieval (Internal Investigations/Debris Sampling)

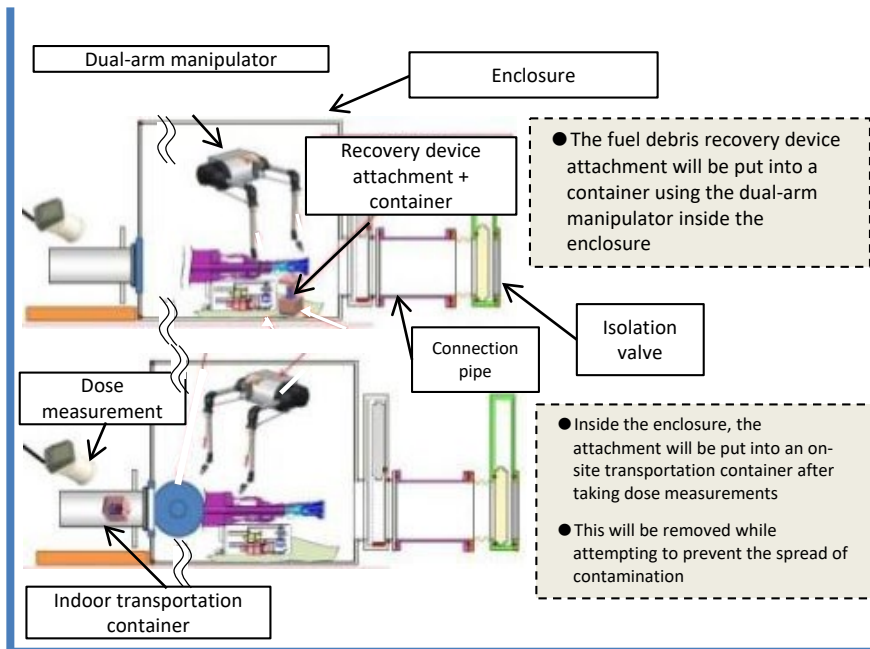
↓ (From Step 6 on the previous slide)

#### 9-1. Collection of fuel debris

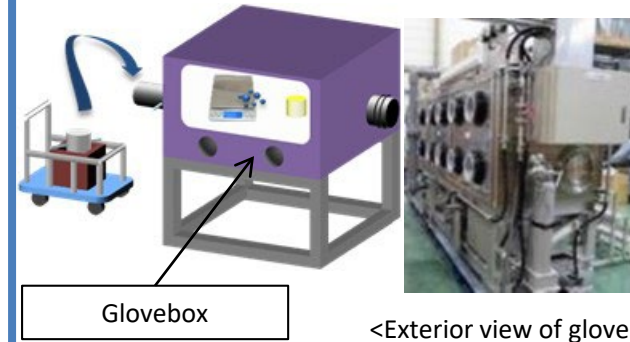


↓ (From Step 8 on the previous slide)

#### 9-2. Inserting the fuel debris recovery device attachment into a container, Inserting into an on-site transportation container/Dose measurements

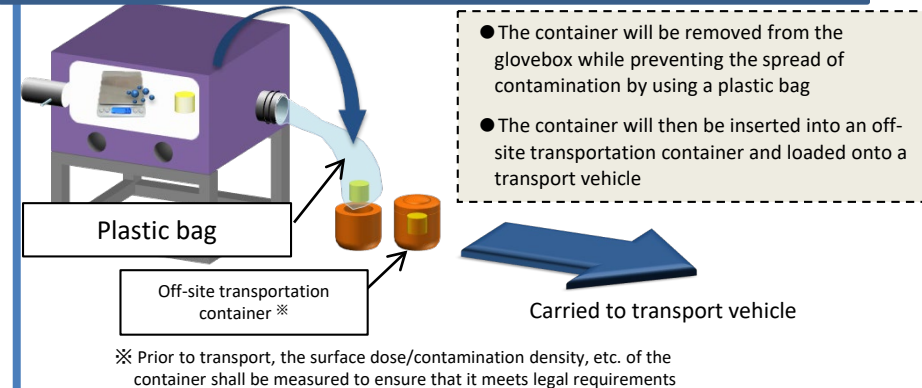


#### 10. Insertion into glovebox/Measurement



- The collected samples will be put into a negative pressure glovebox
- The samples will be subjected to various measurements inside the glovebox and then put into a container

#### 11. Container removal/Insertion into transportation container /Removal from premises

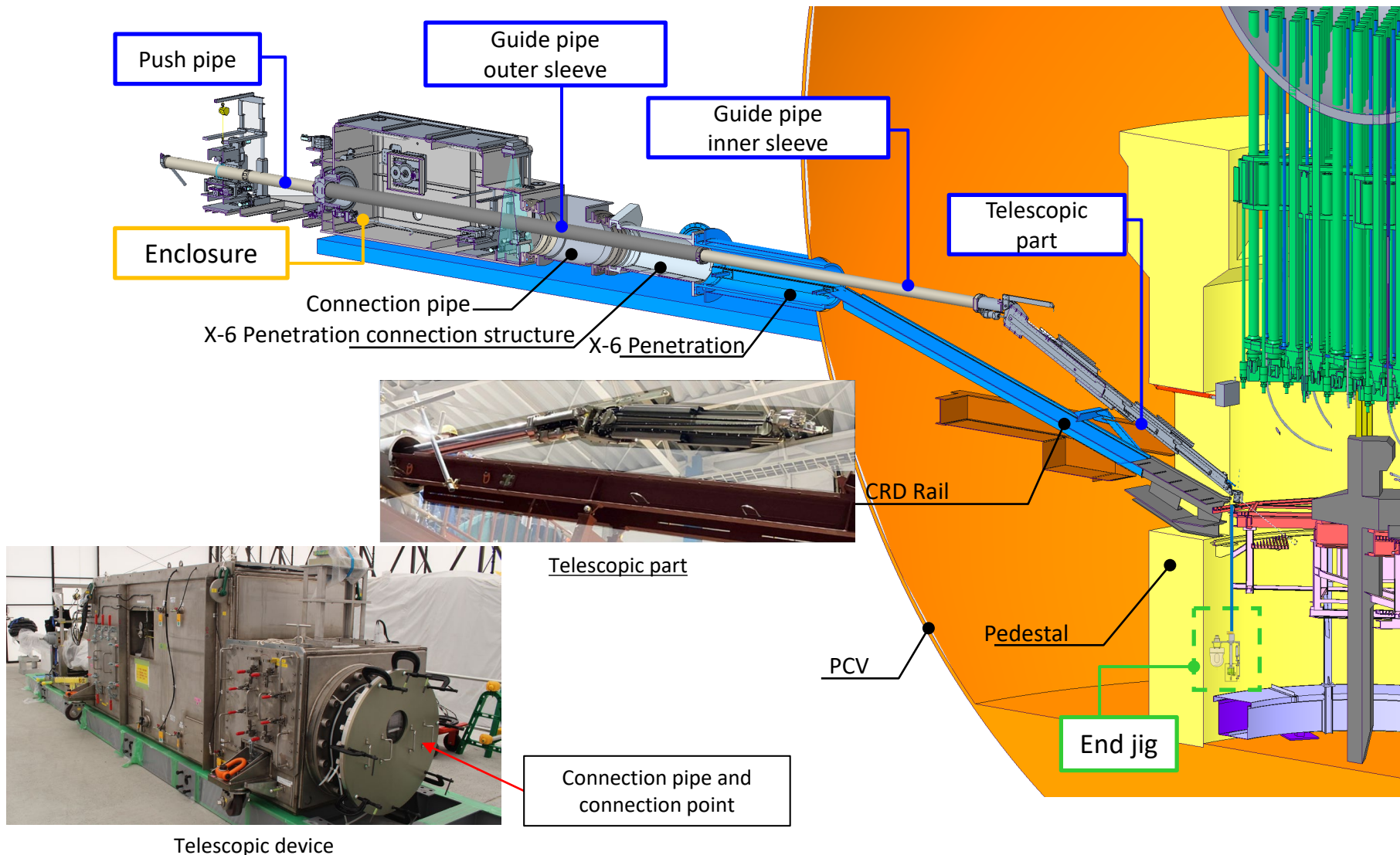


#### 12. Off-site transport and off-site analysis

(Note)  
 DPTE Container is an abbreviation of “Double Porte pour Transfert Etanche”.  
 By opening/closing the lid of the container and double door of the glove box at the same time, it allows the items to be transferred while maintaining a sealed environment.

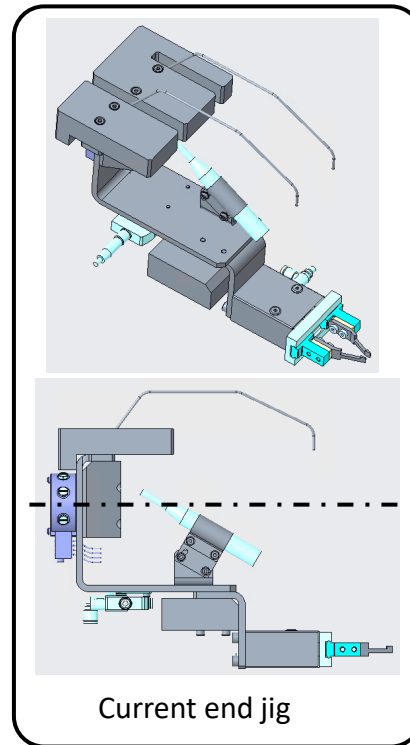
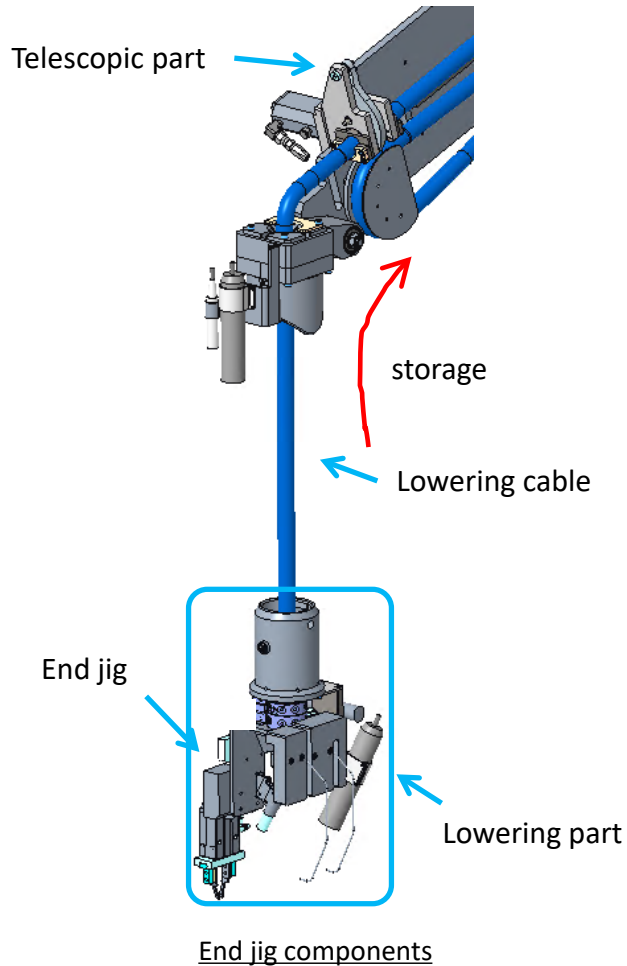
### 3-1. Sampling Debris with the Telescopic Fuel Debris Trial Retrieval Device

- We assume that the attributes and distribution of fuel debris will be quite varied, so in order to increase sample size and expand our knowledge we will continue to use the telescopic device, which is already installed on site and has proven successful, to take additional fuel debris samples.

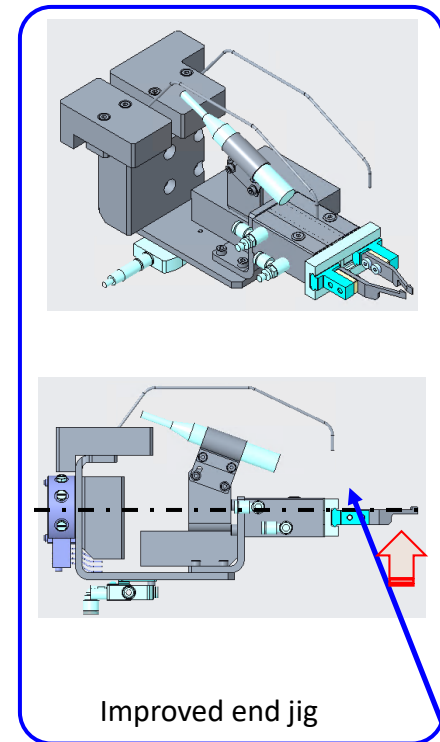


### 3-2. Sampling additional Debris with the Telescopic Fuel Debris Trial Retrieval Device

- During the first fuel debris sampling, time was required to maneuver the end jig because the lowering part was not stable. So we are deliberating how to improve the maneuverability of the end jig before sampling additional fuel debris.



Current end jig



Improved end jig

Concept diagram of end jig improvements

Stability has been improved by moving the location of the gripper to the center of rotation of the end jig

## 4-1. Status of robotic arm tests (Performance tests)

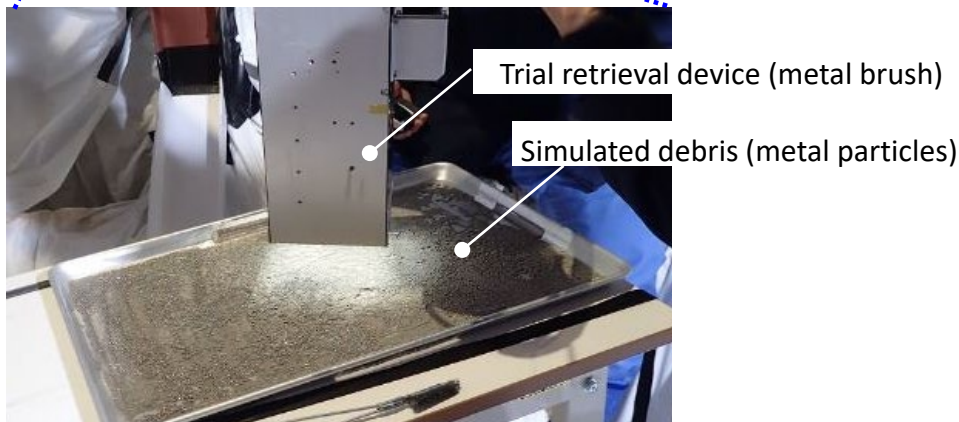
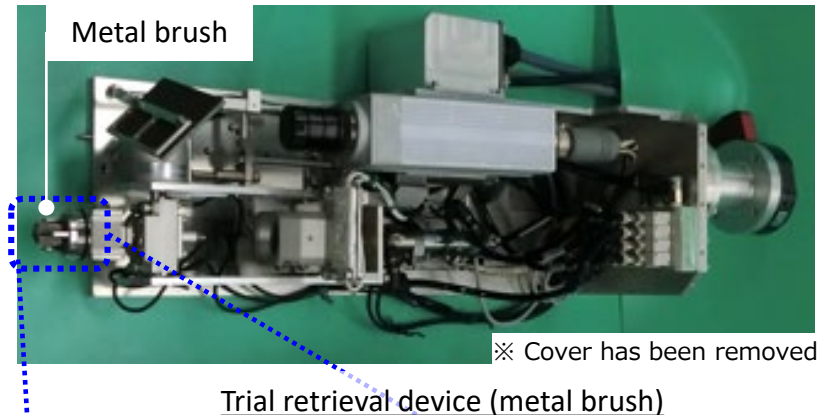
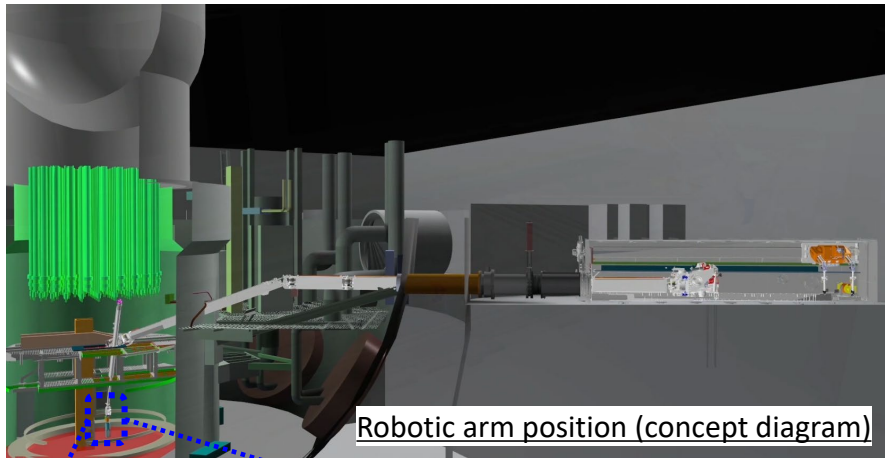
- Tests on a mockup of the decommissioning site are being implemented at the Naraha mockup facility and combined once-through tests are underway.
- In the field, the arm will have to be repeatedly passed through narrow access ways, so the control program is being continually Since the robotic arm will 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. Other tests are also being performed simultaneously.
- Furthermore, in addition to robotic arm developing, we are also confirming this technology applicability to the actual worksite by looking at procedures that simulate actual work tasks, operator operability, and equipment reliability.

### Performance tests

Test category	Test	JAEA 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 measurements, etc.)	Completed
	Ability to access the inside of the PCV (accessing the top and 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	Completed
Combined once-through tests (robotic arm + double arm manipulator)	sensors/external cables, tools/Installing external cables at the arm	Completed
	Investigation of the top of the pedestal (sensors and wand are installed)	Underway
	Investigation of the bottom of the pedestal (sensors and wand are installed)	Underway
	Constructing an access route (removing obstacles using the AWJ)	To be performed going forward

## 4-2. Status of robotic arm tests (pedestal investigation/retrieval work)

- Control program corrections are being made, arm maneuverability is being checked, and the device is being tuned.
- Retrieval devices (metal brush, vacuum chamber) are being attached to the end of the robotic arm and used to retrieve simulated fuel debris in mockup tests simultaneously with pedestal investigation tests.



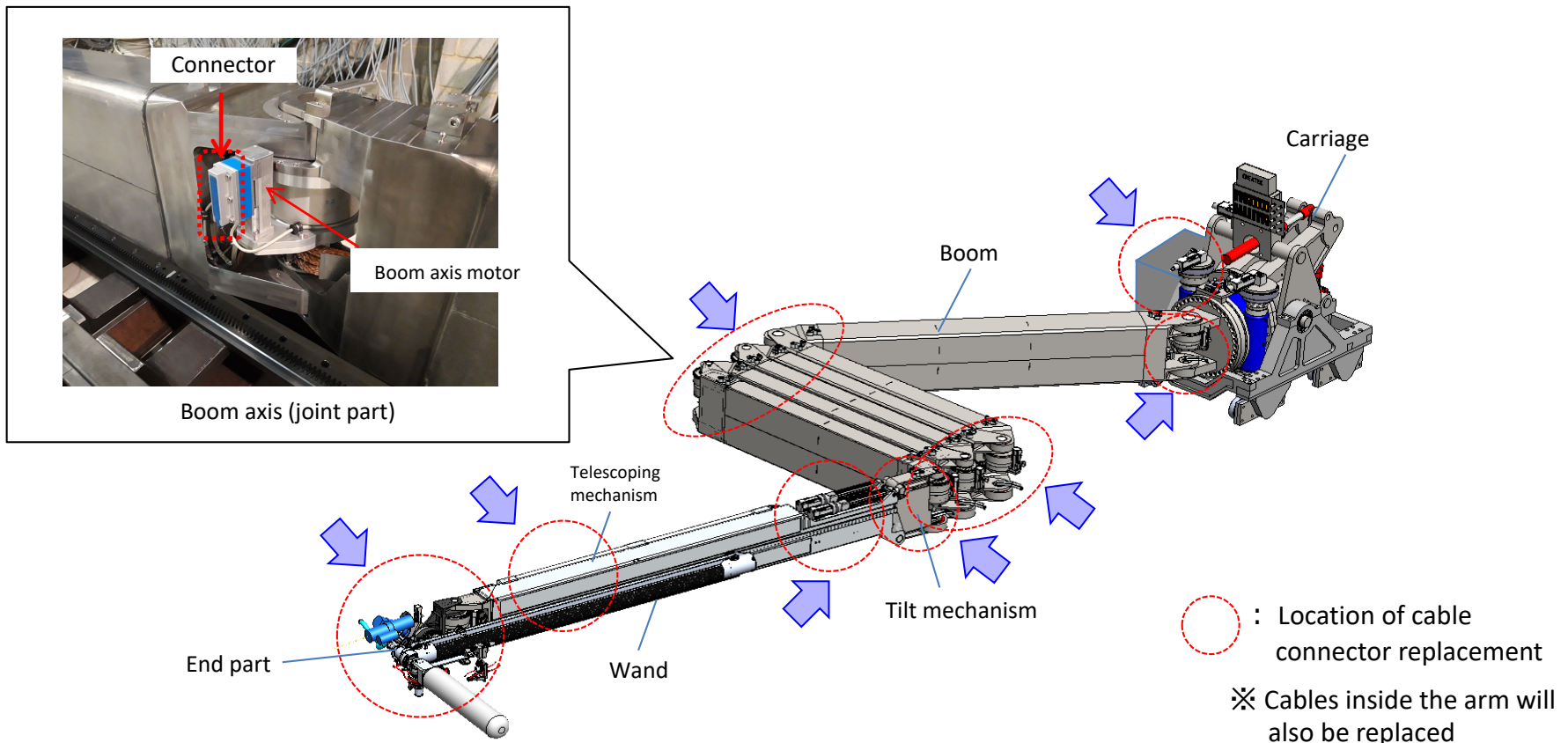
Retrieving simulated debris

Metal brush (after retrieving simulated debris)



## 4-3. Status of robotic arm tests (maintenance)

- During robotic arm maneuverability tests it was found that the motor cable had been severed due to aging, so the cables and connectors were replaced and the tests are underway again.
- Going forward, other similar cables and connectors will be replaced as soon as the timing has been decided on. In conjunction with this, we are performing maintenance on motors and reducers, etc. in preparation for field deployment.
- Furthermore, in light of nonconformities with cameras attached to the telescopic device, precautions to be taken during robotic arm camera function tests and usage are being identified.



Robotic arm diagram

## 5. Work schedule

- We assume that the attributes and distribution of fuel debris will be quite varied, so in order to increase sample size and expand our knowledge we will continue to use the telescopic device, which is already installed on site and has proven successful, to take additional fuel debris samples.
- In preparation to sample additional fuel debris with the telescopic device we will conduct improvements to replace camera attached to the end of the telescopic device and to stabilize lowering of the end jig at the end of the device and mastery training, etc., of workers which is based on previous work results as we aim to begin taking more samples in the spring of 2025.
- Based on information obtained through tests of the robotic arm on a mockup of the decommissioning environment at the Naraha mockup facility, improvements have been made to the control program to reduce the risk of contact with surrounding structures during the retrieval of fuel debris. Furthermore, in addition to improving the accuracy of arm positioning, we are in the process of deliberating how to share information pertaining to the maintenance of aging components discovered during testing and also nonconformities with cameras attached to the telescopic device.
- Based on additional fuel debris trial retrieval using the telescopic device and the test status of the robot arm, we will closely examine the details of the process so that we can safely and carefully proceed with the trial retrieval.

		FY2024				FY2025
		Q1	Q2	Q3	Q4	
Telescopic device	Deposit removal/ device manufacturing/ installation preparations, etc.	[Solid Bar]			[Dashed Box: Preparation for Second]	
	Debris sampling		[Solid Box: First]		[Dashed Box: Second]	
Robotic arm	Inspection/maintenance, etc., and any additional development required based upon once-through tests/test results	[Solid Bar]				[Dashed Box]
	Installation preparation, etc./access route construction					[Dashed Box]
	Internal investigation/debris sampling					[Dashed Box]



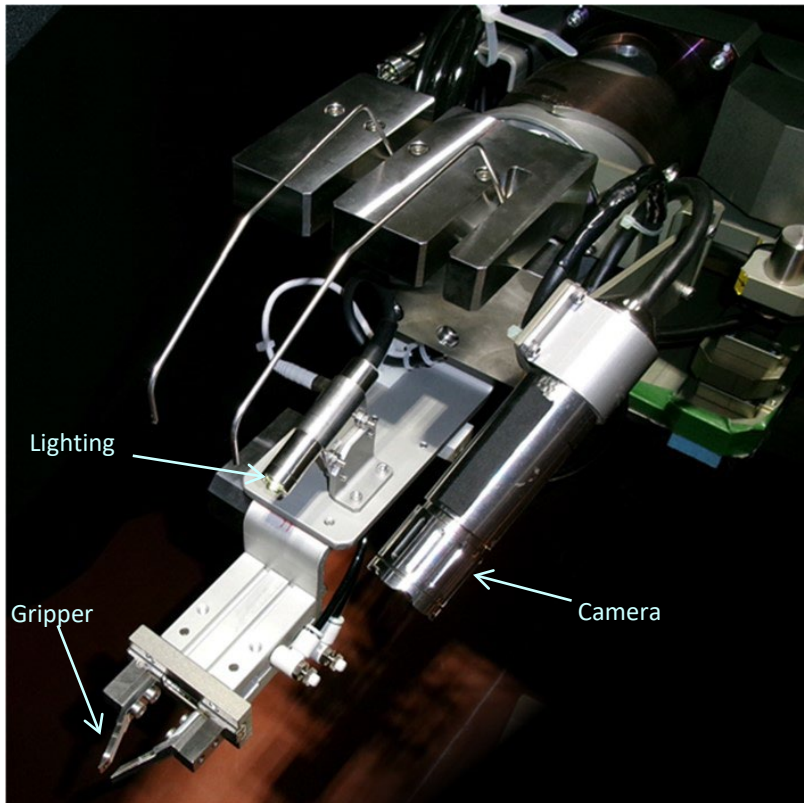
: Past achievements



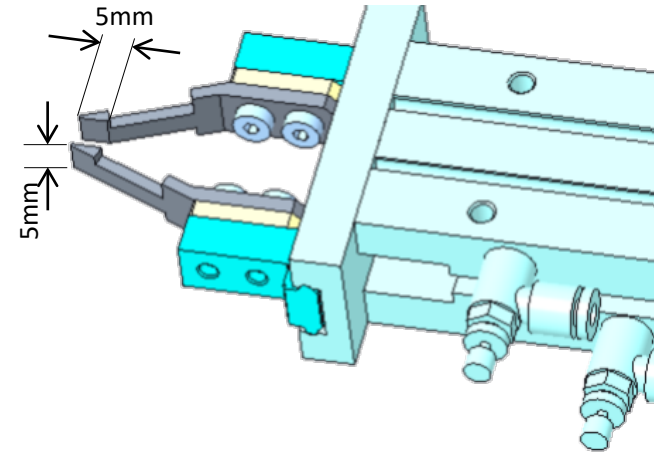
: Start and end dates are under scrutiny

# [Reference] Sampling Debris with the Telescopic Fuel Debris Trial Retrieval Device

- The gripper tool has been selected as the end jig that will be used during the trial retrieval of fuel debris with the telescopic device
- The end jig camera will be used to determine the size of the fuel debris sampled



Gripper tool



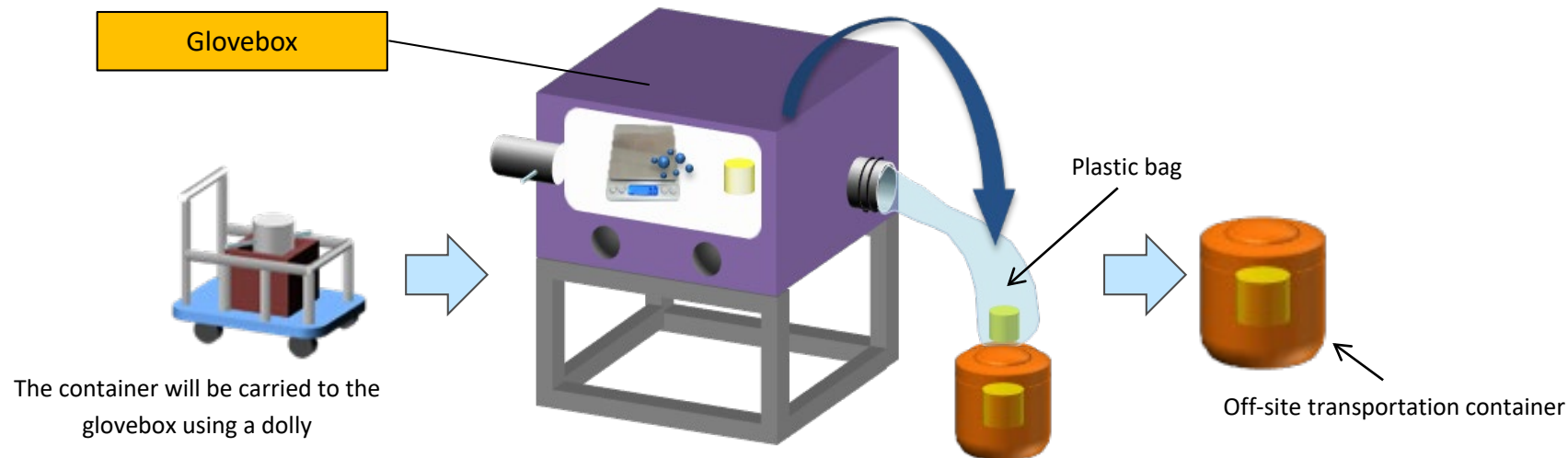
Gripper claws will be used to determine the size (gripper tool)



Camera footage of the gripper tool holding a sphere and a cube shaped mock debris (gripper tool)

## [Reference] Glovebox

- The sampled fuel debris will be subjected to dose measurements when it is taken out from the enclosure of the telescopic device or the robotic arm, and then transported to a glovebox inside the reactor building where it will be subjected to various measurements. After measurements have been taken, measures to prevent the spread of contamination shall be implemented and it will be transported off-site



- The collected samples will be put into a negative pressure glovebox
- The samples will be subjected to various measurements inside the glovebox and then put into a container
- The container will be removed from the glovebox while preventing the spread of contamination by using a plastic bag
- The container will then be inserted into an off-site transportation container and loaded onto a transport vehicle

- The fuel debris sampled during trial retrieval will be transported to an off-site analysis facility (JAEA Oarai)
- We have confirmed that the transport container will remain sealed even when subjected to various test conditions as legally required by law.
- The fuel debris placed inside the specimen container (polyethylene). Then it placed inside a vase-like container (polypropylene, lead). After that it will be sealed inside a bag made of polyvinyl chloride and placed inside the transport container.
- Furthermore, prior to transport we will confirm that surface dose rates and surface contamination density levels fall below legal limits with the fuel debris inside the container.
- Countermeasures have been put in place to prevent the leak of radioactive substances even in the event of an accident.
- In case of a radioactive substances leak, radiation measurements shall be taken and ropes/signs will be used to restrict the area from access after which it will be decontaminated thereby preventing exposure to the general public. All relevant agencies will also be immediately notified.
- Education and training will be provided to parties involved in transport

### Legally required technical standards

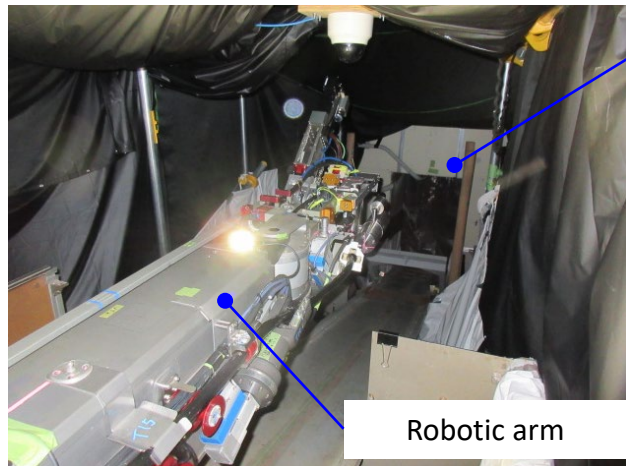
Item	Standard
Amount of reactivity	Sum of A2 level ratios is below 1 (Approx. $3.7 \times 10^{10}$ Bq)
Dose equivalent rate	Surface of transported item: below 2mSv/h 1m from surface of transported item: 100 $\mu$ Sv/h
Surface contamination density	Alpha nuclide: 0.4Bq/cm <sup>2</sup> All other nuclides: 4Bq/cm <sup>2</sup>
Transport container test conditions	Freefall test, compression test, penetration test, etc.



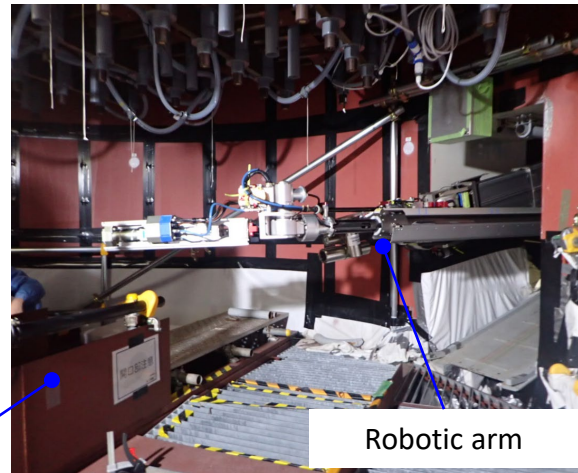
A-type transport container

[Reference] Status of robotic arm tests (Improving positioning accuracy/maintenance)

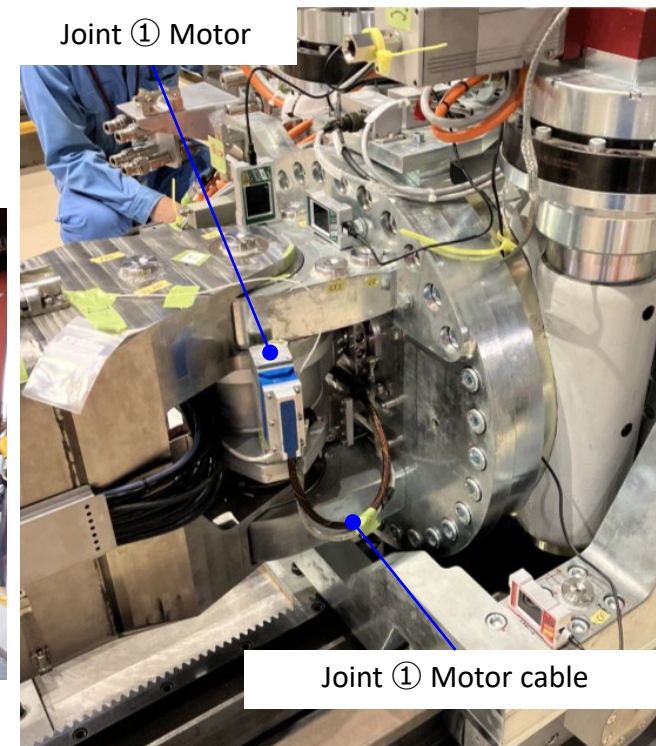
- Control program corrections are being made, arm maneuverability is being checked, and the device is being tuned.
- During robotic arm maneuverability tests it was found that the motor cable had been severed due to aging, so the cables and connectors were replaced and the tests are underway again.
- Going forward, other similar cables and connectors will be replaced. Maintenance will also be performed in preparation for use in the field.



Pedestal opening  
(Simulated)



Inside of the pedestal  
(simulated)



Tests of the robotic arm at the Naraha facility

# [Reference] Environmental Impact (1/2)

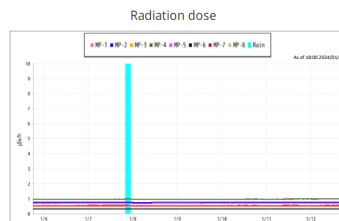
- Although the removal of deposits from inside the Unit 2 X-6 penetration has been ongoing since January 10, and we are planning to begin the trial retrieval of fuel debris in the future, but we have **not seen any radiological impact on the surrounding environment.**
- During investigations, **the gas from inside the primary containment vessel was 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/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



MP Unit : μSv/h Wind Velocity Unit : m/s  
○Measurement value (2024/01/12 18:00)

MP1	MP-2	MP-3	MP-4	MP-5	MP-6	MP-7	MP-8	Measurement value	Unit
0.517	0.793	0.490	0.987	0.703	0.315	0.566	0.530	Measurement value	μSv/h

## 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/m³ 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)

- Although the removal of deposits from inside the Unit 2 X-6 penetration has been ongoing since January 10, and we are planning to begin the trial retrieval of fuel debris in the future, 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](https://www.tepco.co.jp/en/hd/decommission/data/plant_data/unit2/pcv_index-e.html)

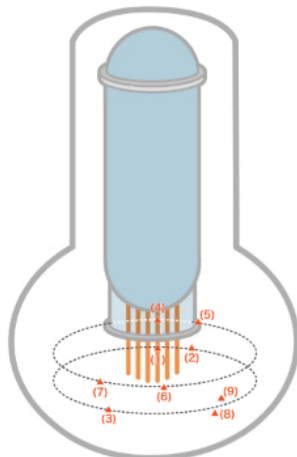
## [Reference] Screen image of our website

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

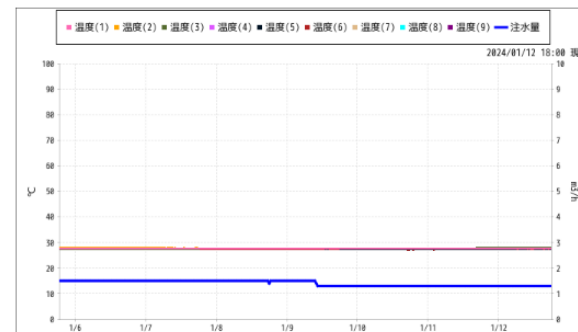
Here are the measurement results of temperatures inside the Unit 2 Primary Containment Vessel at Fukushima Daiichi Nuclear Power Station.

#### Monitoring points

Unit 2 reactor containment vessel



#### Temperature



Temperature Unit: °C. Water Injection Unit: m³/h  
 ○ Measurement value (2024/01/12 18:00)

温度(1)	温度(2)	温度(3)	温度(4)	温度(5)	温度(6)	温度(7)	温度(8)	温度(9)	注水量
27.5	27.8	27.9	27.7	27.4	27.3	27.2	-	-	1.3