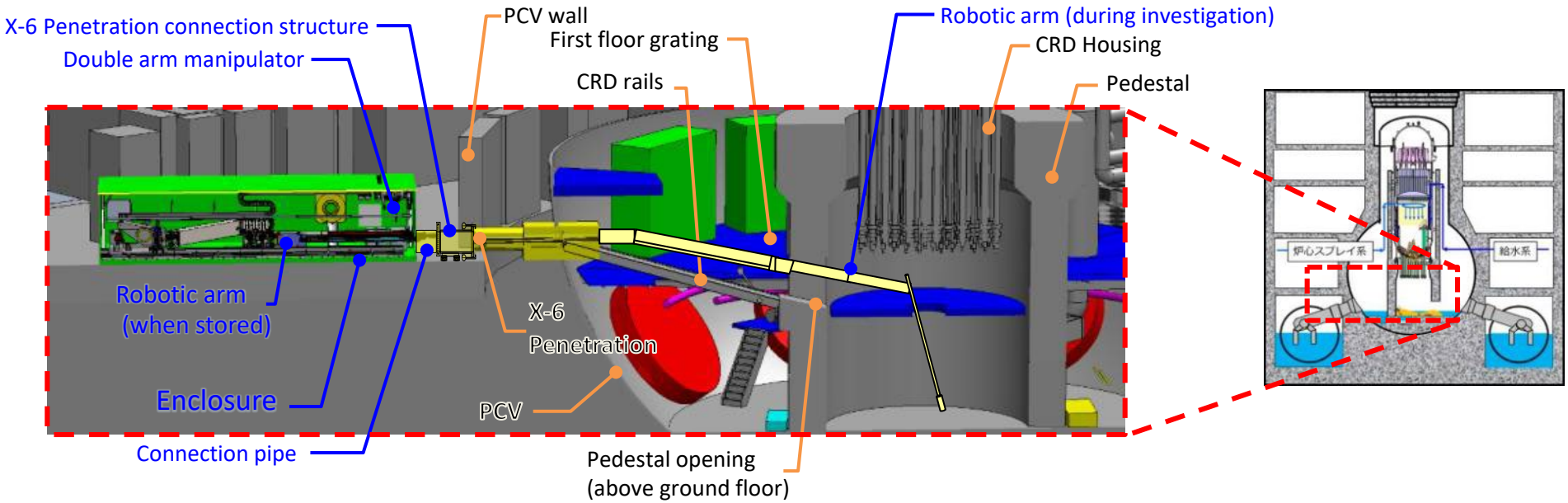
Fukushima Daiichi Nuclear Power Station
Unit 2 PCV Internal Investigation/
Status of Fuel Debris Trial Retrieval

November 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.
  - 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

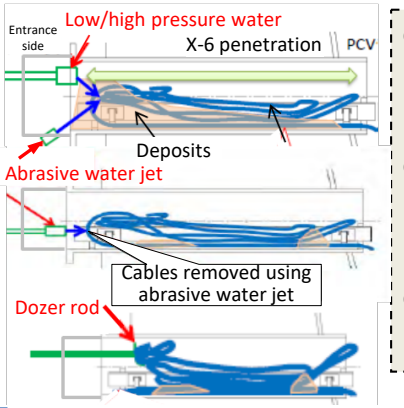
2-1. Field Preparation Work Progress
Primary Steps of the Fuel Debris Trial Retrieval (Internal Investigations/Debris Sampling)

1. Isolation chamber installation

2. Opening of the X-6 penetration hatch

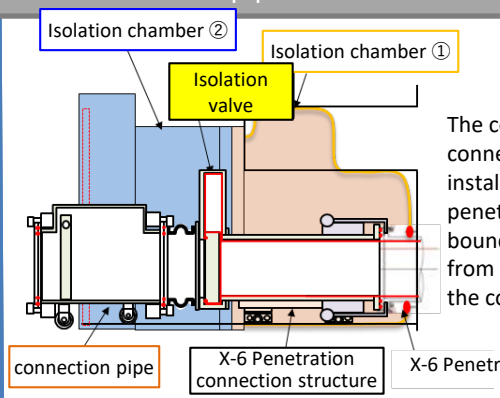
3. Removal of deposits from inside the X-6 penetration

Removing deposits/cables from inside the X-6 penetration



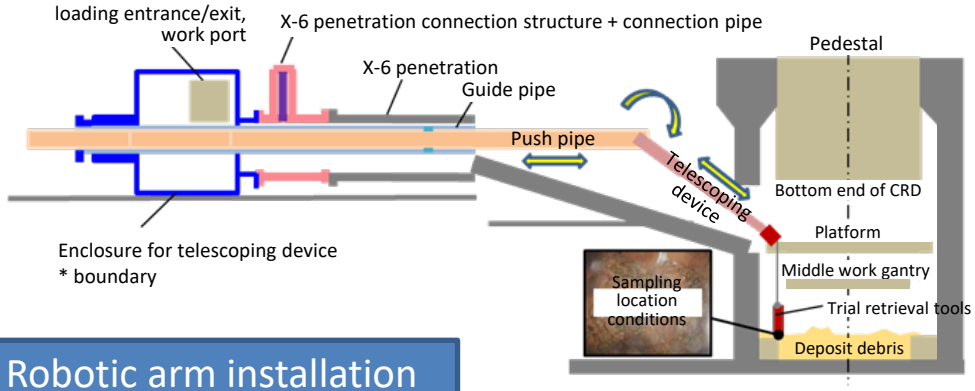
- Deposits pushed with low/high-pressure water
- Cables removed with Abrasive water jet
- Cables pushed with dozer rod

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

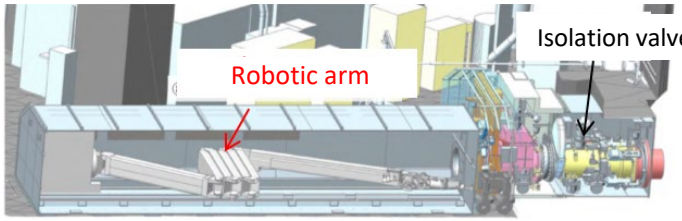


The connecting structure and connection pipe will be installed at the X-6 penetration and the boundary will be changed from the isolation chamber to the connection structure.

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

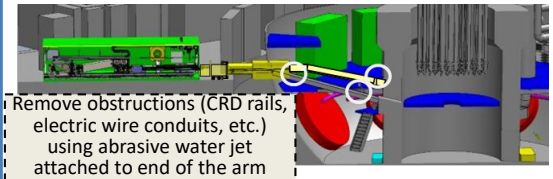


7. Robotic arm installation

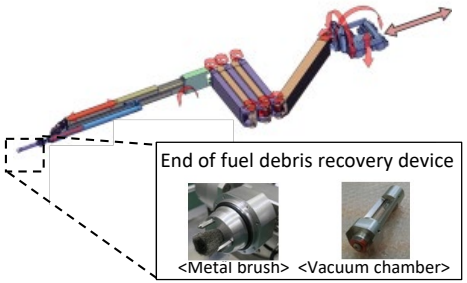


8. Internal investigation/debris sampling using robotic arm

① Internal investigation



② debris sampling using robotic arm



(Note)

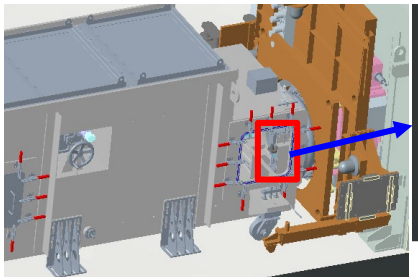
Isolation valve: Valve installed to separate the inside of the PCV from the outside

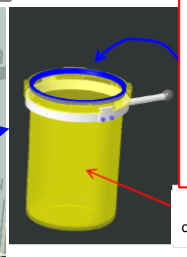
Abrasive Water Jet: Combines high pressure water with an abrasive to improve cutting ability

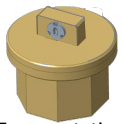
2-2. Field Preparation Work Progress
Primary Steps of the Fuel Debris Trial Retrieval (Internal Investigations/Debris Sampling)

(From Step 6 on the previous slide)

9-1. Collection of fuel debris





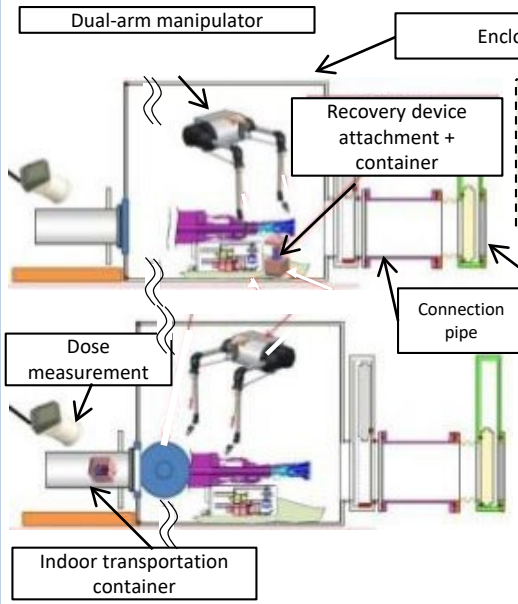


Transportation box

Indoor transportation container (DPTE container)

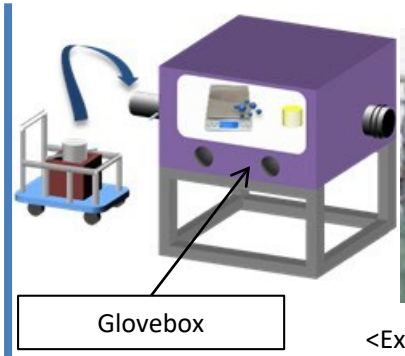
(From Step 8 on the previous slide)

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



- The fuel debris recovery device attachment will be put into a container using the dual-arm manipulator inside the enclosure
- Inside the enclosure, the attachment will be put into an on-site transportation container after taking dose measurements
- This will be removed while attempting to prevent the spread of contamination

10. Insertion into glovebox/Measurement

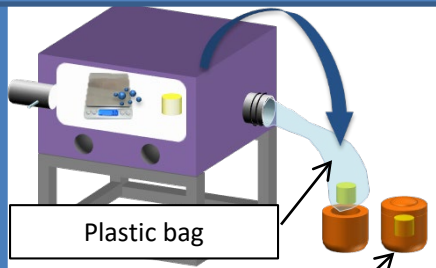


Glovebox

<Exterior view of glovebox>

- 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



Plastic bag

Off-site transportation container ※

Carried to transport vehicle

- 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

※ Prior to transport, the surface dose/contamination density, etc. of the container shall be measured to ensure that it meets legal requirements

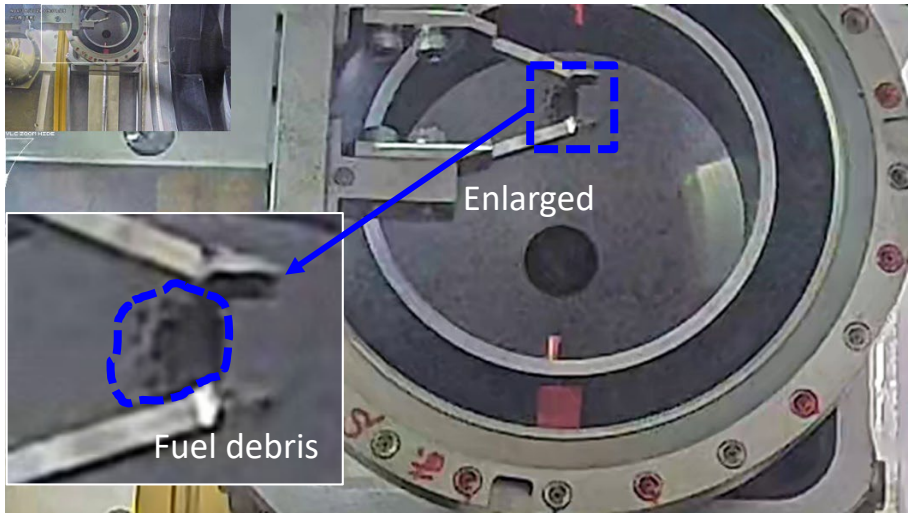
12. Off-site transport and off-site analysis

(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.

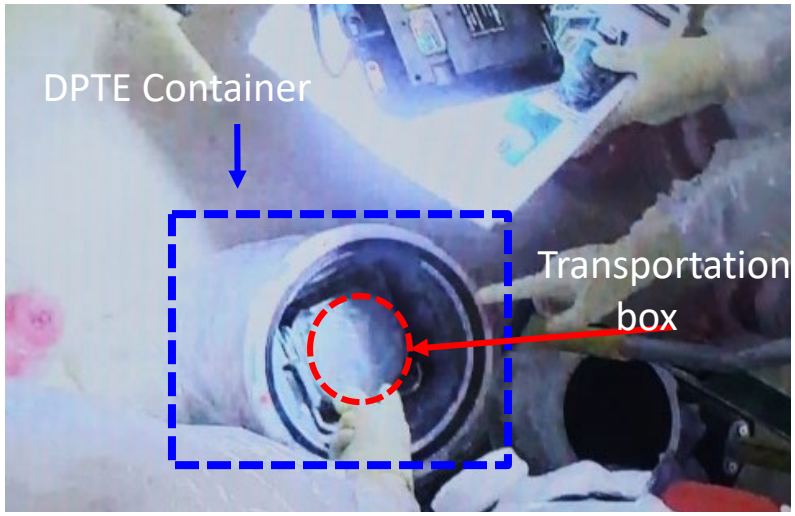
3-1. Field work progress status (completion of fuel debris trial retrieval)

- On November 6, we confirmed that the dose rate of the sampled fuel debris is less than 24mSv/h (at a distance of 20cm), which is the criteria for proceeding with debris retrieval, thus the grasped sample was inserted into a transportation box.
- On November 7, the side hatch of the enclosure was opened and the transportation box was removed from inside the enclosure. Then finally the box was stored in a DPTE (Double Porte pour Transfer Etanche) container.

(The fuel debris trial retrieval work is deemed to have been completed when the transportation box is inserted into the DPTE container.)



Loading the grasped fuel debris into a transportation box



Loading the transportation box into a DPTE container

3-1. Field work progress status (completion of off-site transport of fuel debris)

- Transport of the sampled fuel debris to the Japan Atomic Energy Agency (JAEA) Oarai Nuclear Engineering Institute has been completed.
- The transported fuel debris will be analyzed over a period of several months to approximately one year at analysis facilities such as the JAEA, etc., and the data acquired will be leveraged to deliberate when gradually enlarging the scope of fuel debris retrieval in the future.

Off-site transport container loaded onto the off-site transport vehicle

Final check of the off-site transport vehicle before it departs from the Fukushima Daiichi Nuclear Power Station

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

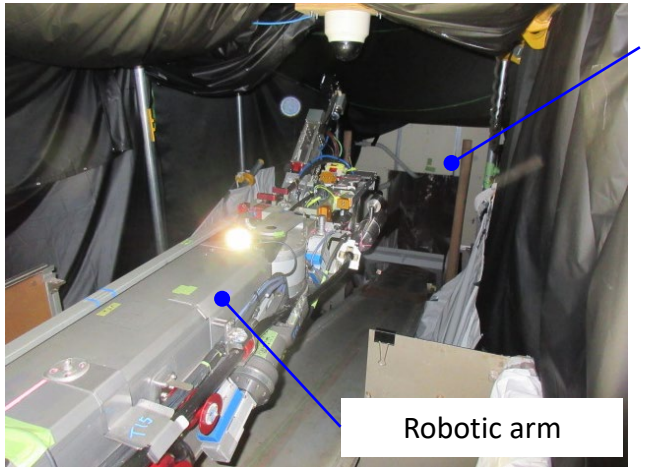
- Tests on a mockup of the decommissioning site are being implemented at the Naraha mockup facility and combined once-through tests are underway.
- In the field, the arm will have to be repeatedly passed through narrow access ways, so the control program is being continually Since the robotic arm will 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

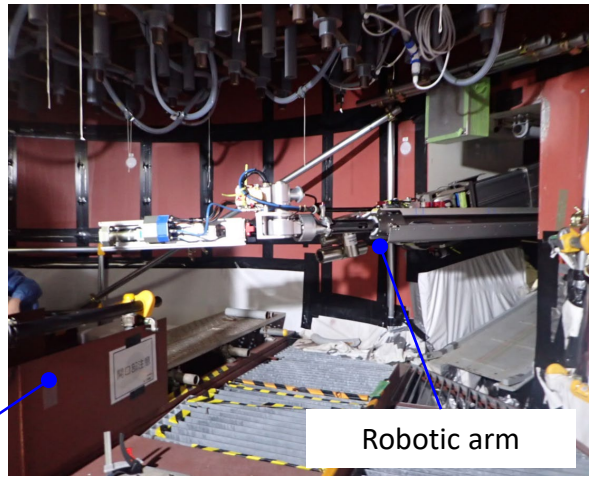
Test category	Test	JAEA Naraha
Robotic arm-related tests	Ability to pass through the X-6 penetration	Completed
	Removing obstacles at the exit for the X-6 penetration using the AWJ	Completed（Work efficiency being examined）
	Function tests (deflection measurements, etc.)	Completed
	Ability to access the 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)	To be performed going forward
	Constructing an access route (removing obstacles using the AWJ)	To be performed going forward

4-2. 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.

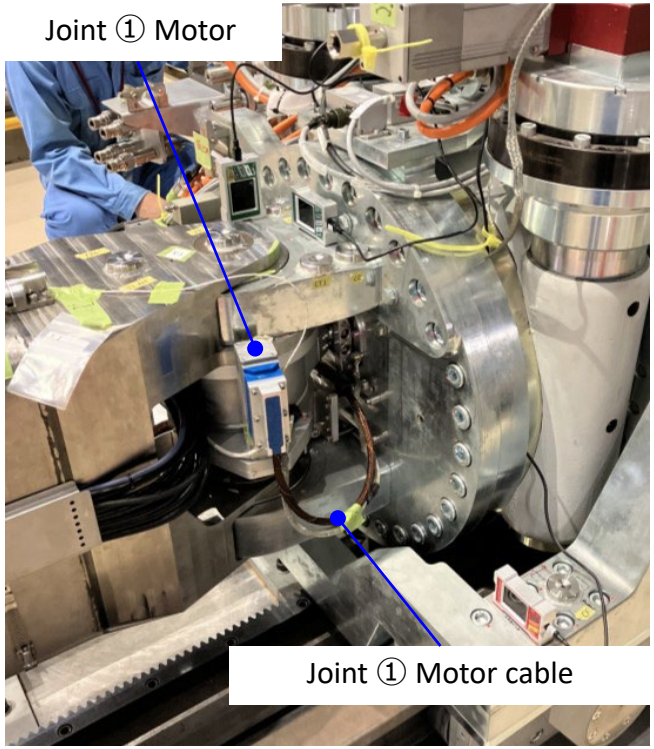


Pedestal opening
(Simulated)



Inside of the pedestal
(simulated)

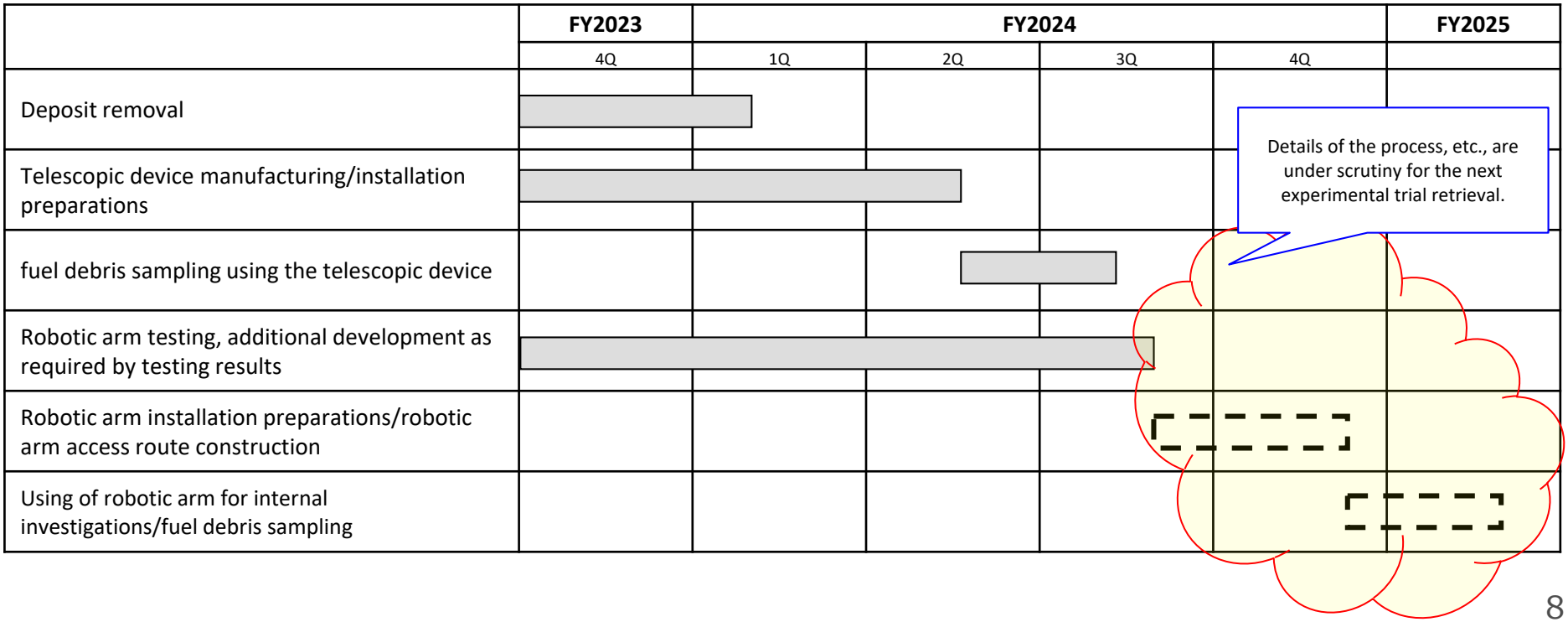
Joint ① Motor



Tests of the robotic arm at the Naraha facility

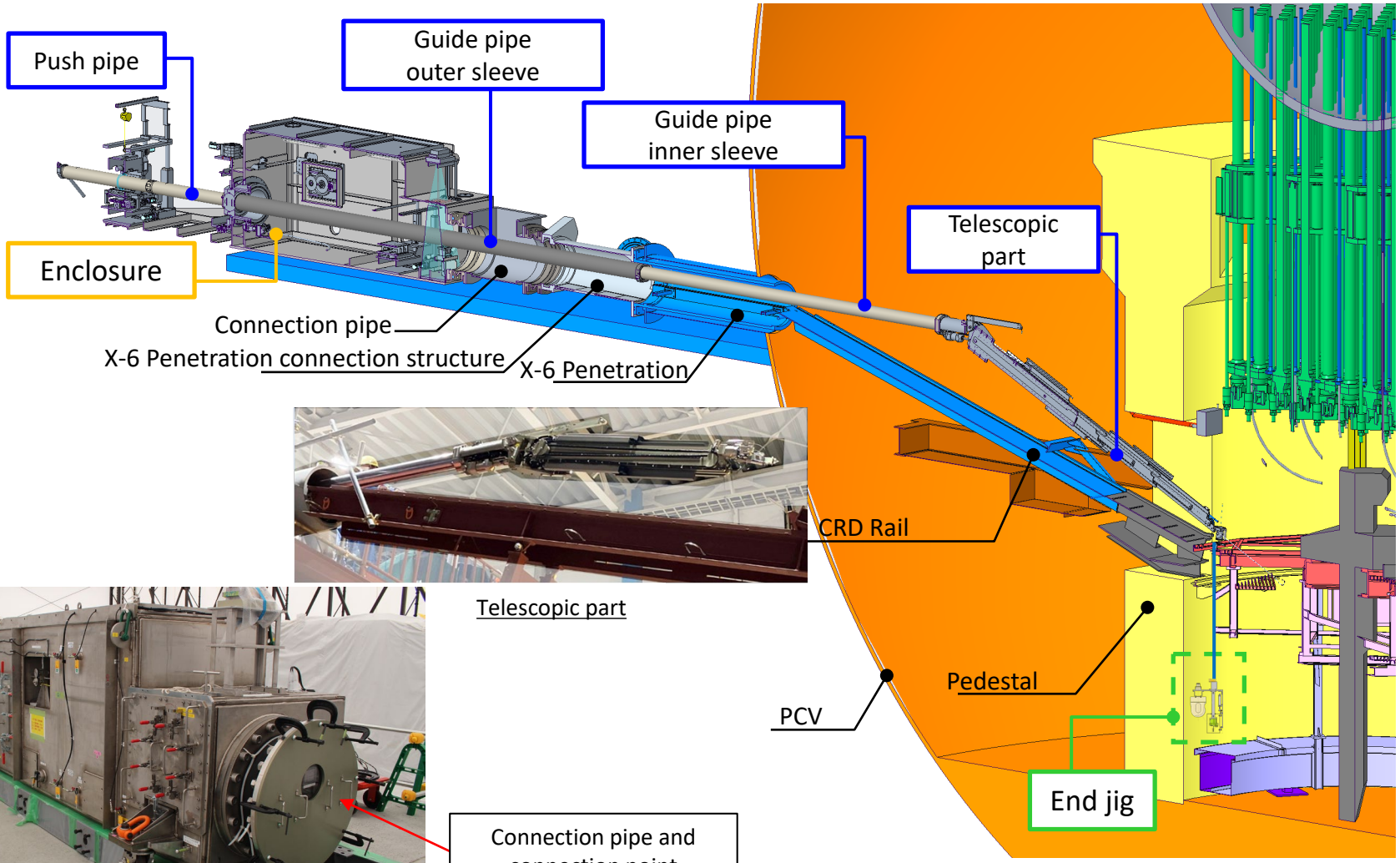
5. Schedule

- Fuel debris trial retrieval using the telescopic device was completed on November 7.
- On November 12, the sample fuel debris was transported off-site.
- 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.
- In order to increase the sample size and expand our knowledge, we are considering the next fuel debris trial retrieval . Based on the results of a series of 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.



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

- The telescopic device will be used for the trial retrieval of fuel debris by accessing the inside of the PCV from the X-6 penetration
- Since it will be connected to the connection pipe, the enclosure will serve as a PCV boundary during the trial retrieval of fuel debris.



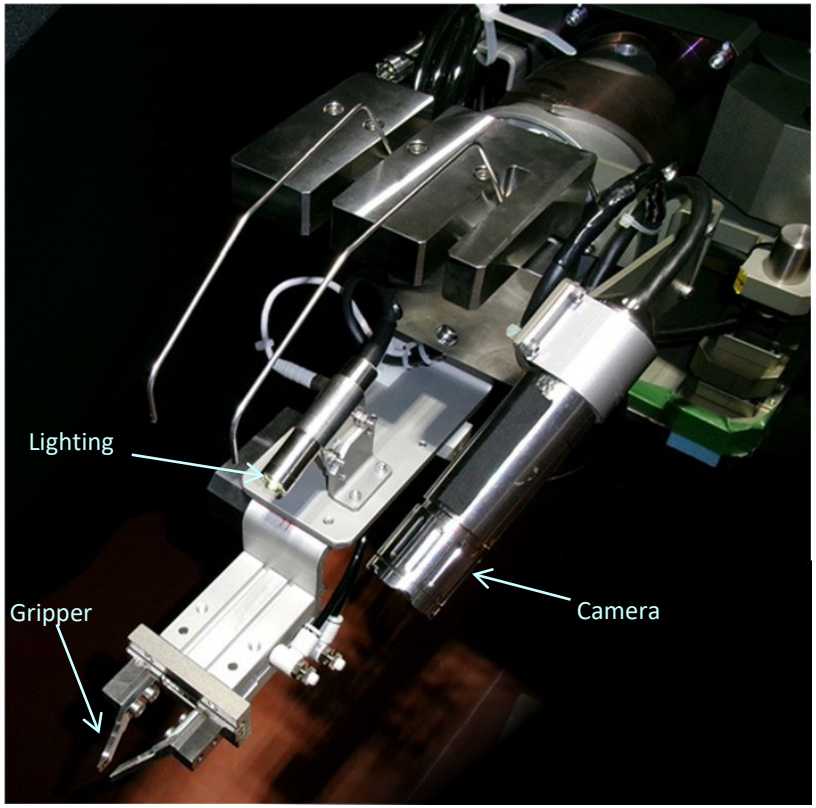
Telescopic part

Connection pipe and connection point

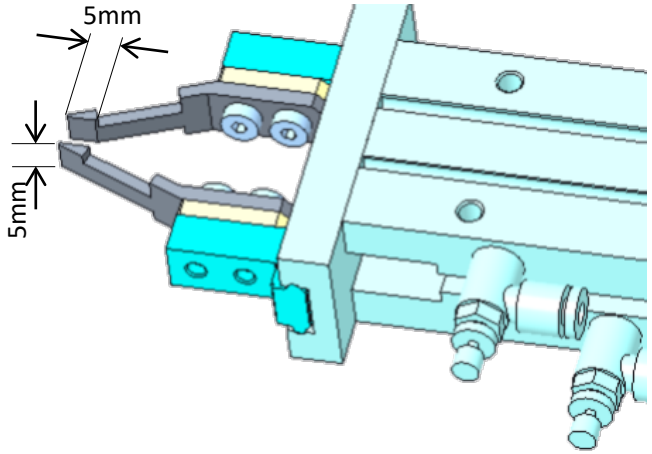
Telescopic device

[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

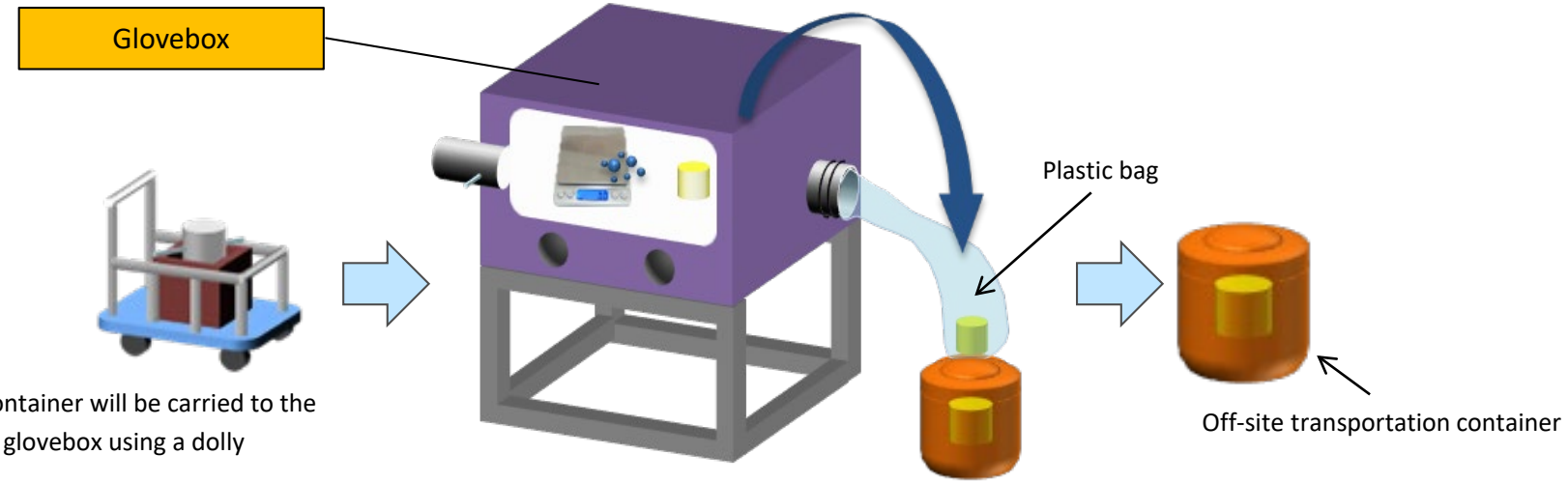


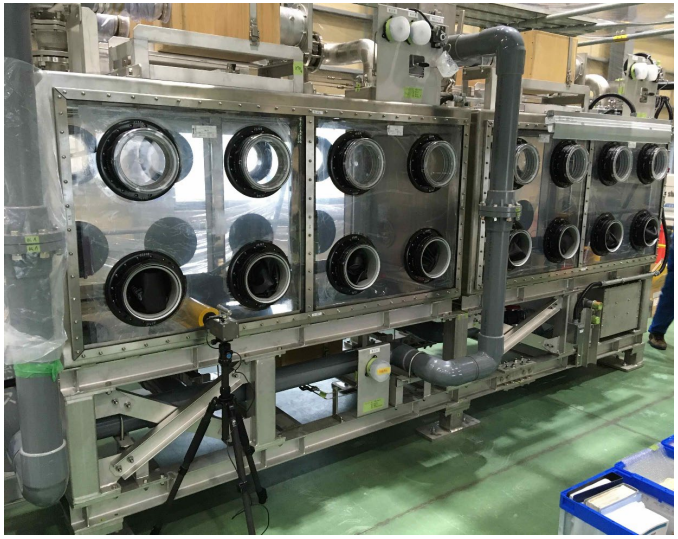
Gripper claws will be used to determine the size (gripper tool)

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

[Reference] Safety during Off-site Transport

- 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. 3.7×10^{10} Bq)
Dose equivalent rate	Surface of transported item: below 2mSv/h 1m from surface of transported item: 100μSv/h
Surface contamination density	Alpha nuclide: 0.4Bq/cm^2 All other nuclides: 4Bq/cm^2
Transport container test conditions	Freefall test, compression test, penetration test, etc.

A-type transport container

[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/dustmonitor/index-e.html

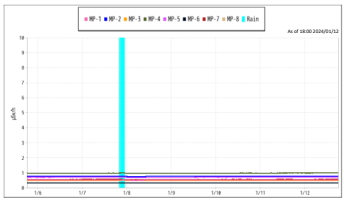
Radiation Dose measured at Monitoring Post of Fukushima Daiichi Nuclear Power Station

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(2024/01/12 18:00)

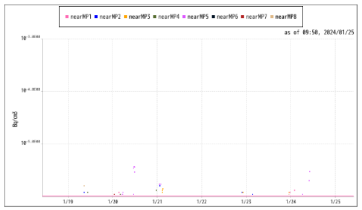
MP-1	MP-2	MP-3	MP-4	MP-5	MP-6	MP-7	MP-8	Wind Direction	Wind Velocity	Rain
0.517	0.783	0.490	0.987	0.703	0.315	0.566	0.530	North-northwest	1.4	No

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)

- 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

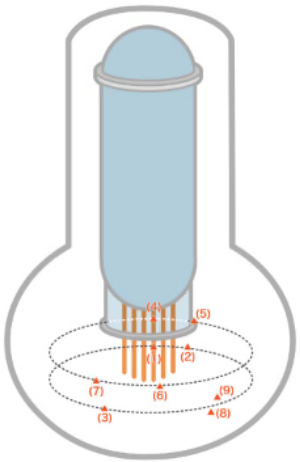
[Reference] Screen image of our website

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

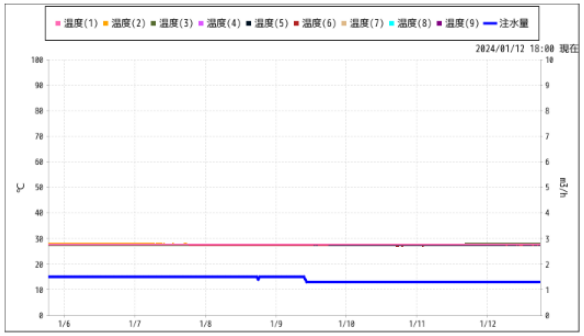
Here are the measurement results of temperatures inside the Unit 2 Primary Containment Vessel at Fukushima Daiichi Nuclear Power Station.

Monitoring points

Unit 2 reactor containment vessel



Temperature



Temperature Unit:℃、 Water Injection Unit：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