Subsidy Project of Decommissioning and Contaminated Water Management started in FY2020

Development of Technology for Further Increasing the Scale of Retrieval of Fuel Debris and Reactor Internal Structures (Technological development related to ensuring safety during fuel debris retrieval)

Accomplishment Report for FY2020

September 2021

International Research Institute for Nuclear Decommissioning (IRID)

Contents

1. Purposes and goals of Development of Technology for Further Increasing the Scale of Retrieval of Fuel Debris and Reactor Internal Structures (Technological development related to ensuring the safety during fuel debris retrieval)

[Purposes of Development of Technology for Further Increasing the Scale of Retrieval of Fuel Debris and Internal Structures]

It is assumed that the nuclear fuel has melted along with the reactor internals at Tokyo Electric Power Company Holdings, Inc. (TEPCO) Fukushima Daiichi Nuclear Power Station (1F) and exists molten fuel debris in the Reactor Pressure Vessel (RPV) and the Primary Containment Vessel (PCV).

The fuel debris accumulated inside the RPV and PCV is estimated to be currently in a sub-critical state; however the plant itself is in an unstable condition unlike its initial design since the Reactor Building (R/B), RPV, PCV, etc. have been damaged due to the accident. Therefore, it is necessary to retrieve the fuel debris in order to maintain the sub-critical state, and to prevent diffusion of radioactive materials.

Against this background, this project is intended to study based on the “Mid-and-Long-Term Road-map Towards Decommissioning of TEPCO’s Fukushima Daiichi Nuclear Power Station” (hereinafter “Mid-and-Long-Term Road-map”), aiming towards the implementation of large-scale fuel debris retrieval in coordination with the engineering and project management activities undertaken by TEPCO. The development results of this project will be used in TEPCO’s engineering activities.

The purpose of this project is to smoothly carry out decommissioning and contaminated water management at 1F by implementing projects that support technological development contributing to the decommissioning and contaminated water management at 1F based on the Mid-and-Long-Term Road-map and the “FY2020 Research & Development Plan” (the 75th Secretariat Team Meeting for Countermeasures for Decommissioning and Contaminated Water Treatment), and in addition, to enhance the standard of science and technology in Japan.

As part of the “Technological development related to ensuring the safety during fuel debris retrieval”, elemental technologies for confinement of radioactive materials, reduction of exposure dose of the workers, etc. which are essential to ensure the safety of the public and workers during fuel debris retrieval work, will be developed.

[Project goal]

A goal of the project is to start studying towards accomplishment of a large scale of fuel debris according to the Mid-and-Long Term Road-map.

[Duration of Project] December 2020 to March 2022 (16 months)

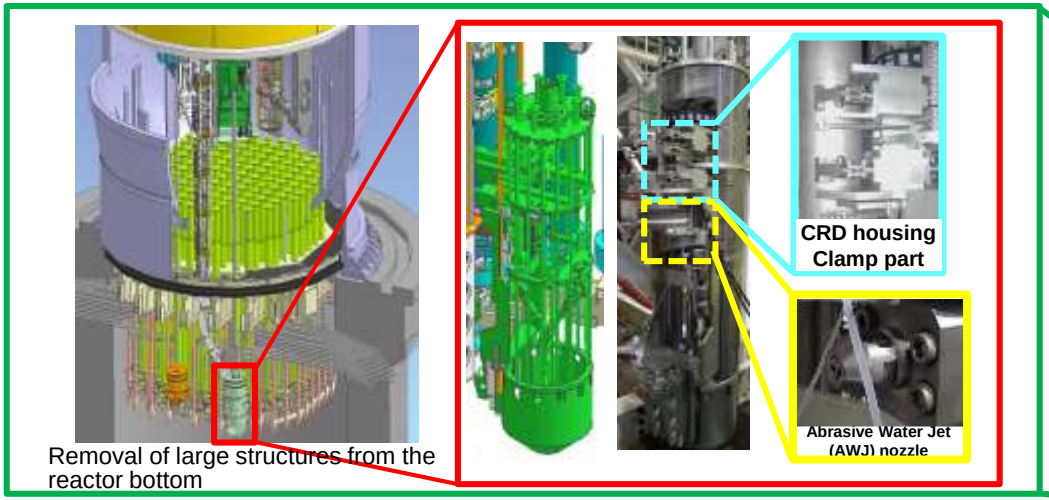
2. Accomplishments of projects implemented in FY2017-18 and FY2019-20

The results of past subsidized projects that are related to this project are provided below.

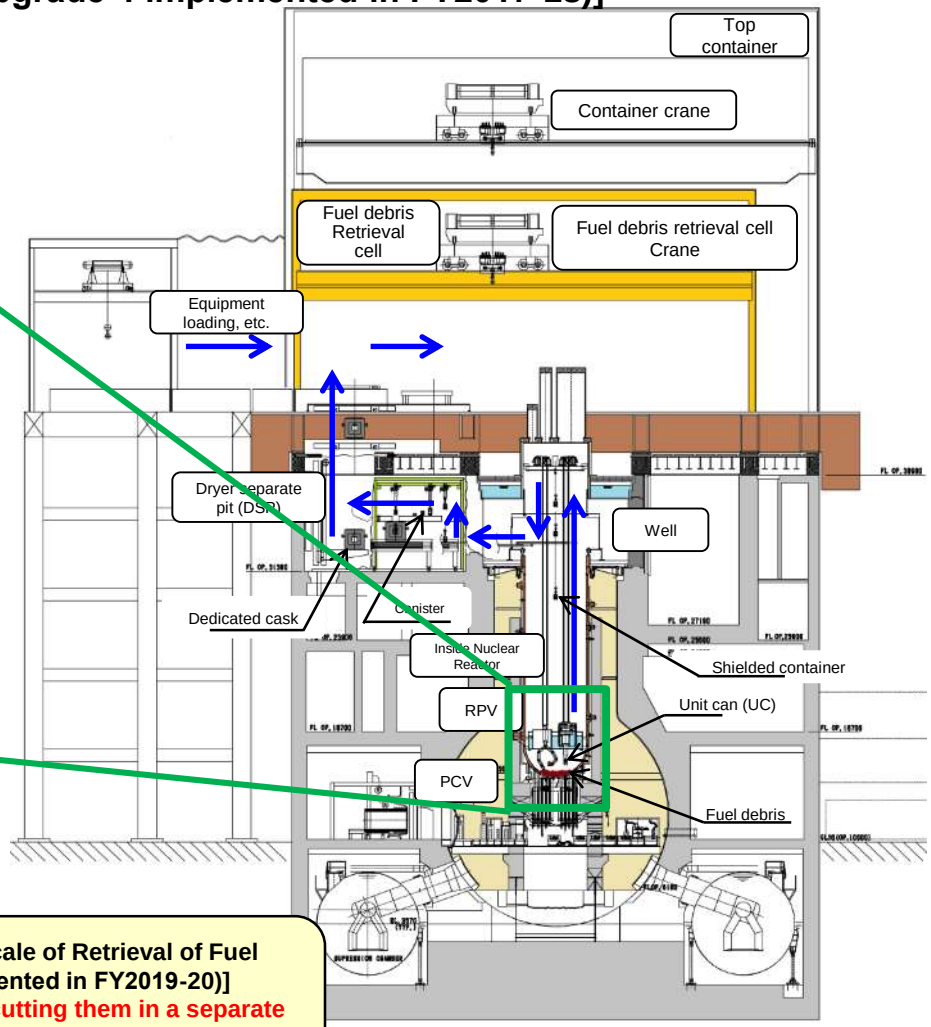
(1) Method of accessing from the top and transferring the whole unit of large structures

[Main results of studies conducted as part of upgrading of fundamental technology for retrieval of fuel debris and internal structures (hereinafter "Fundamental technology upgrade": implemented in FY2017-18)]

- An image of establishing the access route (removal of interferences) was created and elemental tests were conducted using simulated structures of the reactor bottom to verify the feasibility of the removal procedure.
- The retrieval duration (throughput) was estimated by assuming details of the procedure such as the unit to be cut out, the shape and thickness of the portion to be cut, the cutting method, etc.



Removal of large structures from the reactor bottom



The method of cutting the structures inside the PCV, containing them in unit cans and transferring them **is quite challenging in terms of work efficiency and time required for the work.**

Items implemented in the Project of Development of Technology for Further Increasing the Scale of Retrieval of Fuel Debris and Reactor Internals (hereinafter, "Further Increasing the Scale of Retrieval": implemented in FY2019-20)]
Verifying the feasibility of **the method for transferring as large structures as possible and then cutting them in a separate building**

2. Accomplishments of projects implemented in FY2017-18 and FY2019-20

(1) Method of accessing from the top and transferring the whole unit of large structures

[Concept of the new top access method (removing and transferring the whole unit of the structures)]

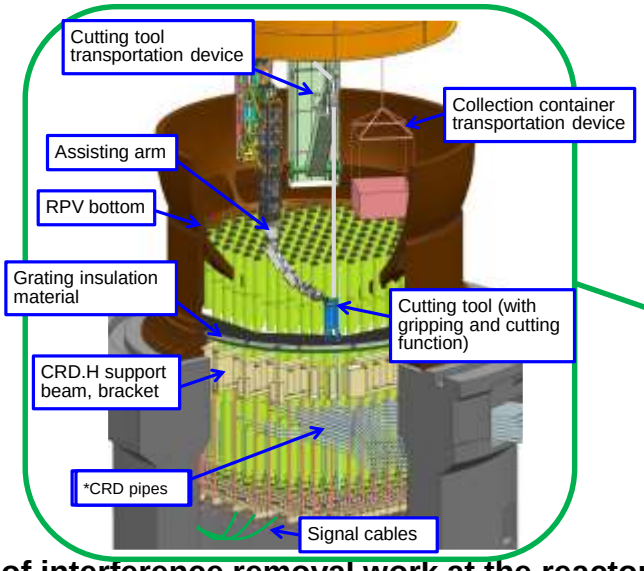
The concept of the method for removing and transferring the whole unit of the structures, which was studied under “Further Increasing the Scale of Retrieval”, is indicated below.

- ✓ Each structure will be transferred as it is the whole unit of the structure.
- ✓ The reactor core will be cut into multiple units, and for the reactor bottom the lower part of the reactor will be separated the unit from the RPV.
- ✓ The shielding and air-tightness of the object to be transferred will be ensured by means of a container or access route or a combination of both.
- ✓ The work of cutting the structures that are retrieved and enclosing them in a container will be carried out in a building that is at a distance from the R/B.

[Contents studied under “Further Increasing the Scale of Retrieval”]

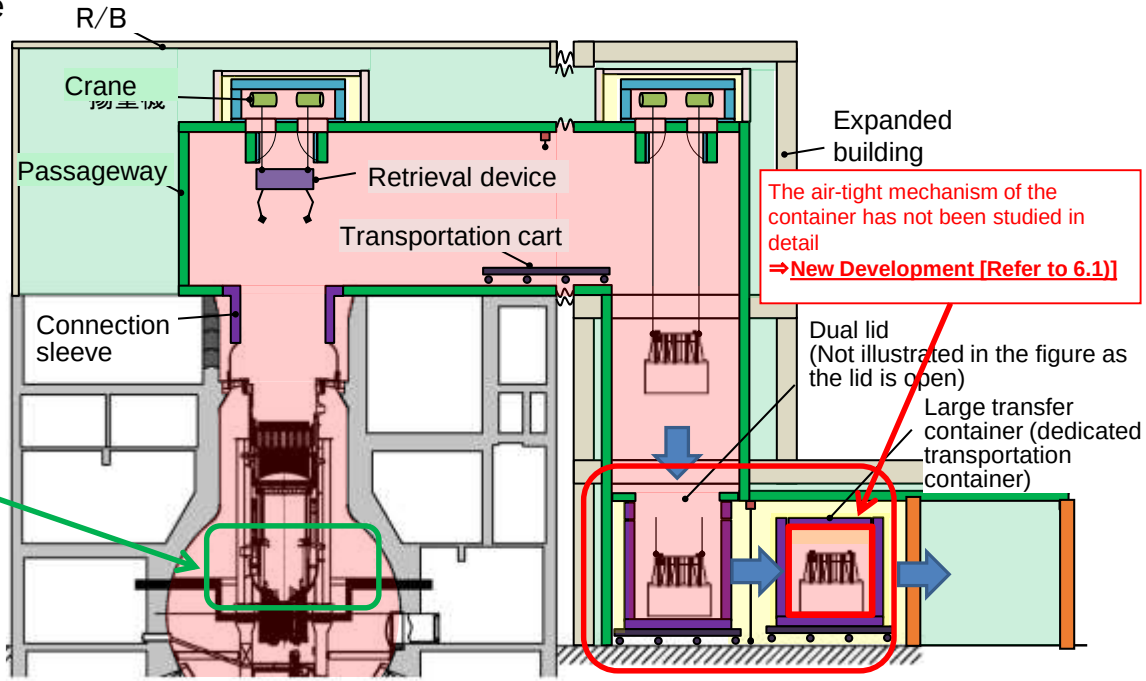
The following items were studied in the FY2019-20 Subsidized Project (Further Increasing the Scale of Retrieval).

- ✓ Study of method for transferring (transfer route) the whole unit of the structures.
- ✓ Study of the method of disassembling the reactor bottom and related elemental tests



*Control rod drive

Illustration of interference removal work at the reactor bottom



Method for transferring (transfer route) the whole unit of the structures, that is being studied

2. Accomplishments of projects implemented in FY2017-18 and FY2019-20

(1) Method of accessing from the top and transferring the whole unit of large structures

[The major issues in the method for removing and transferring the whole unit of the structures, which was studied under “Further Increasing the Scale of Retrieval”]

the major issues studied in the “Further Increasing the Scale of Retrieval” Project are shown in the ① to ⑤ as below. Refer to the FY2020 Final Report on “Further Increasing the Scale of Retrieval” (August 2021) for the study results.

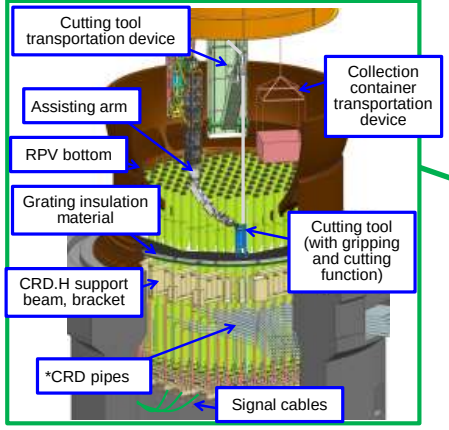
Issue ③: Crane

- **Method of handling large structures**
- **Maintenance of the lifting machine**

Issue ② : Shielding and air tightness of the passageway

- **Shield thickness based on mass reduction of the passageway and taking the building load (load on the refueling floor) as well into consideration**
- **Ensuring air-tightness while transferring the structures**

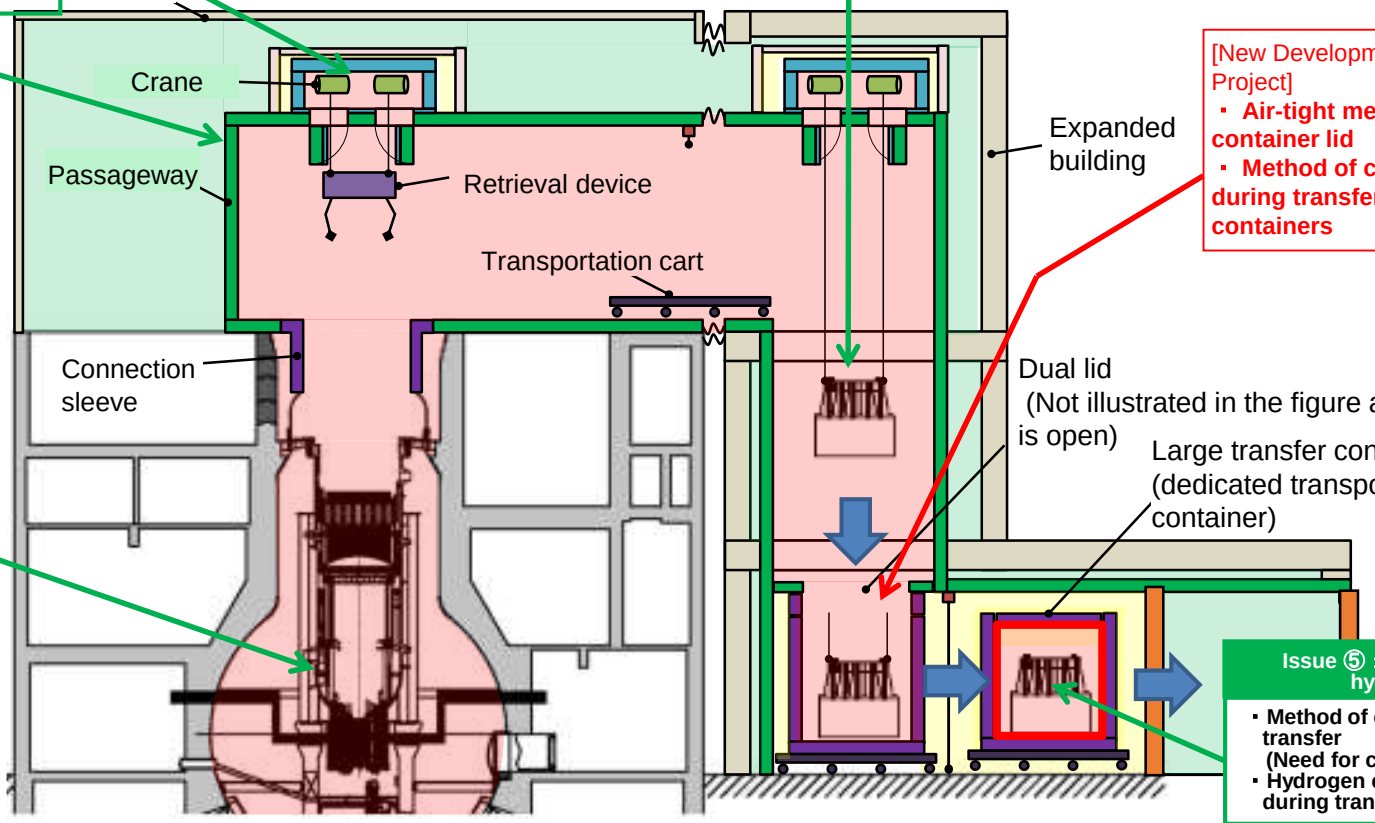
Issue ① : Method of removing the reactor bottom



*Control rod drive

Issue ④ : Criticality control

- **Method of criticality control until storage in containers**



[New Development under this Project]

- **Air-tight mechanism of the container lid**
- **Method of criticality control during transfer after storage in containers**

Issue ⑤ : Cooling and hydrogen

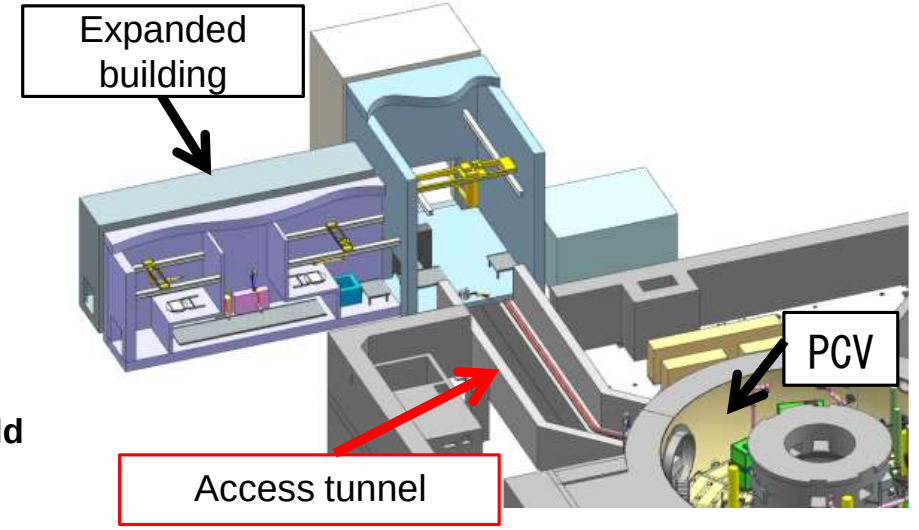
- **Method of cooling during transfer (Need for cooling)**
- **Hydrogen countermeasures during transfer**

(2) Access tunnel

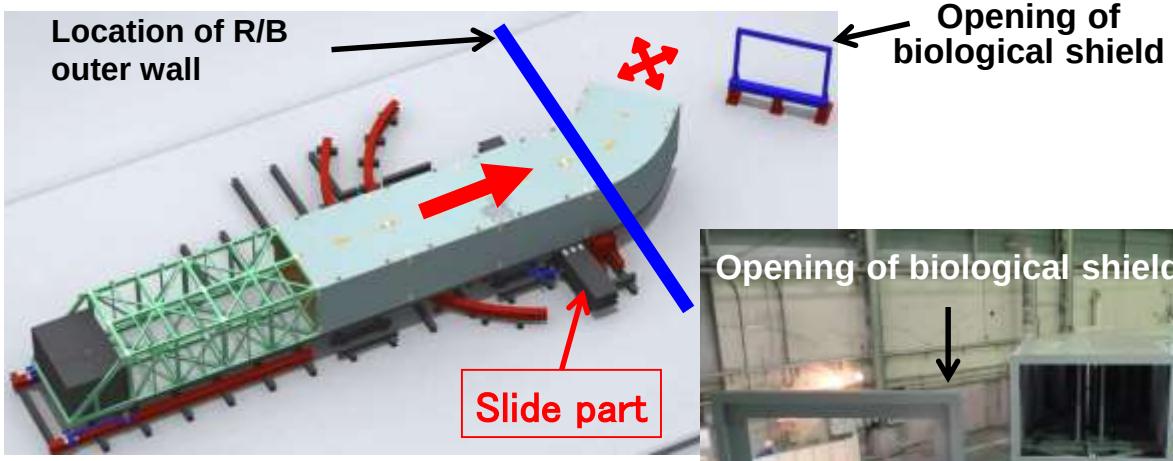
[Main results of studies conducted as part of Upgrading of Approach and Systems for Retrieval of Fuel Debris and Internal Structures (hereinafter "Approach & Systems Upgrade": implemented in FY2017-18)]

- The expanded building outside R/B and the PCV will be connected with an access tunnel having a shielding function to build the carrying-in/out route.
- The load of the access tunnel will be borne by the outer wall of R/B and the biological shielding wall, in order to keep within the load limit for the floor surface on the first floor.
- The tunnel will be assembled outside the R/B, and will be introduced and set up by means of remote operation so as to reduce worker exposure.

The above-mentioned items were studied, elemental tests related to delivery were conducted by **simulating the shape and dimensions** and feasibility was verified.



Overview of access tunnel



Desk study

The slide part needs to be studied by simulating the load (New Development [Refer to 6.2) ①])

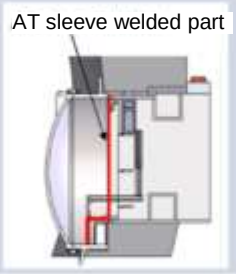
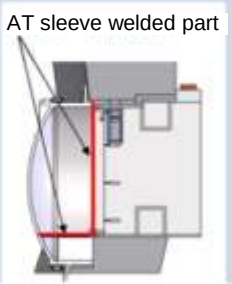
Implementation status of elemental tests

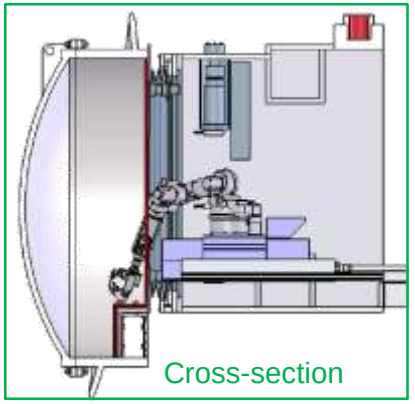
2. Accomplishments of projects implemented in FY2017-18 and FY2019-20

(2) Access tunnel

[Items implemented under “Further Increasing the Scale of Retrieval” (implemented in FY2019-20): ① Study on the method of connecting the access tunnel sleeve (AT sleeve)]

- Multiple welded connection structure proposals were studied and a comparative evaluation was carried out. The following Case 1 was studied as the main proposal.
- After studying the structure of the AT sleeve, tests related to welded connection were implemented.

		Case 1	Case 2
		 	 
		• Partially removing the scaffolding from inside the equipment hatch • Welding the AT sleeve to the edge of the equipment hatch shell • Welding the lower side of the AT sleeve to the inner surface of the equipment hatch shell via the scaffolding seal cover	• Partially removing the scaffolding from inside the equipment hatch • Welding the AT sleeve to the edge of the equipment hatch shell • Installing a plate above the scaffolding, and welding it to the lower side of the AT sleeve and the inner surface of the equipment hatch and the equipment hatch door
Confinement of contamination inside the AT sleeve		Very good Welding all connection parts	Very good Welding all connection parts
Workability	Number of steps involved in installation	Good Removing the scaffolding, pressure resistance test conducted once	Acceptable Removing the scaffolding, pressure resistance test conducted twice
	Groove alignment (inside the equipment hatch)	Good The connecting portion between the scaffolding seal cover and the portion of the scaffolding that is removed, needs to be examined.	Very good It is assumed that the scaffolding plate is only kept
	Welding work efficiency	Good	Good
Comprehensive evaluation		Good	Acceptable



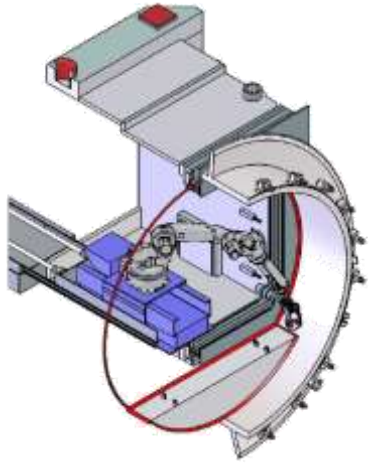


Illustration of welding the AT sleeve to the equipment hatch

2. Accomplishments of projects implemented in FY2017-18 and FY2019-20

(2) Access tunnel

Vertical displacement*

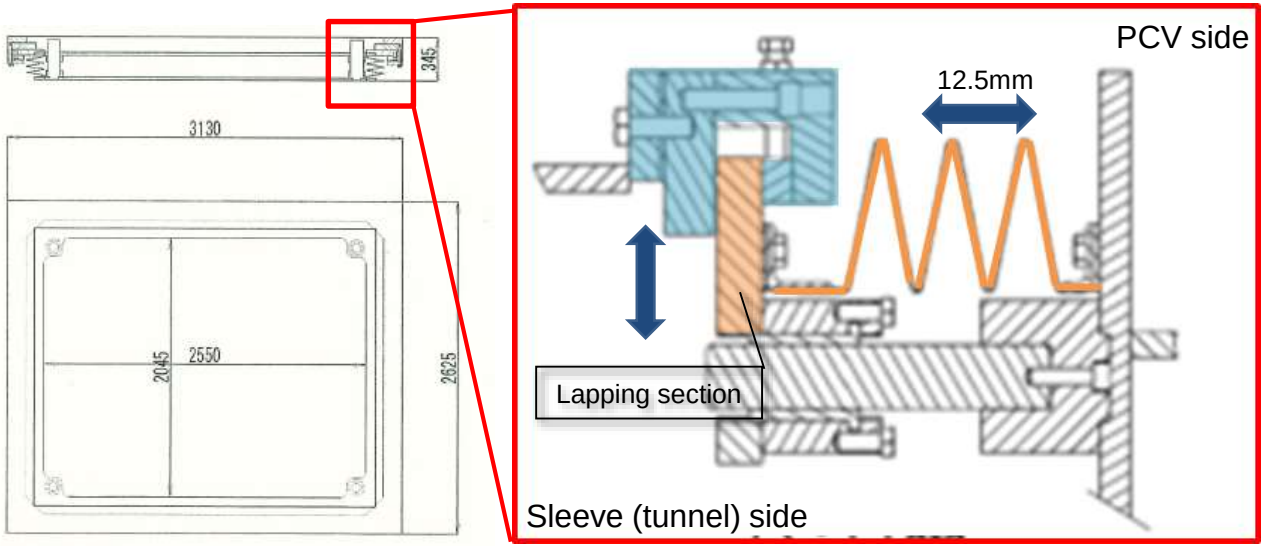
Location	Level from OP [mm]	Evaluation point [mm]	Vertical displacement [mm]
Top edge of hatch	12905	13490	0.12

[Items implemented under "Further Increasing the Scale of Retrieval" (implemented in FY2019-20):
② Study of the structure of AT sleeve]

- The PCV and access tunnel will be connected by means of the AT sleeve. The AT sleeve will support the load of the access tunnel, and in addition, will absorb displacements in the event of an earthquake by means of the displacement absorption mechanism installed on the PCV side.
- The AT sleeve including the displacement absorption mechanism was studied.
  ⇒ Considering the amount of displacement in the event of an earthquake, displacement of ±12.5mm needs to be secured * in the horizontal direction.
  There is a distance of approximately 350 mm between the surfaces of the applicable parts.
  Since existing technologies such as bellows structure, etc. is not applicable to this situation, a new structure was studied.

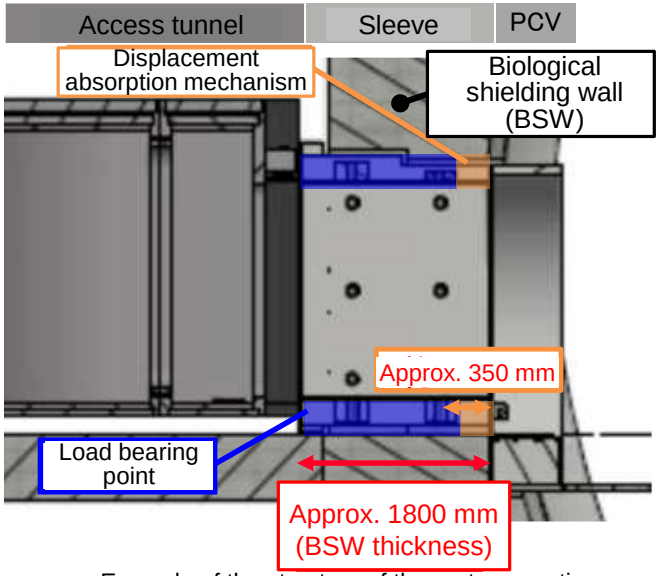
Horizontal displacement*

Location	Level from OP [mm]	Evaluation point [mm]	Vertical displacement [mm]
Top edge of hatch	12905	13490	12.5
Center of hatch	11260	11180	9
Bottom edge of hatch	9675	9760	7



Proposed structure of the displacement absorption mechanism being studied

Details of the displacement absorption structure



Example of the structure of the part connecting the PCV and the access tunnel

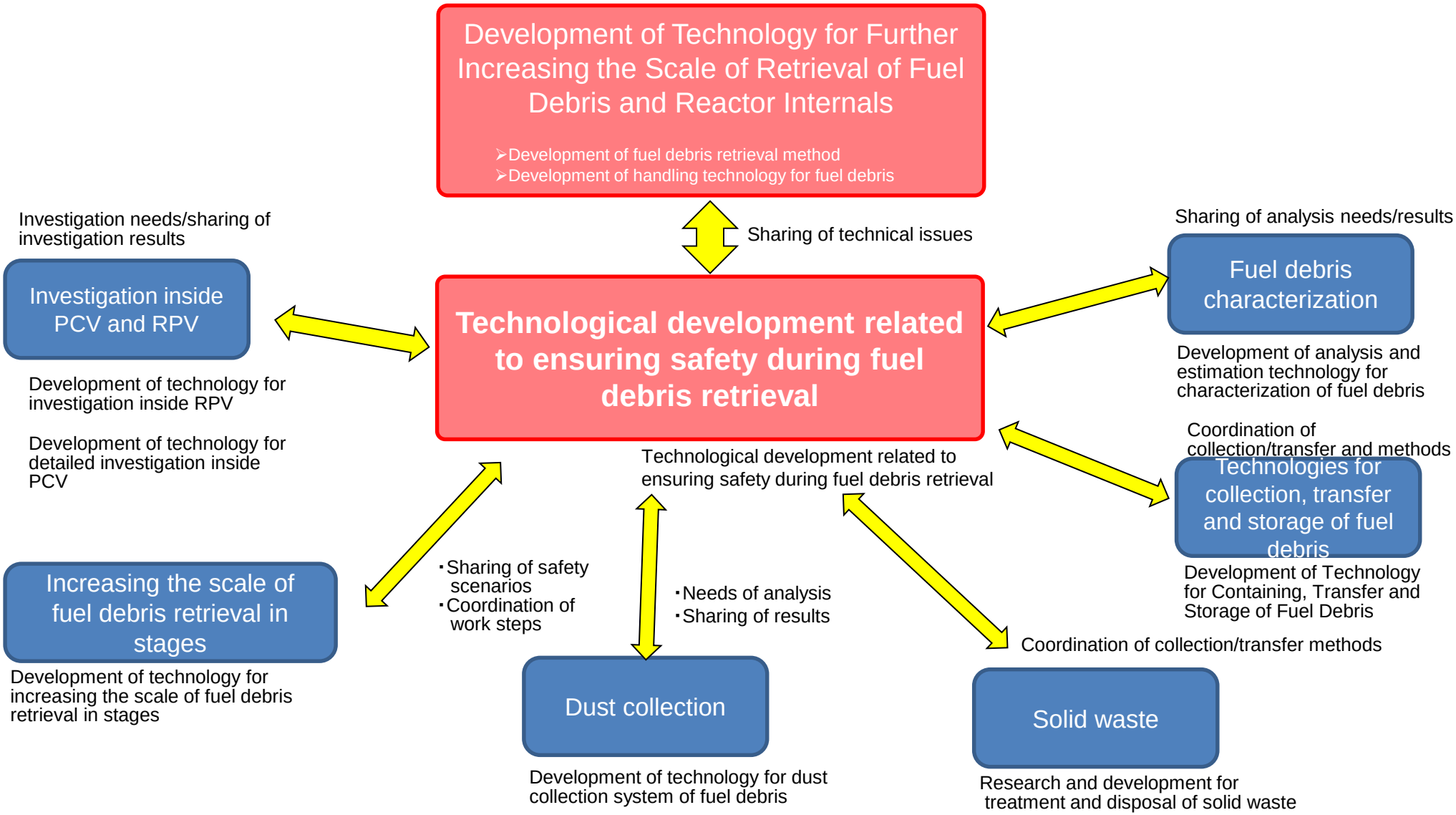
[Supplementary information] The tunnel and the sleeve are fixed and move together with the R/B as a whole in the event of an earthquake.
(The displacements during an earthquake are absorbed by the displacement absorption mechanism)

The displacement absorption mechanism was studied in detail in the "Further Increasing the Scale of Retrieval" Project.
⇒ **The feasibility of the displacement absorption mechanism needs to be verified through embodiment (test manufacturing) and elemental tests. (New Development [Refer to 6.2) ②])**

*Set up based on the contents of the report on Subsidy Project of Decommissioning and Contaminated Water Management in the FY2015 Supplementary Budgets "Development of Assessment Method for Seismic Resistance and Impact of Pressure Vessel and Containment Vessel" (Refueling floor additional equipment: 6100 ton, Seismic motion: 900Gal)

3. Project overview

3. 1. Collaboration with other projects



In this project, joint meetings will be conducted as required in coordination with the above-mentioned projects.

3. 2 Development items involving Request for Proposal (RFP) and implementation policy

Development items involving RFP	Implementation policy (proposed)	Corresponding slides
1) Development of an air-tight mechanism for large transfer containers	With respect to retrieving fuel debris and reactor internals, the method of transferring the whole unit of large structures is being studied to improve the throughput of the top nit o whole method as part of the development being undertaken since FY2019. In order to transfer large structures, it is necessary to develop large transfer containers with a function for preventing the spread of contamination and shielding function for high radiation items stored in containers. Upon studying the pre-conditions for the large transfer containers and the required development items, an air-tight mechanism for the lid of the large transfer container will be developed. And, the criticality control method for the period from after collection of the structures until they are stored, will be studied.	No. 14 to 32
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts	① Technology for connecting heavy structures to accessing PCV As the new access equipment (access tunnel, cell, etc.) to be installed in the R/B is heavy equipment weighing several hundred tons, technology for connecting the heavy structures to PCV by remote operation will be developed.	No. 35 to 43
	② Confinement structure for the connection parts As the equipment to be newly installed needs to be equipped with the function of absorbing displacements in the event of an earthquake in addition to a confinement function for the connection parts, a displacement absorption structure for the PCV connection parts will be developed.	No. 44 to 49

3. Project overview

3. 3 Points to be noted while executing this project

The points to be noted while executing the plans under this project are described below.

[Points to be noted]

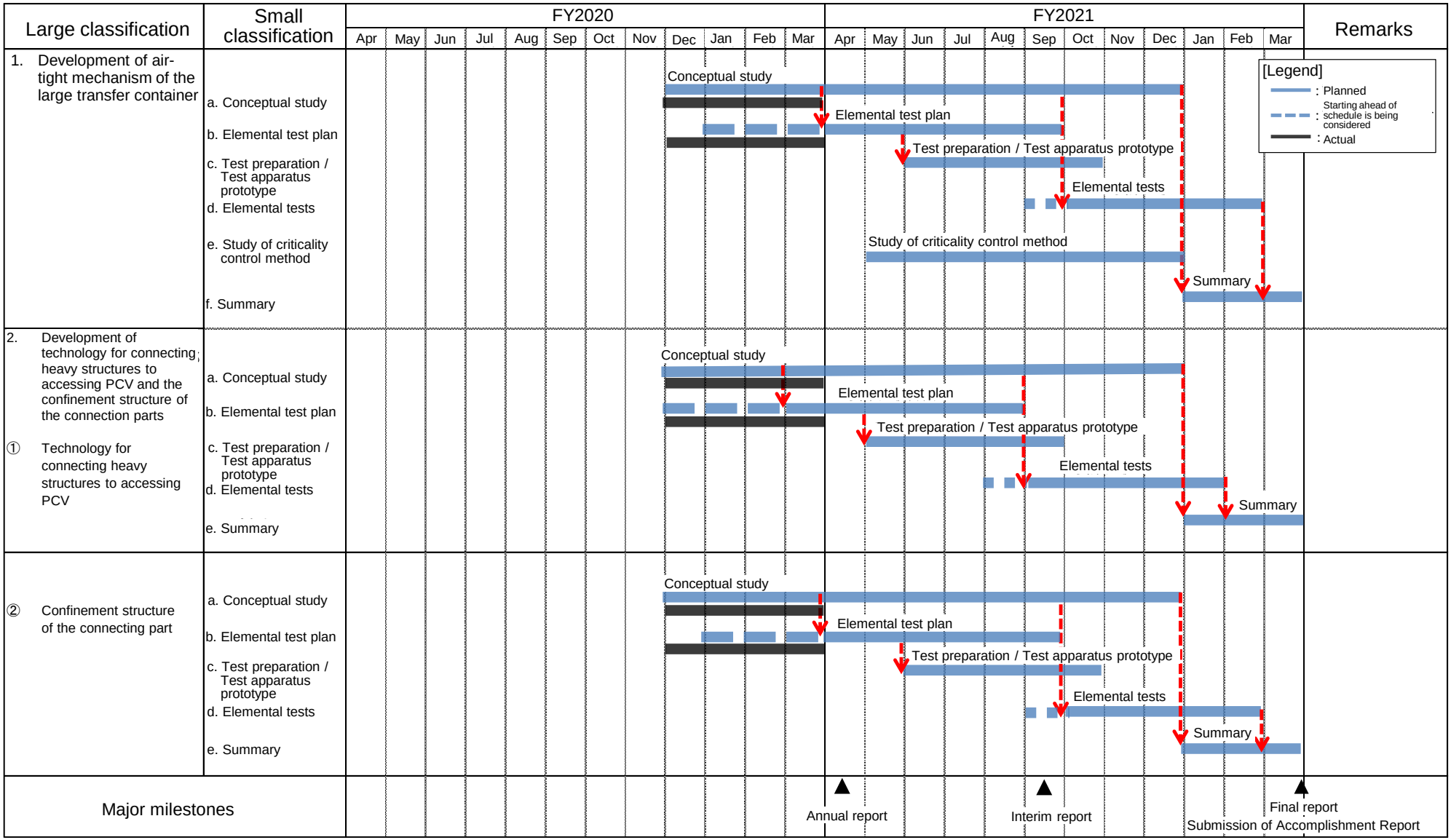
The air-tight mechanism of large transfer containers for transferring structures, technology for remotely connecting the new access equipment to be connected to PCV and for confining the connection parts, which is important for ensuring the safety of the public and the workers while retrieving fuel debris on a large scale, will be studied.

During the study, development will be carried out while considering the handleability in terms of the following and maintenance method of the equipment that will be operated remotely.

- **As the equipment will be installed in areas with high radiation, as a general rule, maintenance will be carried out remotely.**
- **The contamination of the equipment and the required decontamination will need to be taken into consideration.**
- **Work area will be limited for maintenance work.**
- **Waste generated during maintenance work will need to be minimized as much as possible.**
- **Installation and handling of criticality monitoring system will need to be considered.**

4. Implementation schedule of this project

Implementation schedule for the Development of technology for further increasing the scale of retrieval of fuel debris and reactor internal structures
(Technological development related to ensuring the safety during fuel debris retrieval)



5. Project organization

International Research Institute for Nuclear Decommissioning (IRID)

- Coordination of overall planning and technology management
- Coordination of technology administration including technology development progress management

Hitachi-GE Nuclear Energy, Ltd.

[Elemental test, technical development]
(1) Development of an air-tight mechanism for large transfer containers

(2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

Tokyo Electric Power Company Holdings, Inc.

- Various coordination for site application

Project teams to cooperate for technological development

- Development of technology for further increasing the scale of retrieval of fuel debris and reactor internals
- Development of technology for gradually increasing the retrieval scale of fuel debris
- Development of technology for retrieval of fuel debris and reactor internals (Technical development of fuel debris dust collection system)
- Development of technology for investigation inside RPV
- Development of Technology for Detailed Investigation inside PCV (Onsite validation of the technology for detailed internal investigation using X-6 penetration)
- Development of analysis and estimation technology for characterization of fuel debris
- Development of Technology for Detailed Investigation inside PCV (Onsite validation of the technology for detailed internal investigation on the premise of sediment deposit countermeasures)
- Development of technology for containing, transfer and storage of fuel debris
- Research and development for treatment and disposal of solid radioactive waste

1) Development of an air-tight mechanism for large transfer containers

With respect to retrieving fuel debris and reactor internals, the method of transferring the whole unit of large structures is being studied in order to improve the throughput for the top access method as part of the development being undertaken since FY2019.

To accomplish fuel debris and reactor internals, it is necessary to separate the structures from PCV and transfer these large structures. And, large transfer containers to be used for transferring the large structures are required for development of a function of preventing contamination spread and a shielding function for the high radiation items stored in containers.

Upon studying the pre-conditions for the large transfer containers and the required development items, an air-tight mechanism and shielding structure for the lid of the large transfer container will be developed, the leakage rate (evaluation method will be investigated as required) is estimated, and a conceptual study of the system for transferring the structures from the R/B (or the expanded building) by means of the large transfer containers will be conducted. Additionally, elemental tests related to the air-tight structure of the lid will be performed to confirm technical feasibility. Along with that, studies on ensuring criticality safety of the large transfer containers used for containing the whole unit of large structures on which fuel debris is adhered will be conducted. Based on these studies and development, the onsite applicability of the large transfer containers will be evaluated and issues will be clarified.

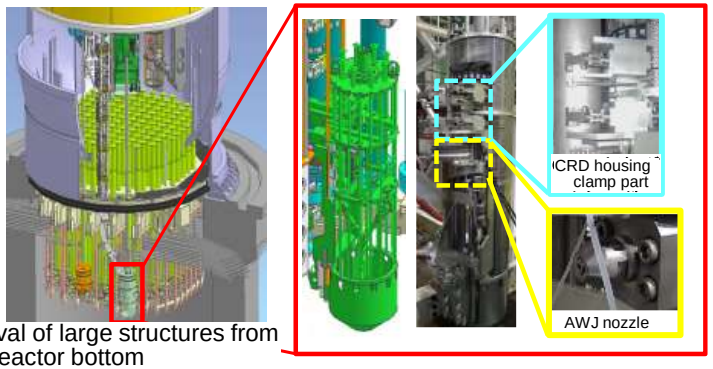
6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

Fundamental technology upgrade (implemented in FY2017-18)

[Study of the method for finely cutting inside PCV]

- Implementation of elemental tests using simulated reactor bottom structures
- Estimation of throughput, identification of issues

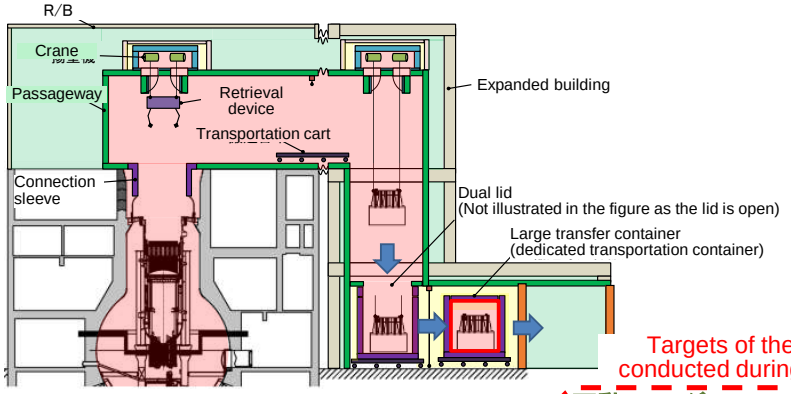


Removal of large structures from the reactor bottom

Further increasing the scale of retrieval (implemented in FY2019- 20)

[Study of the method of transferring the whole unit of the structures]

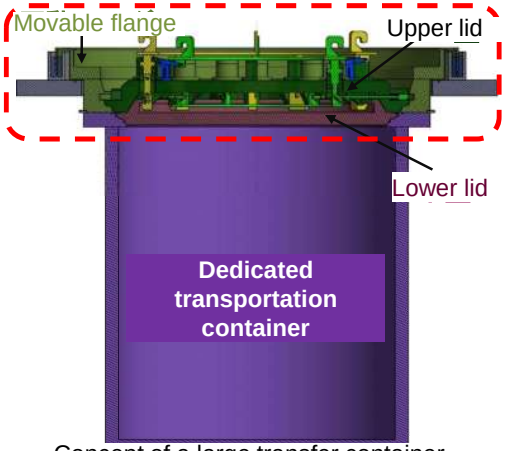
- Implementation of elemental tests related to disassembling the reactor bottom
- Conceptual study related to the large transfer containers
- Study of the method of criticality control until storage in containers



Implemented in this project

[Feasibility verification of the large transfer container lid]

- Development of the air-tight mechanism for the container lid and elemental tests
- Study of the method of criticality control after storage in containers (during transfer)



Concept of a large transfer container (dedicated transportation container)

Items to be studied in the future

- Feasibility verification of the large transfer container body (manufacturability, etc.)
- Feasibility verification of the method of cutting large structures and the transportation device

6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

[Issues]

- Conceptual study of the air-tight structure taking into consideration the shielding of the lid portion of the large transfer container
- Feasibility verification of the lid portion air-tight structure that was studied
- Method of criticality control until the structures to which fuel debris is adhered to are enclosed in the large transfer containers and transferred to a separate building for storage

[Implementation Details]

• Study on the prevention function of spread of contamination (air-tight structure) of the large transfer container for transferring large structures or high radiation contaminants are conducted.

•Study on the shielding structure of the large transfer containers are conducted taking into consideration that high radiation structures are stored in them.

• Conceptual study is conducted for evaluating (evaluation method is investigated as required) the leakage rate from the lid portion and a test plan are developed after examining the test conditions.

• Elemental tests are conducted to verify the feasibility of the lid portion air-tight structure that is studied.

(During the test, the plan is to verify the air-tightness when the upper lid and lower lid are connected and the air-tightness of the lid portion when the lower lid and container are connected, for preventing contamination of the lower lid surface.)

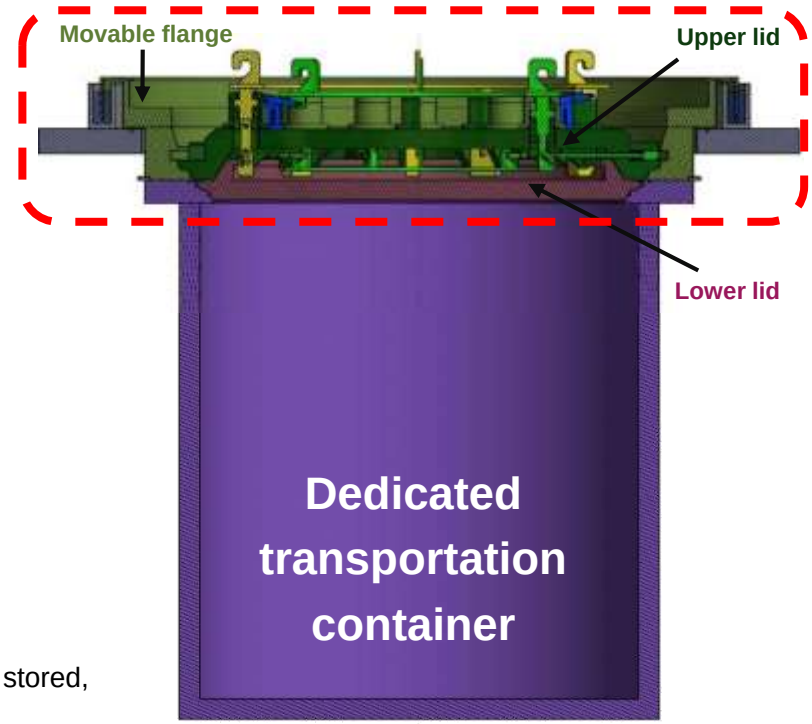
•The method of criticality control until the structures to which fuel debris is adhered to are enclosed in the containers and transferred to a separate building for storage, are studied.

[Expected outcome]

•Air-tight structure taking into consideration the shielding of the lid portion of the large transfer container will be presented.

•The criticality control method for the period from after collection of the structures until they are stored, will be presented.

Targets of elemental tests conducted during this development

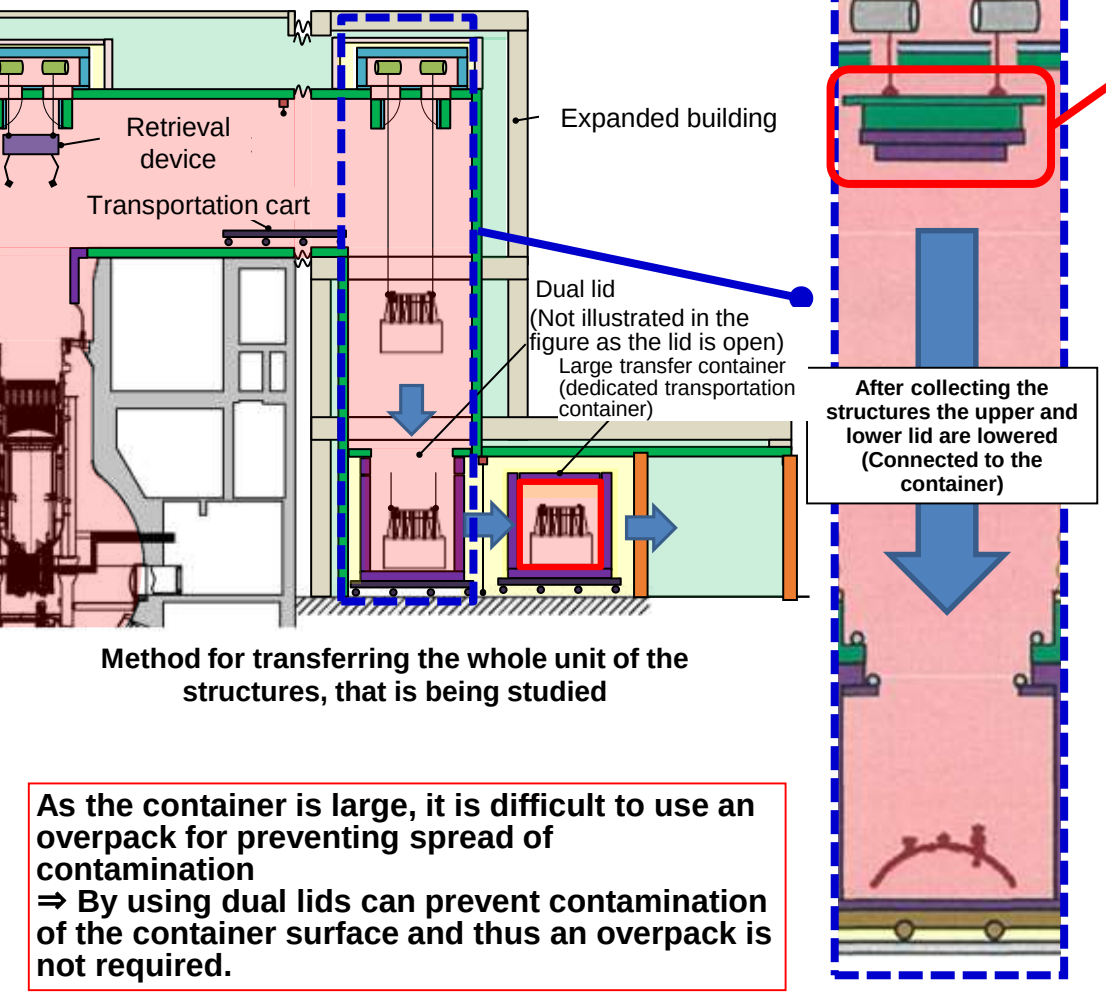


Concept of large transfer container (dedicated transportation container)

6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

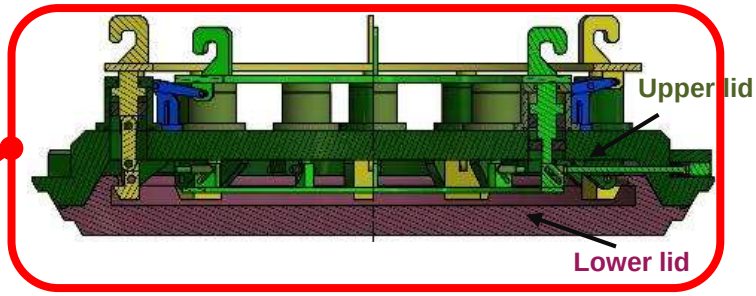
[Application method for the dedicated transport container]



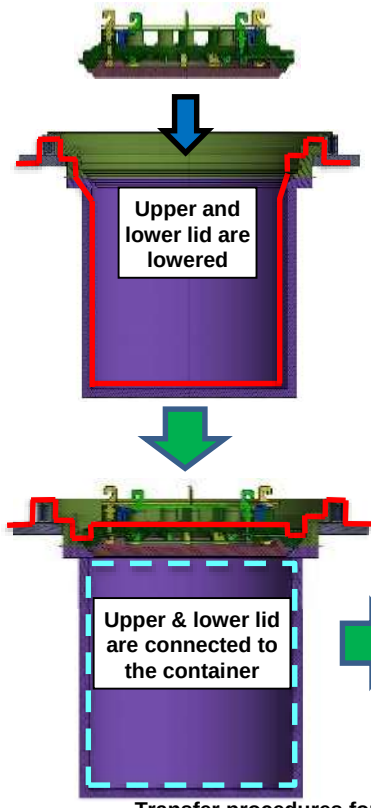
Method for transferring the whole unit of the structures, that is being studied

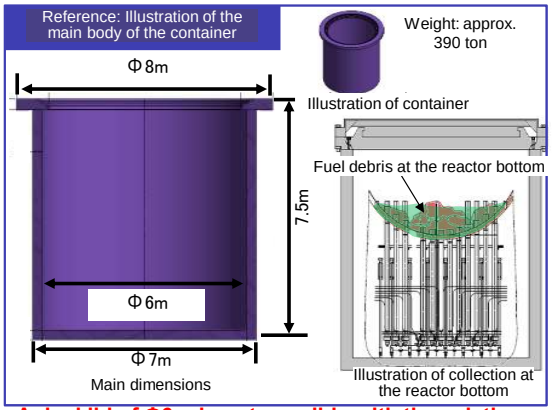
As the container is large, it is difficult to use an overpack for preventing spread of contamination
⇒ By using dual lids can prevent contamination of the container surface and thus an overpack is not required.

Targets of elemental tests conducted during this development



Dedicated transportation container dual lid structure (proposed)





・**A dual lid of Φ6m is not possible with the existing technology**
⇒**Will be newly developed due to issues such as sealability**

Transfer procedures for the dedicated transportation containers (proposed)

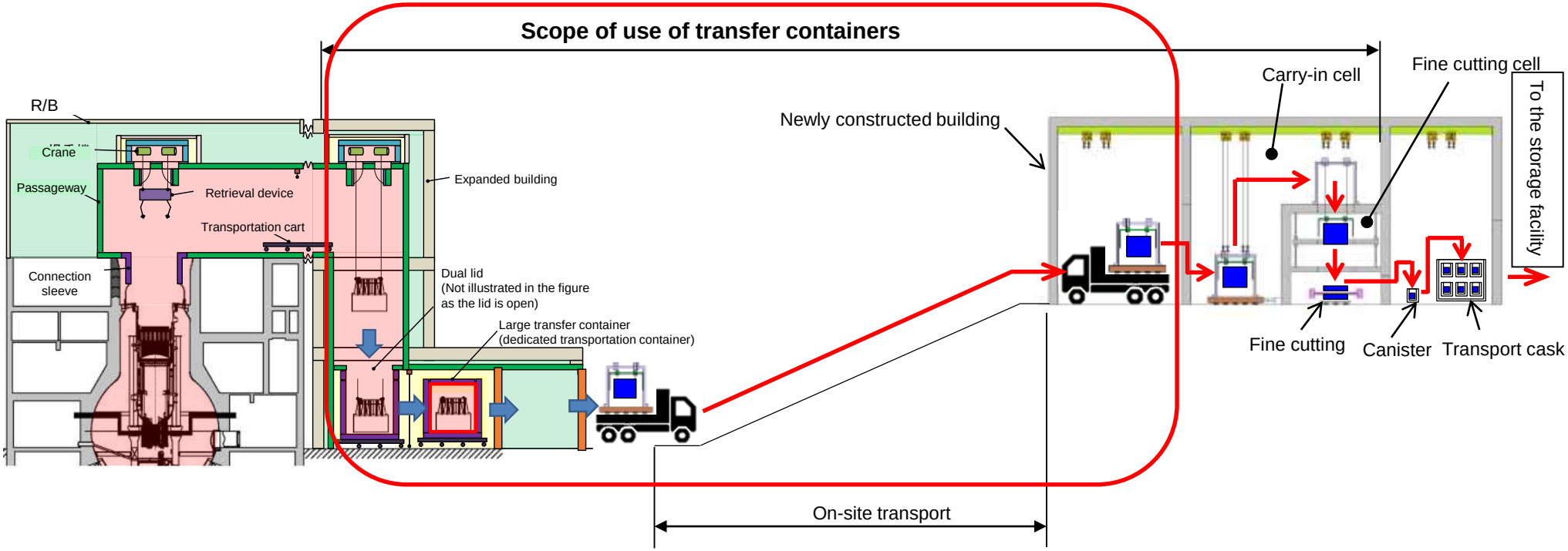
6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

[Study on criticality control methods]

The methods for criticality control until the structures to which fuel debris is adhered to are enclosed in the large transfer containers and transferred to a separate building for storage, will be studied.

Scope of the study on criticality control methods under this project



Basic policy: Maintaining sub-criticality by retaining the current shape

⇒ Issues will be identified and response measures will be studied (will be studied in FY2021)

1) Development of an air-tight mechanism for large transfer containers

[Basic policy and specifications related to the large transfer containers]

- Containers with common specifications will be used regardless of the structures that they will contain.
- Additional shielding will be installed depending on the structure (radiation dose).
- The containers will be used repeatedly as dedicated transportation containers ⇒ Rubber O-ring will be used considering the vibrations, etc. during transport

Items	Container specifications	Remarks
Use	On-site transport container	
Items to be transported	Dryer, separator, upper grid plate, reactor core, reactor bottom, etc.	Refer to No. 20
Approximate dimensions	Φ6000 × H7500 [mm]	
Approximate weight	390 [ton]	Only container body (not including the structures and lids)
Volume	220 m^3	
Maximum dose rate of contents	1000 Sv/h	Upper grid plate
Shielding thickness (γ rays)	280 [mm]	Separately added shielding 130 mm
Shielding thickness (neutron rays)	100 [mm]	Evaluated based on the radiation source of fuel debris
Pressure within the cell	-100 [Pa]	With respect to the room where the container is installed
Container surface design temperature	130° C	Packing
Main material	Low alloy steel	
Number of times it will be used	To be determined	Using it multiple times is being considered

1) Development of an air-tight mechanism for large transfer containers

[Items to be transferred using the large transfer container (1/2)]

Items to be transferred using the transfer container are listed below. (Including all structures that will be removed by the method of transferring the whole unit of the structures)

No.	Items to be transferred	Approximate dimensions during transport [m]	Approximate weight [ton]	Dose rate [Sv/h]	Remarks
1	Shield plug	Under consideration		Under verification	
2	PCV head	Under examination	12	4 (Cs)	
3	PRV Insulation Material	Under consideration		4 (Cs)	
4	RPV head	Under consideration	24	30 (Cs)	
5	Dryer	Φ5.5 × H5.5	29.4	400 (Cs)	
6	Separator + Shroud head	Φ5.4 × H5.1	51.8	200 (Cs)	
7	Guide rod	Φ90 × L3.1	0.1	200 (Cs)*	Maximum dimensions and weight when divided into 3 parts
8	Feedwater sparger	3.6 × 0.9 × t0.5	0.3		Divided into 4 parts and retrieved
9	Core spray pipes	3.6 × 0.9 × t1.6	0.3		
10	Upper grid plate (upper section of the shroud body)	Φ5.5 × H1.5	15.6	1000 (Co)	
11	Reactor core part (middle section of the shroud body)	Φ4.5 × H4.5	235.5	350 (Co)	Filled with geopolymer
12	Jet pump	0.5 × 1.2 × t4.3	0.8	200 (Cs)*	Dimensions and weight of the top portion of the jet pump
13	In core monitor (ICM) guide pipe / stabilizer	3.2 × 3.2 × 3.8	1.2		
14	Shroud support (includes the lower section of the shroud body)	Φ5.4 × H3.8	11.0		
15	Reactor bottom	Φ4.9 × H5.5	249	150	Filled with geopolymer, including various supports
16	Granular fuel debris etc.	–	–	–	Collected in small containers and transferred all at once in a large container

(Note) The approximate dimensions and weight were studied based on 1F-Units 2/3 and the dose rate was studied based in 1F- Unit 1.

*: Estimated to be comparable to Separator + Shroud head

: Representative structure**

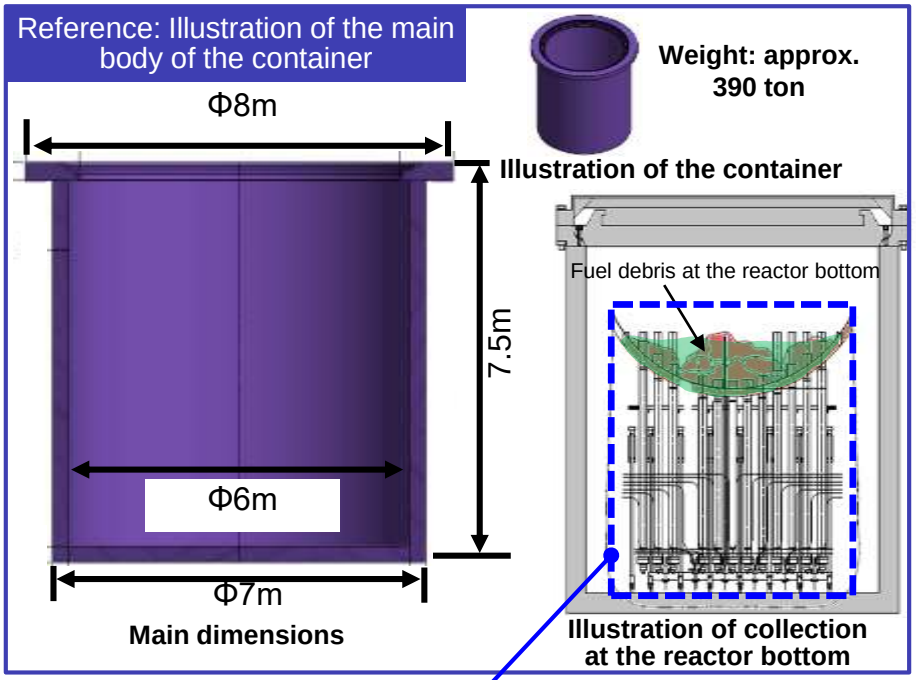
**: Structures with comparatively large dimensions and dose rate and which need to be taken into consideration, in particular, while establishing the specifications.

1) Development of an air-tight mechanism for large transfer containers

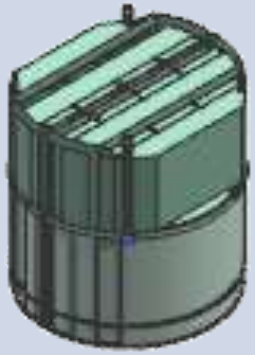
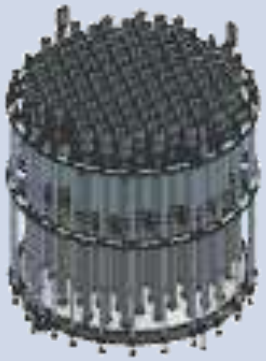
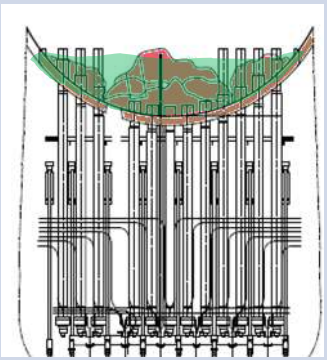
[Items to be transferred using the large transfer container (2/2)]

In order to transfer the whole unit of the structures or large structures, it was ensured that the dimensions (inner diameter) of the containers can enclose the structures to be transferred. Dryer, separator & shroud head and reactor bottom, which have larger dimensions or are heavier, are shown below as examples of the structures.

Reference: Illustration of the main body of the container



Main dimensions of the structures

	① Dryer	② Separator shroud head	③ Reactor bottom
Figure			
Dimensions [m]	Approx. Φ5.5 × H5.5	Approx. Φ5.4 × H5.6	Approx. Φ4.9 × H5.5
Weight [ton]	Approx. 30	Approx. 52	Approx. 250 (including filler material)
Remarks			Solidification by means of filler material is being considered for fall prevention

6. Implementation Items of This Project

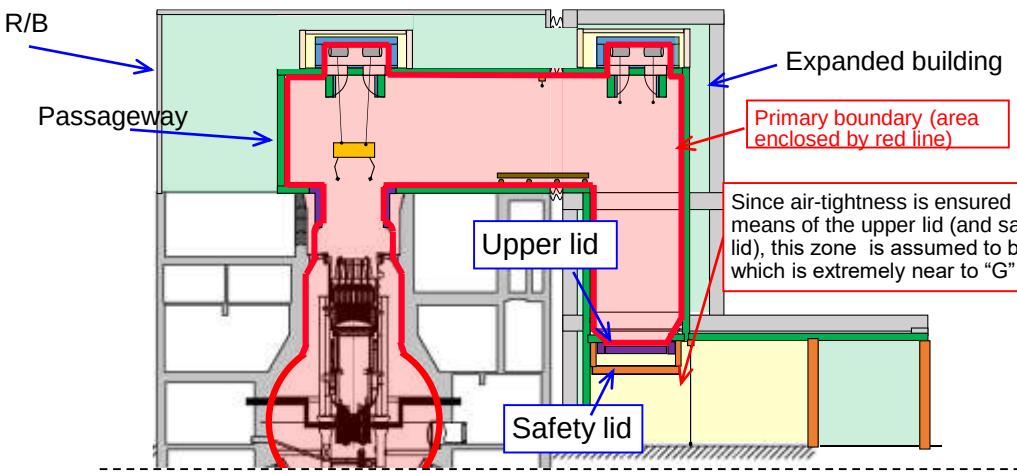
1) Development of an air-tight mechanism for large transfer containers

[Notes]
R: Red (high contamination) zone
Y: Yellow (moderate contamination) zone
G: Green (low contamination) zone

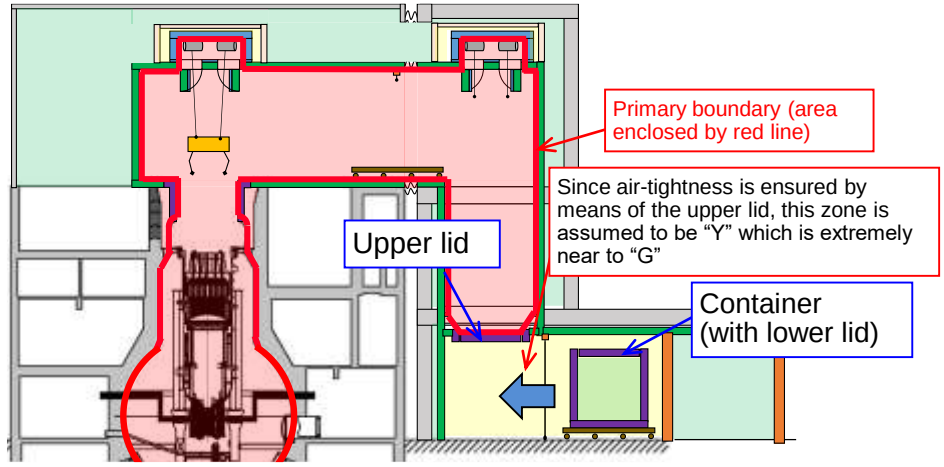
[Rough outline of the steps involved in transferring the whole unit of the large structures (1/2)]

A rough outline of all the steps involved in transferring structures and the primary boundary are described below.

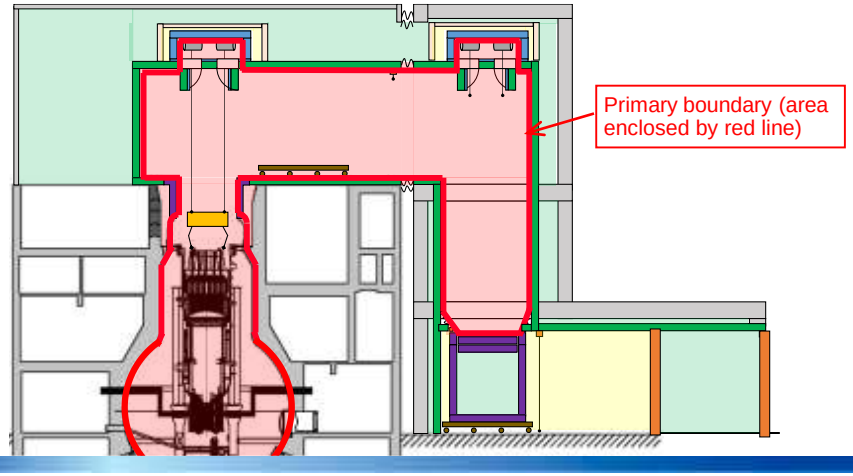
① Preparation for carrying-in the container: Removing the safety lid



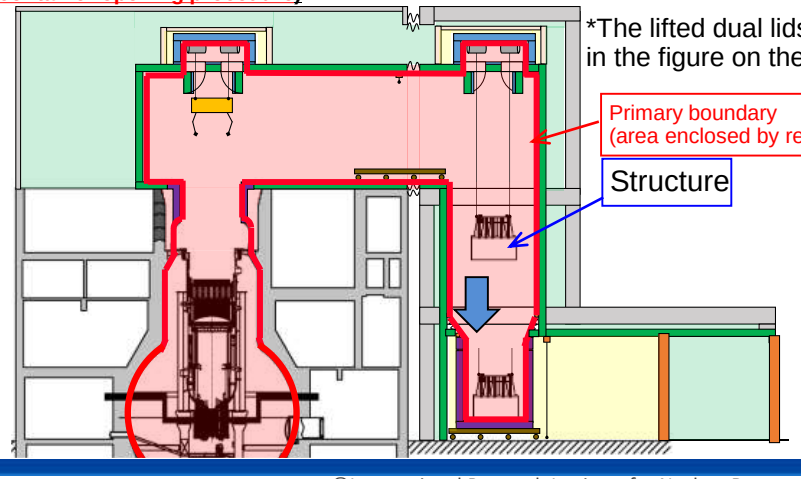
② Carrying-in the container: Carrying-in the large transfer container



③ Container connection: Connecting upper lid and lower lid (container)



④ Opening of the container and enclosing the structures (Refer to No. 24 onwards for the container opening procedure)



*The lifted dual lids are omitted in the figure on the left.

6. Implementation Items of This Project

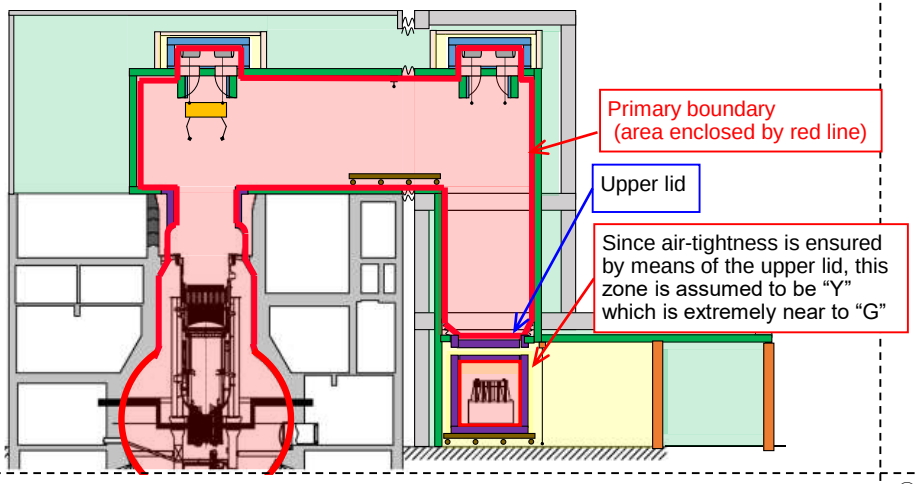
1) Development of an air-tight mechanism for large transfer containers

[Notes]
R: Red (high contamination) zone
Y: Yellow (moderate contamination) zone
G: Green (low contamination) zone

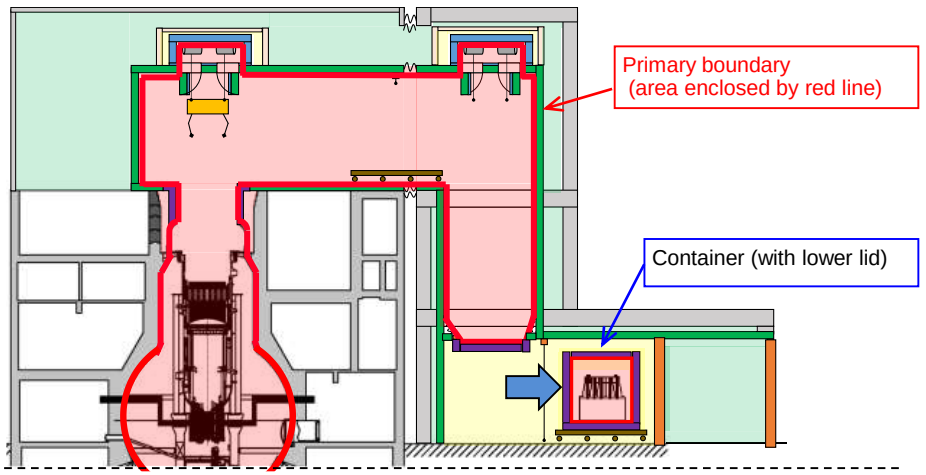
[Rough outline of the steps involved in transferring the whole unit of the large structures (2/2)]

A rough outline of all the steps involved in transferring structures and the primary boundary are described below.

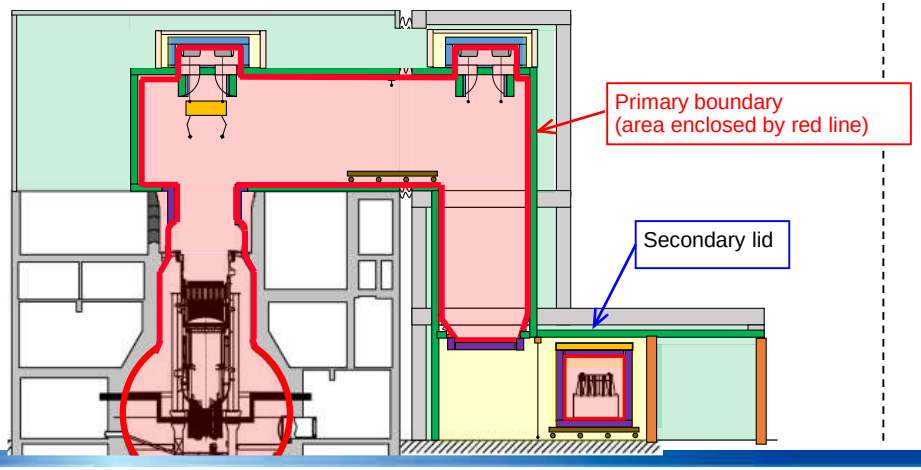
⑤ Separating the container: Decoupling the upper lid and lower lid



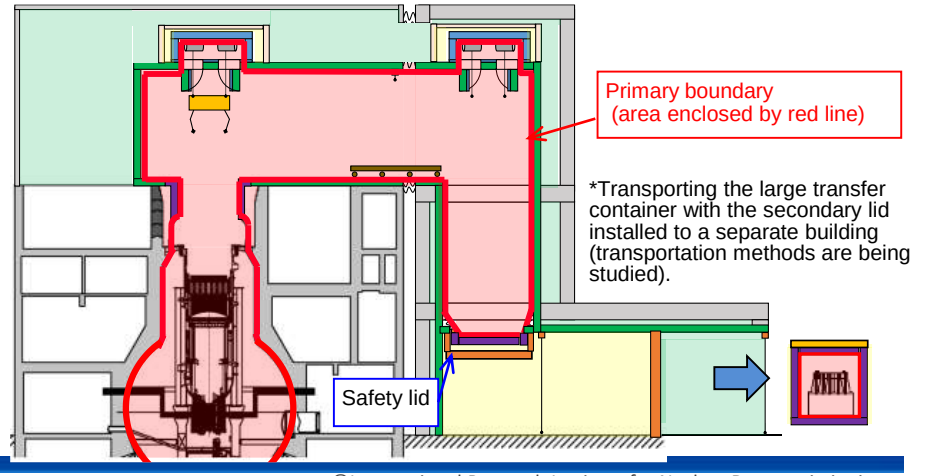
⑥ Carrying-out the container: Carrying-out the large transfer container



⑦ Installation of secondary lid: Installing a secondary lid for on-site transportation



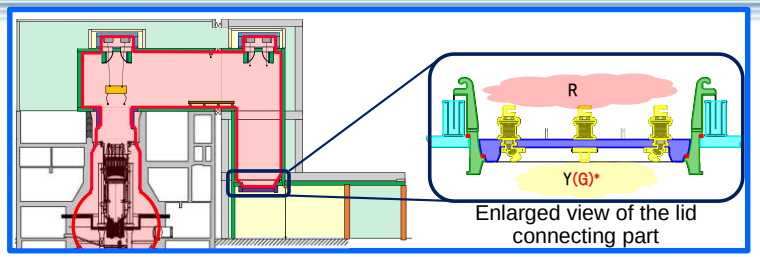
⑧ Transportation to a separate building: Transporting the large transfer containers to a separate building



6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

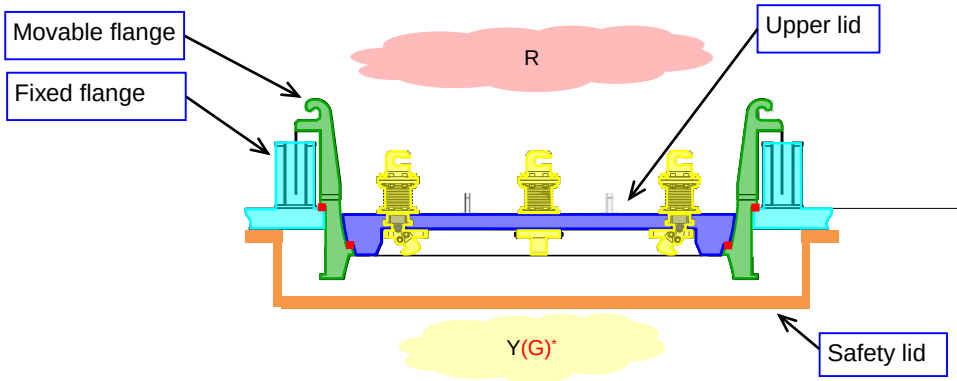
[Rough outline of the steps involved in the operation of the dedicated transportation container lid (1/2)]



[Notes]
R: Red (high contamination) zone
Y: Yellow (moderate contamination) zone
G: Green (low contamination) zone

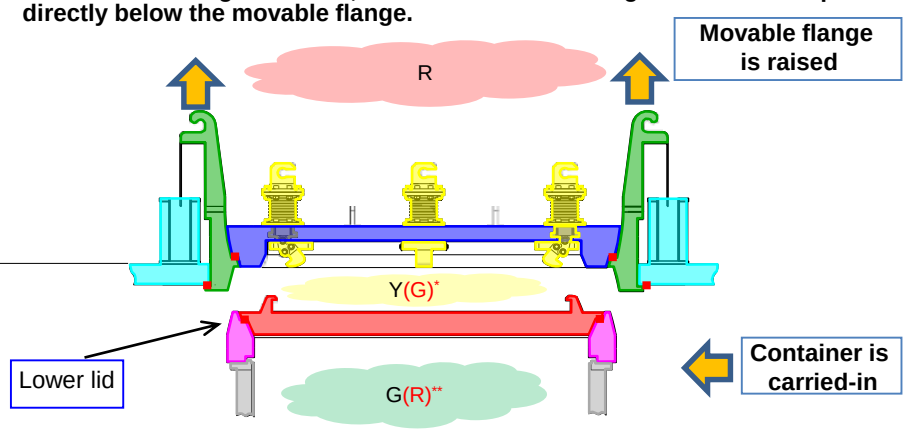
① Preparation for carrying-in the container

The safety lid is removed.



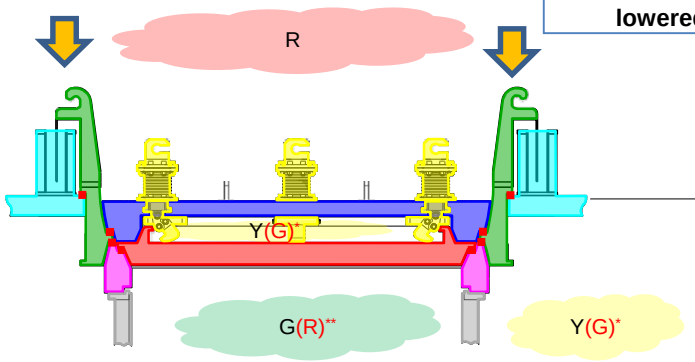
② Carrying-in the container

The movable flange is raised, and the container is aligned so that it is positioned directly below the movable flange.



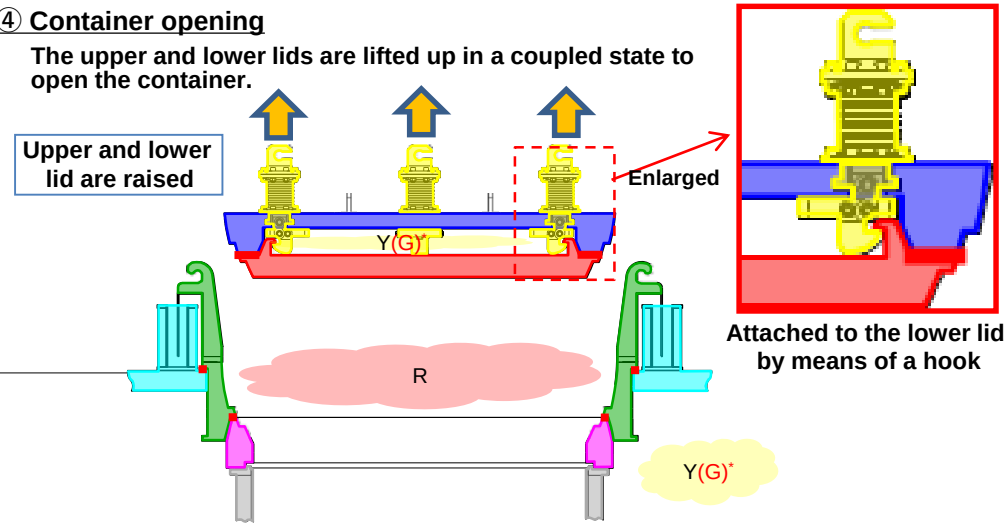
③ Container connection

The movable flange is lowered, and connected to the container body.



④ Container opening

The upper and lower lids are lifted up in a coupled state to open the container.



* Here, "Y" is assumed to be extremely near to "G"
** When the dedicated transport container is reused, the inside of the container may not be "G".

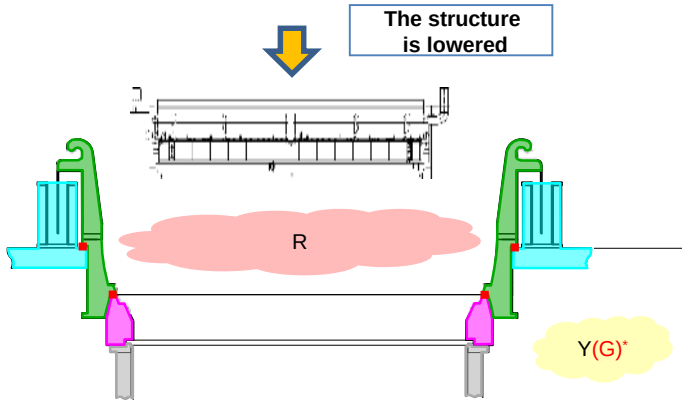
1) Development of an air-tight mechanism for large transfer containers

[Notes]
R: Red (high contamination) zone
Y: Yellow (moderate contamination) zone
G: Green (low contamination) zone

[Rough outline of the steps involved in the operation of the dedicated transportation container lid (2/2)]

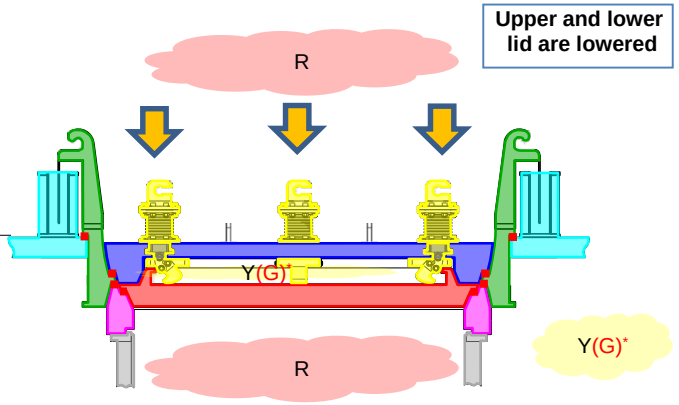
⑤ Containing of the removed structures

The structures are contained in the container.



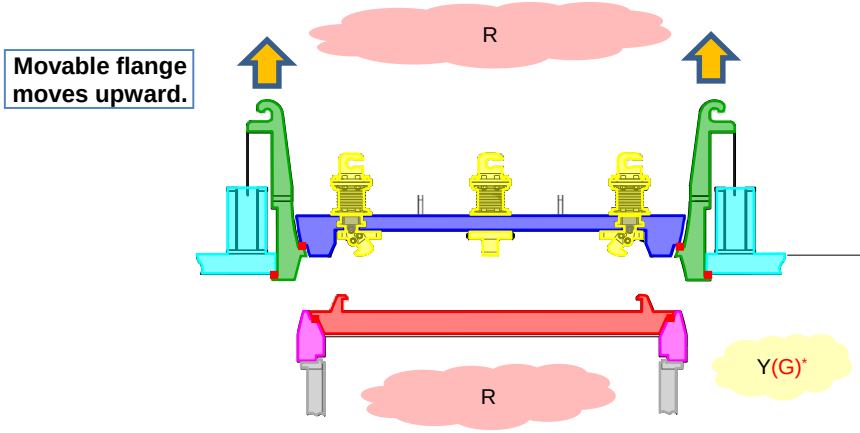
⑥ Closing of container

The upper and lower lids are lowered in a coupled state to close the container.



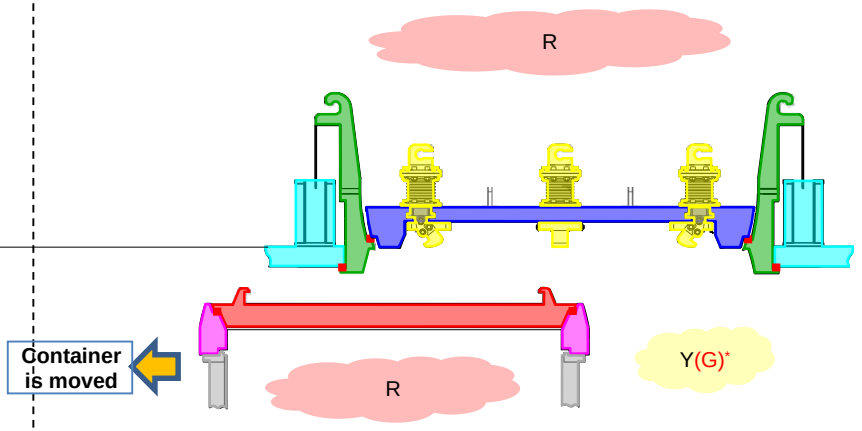
⑦ Container separation

The upper lid and lower lid are decoupled and the container is separated.



⑧ Carrying-out of container

The container is carried-out.



*"Here, Y" is assumed to be near limitless "G"

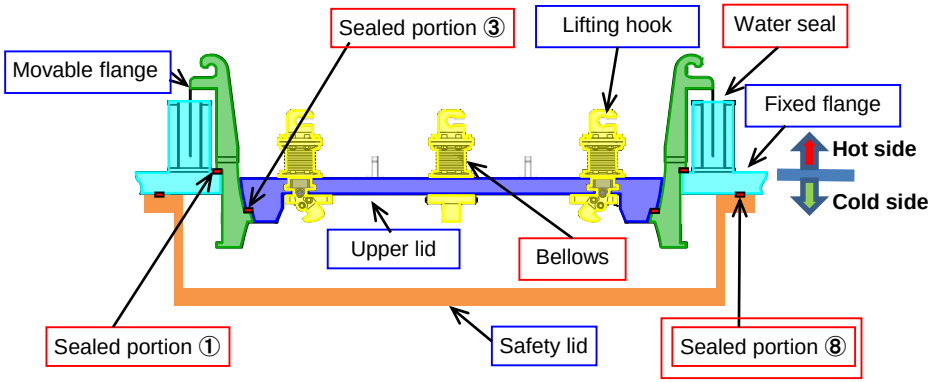
1) Development of an air-tight mechanism for large transfer containers

: Air-tight portion : Boundary : Component name : Sealed portion

[Structure of the dedicated transportation container lid (1/2)]

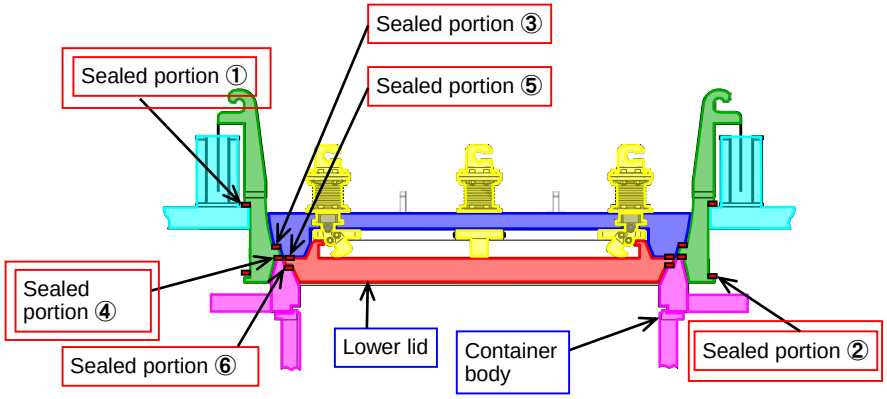
The structure at the main steps is indicated below (Refer to the next slide for an overview of the components).
The containers are exclusively for transportation and will be used repeatedly (will be opened and closed many times). Hence a rubber seal is being considered for the sealed portion.

Normal condition (other than during work such as transferring structures, etc.)



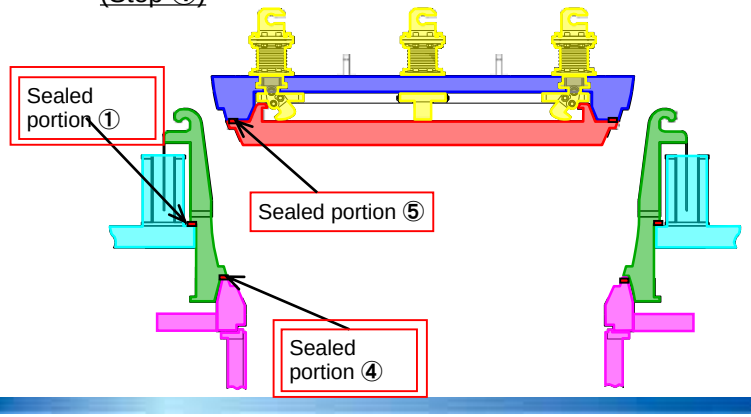
This condition continues for the longest time during the retrieval period and hence the safety lid is installed considering safety

While connected to the container (Step ③)

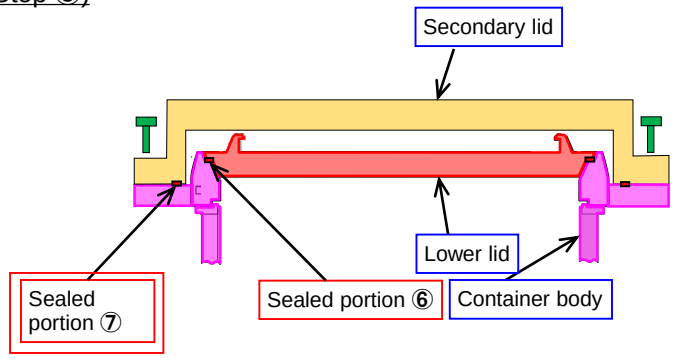


Sealed portion ② plays the same role as Sealed portion ① when the movable flange is raised before container connection.

When the container is open (Step ④)



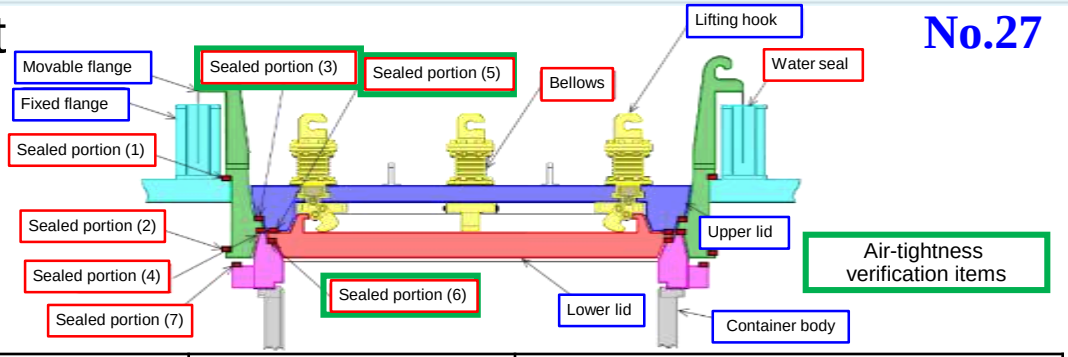
While carrying-out the container (Step ⑧)



6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

[Structure of the dedicated transportation container lid (2/2)]
A brief overview of the components is described below.



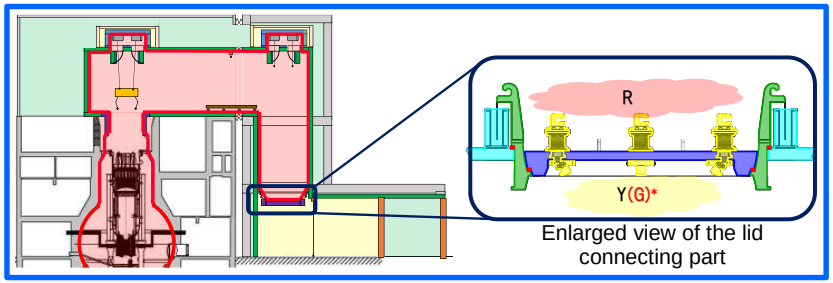
Equipment	Overview	Shielding	Air-tight connecting part (Seal No.)		Reason for selection
Fixed flange	Port attached to the expanded building forming the boundary	Present (Equivalent to expanded building)	Upper part of fixed flange	①	The fixed flange is installed during construction. It makes a simple vertical movement. Hence it is determined to have a lower priority.
			Lower part of fixed flange	②	
Movable flange	➢ The movable flange moves when the container is mounted. It is normally connected to the upper lid and forms the boundary. ➢ At the time of connecting the container, it connects with the container and forms the boundary.	Present (Equivalent to expanded building)	Upper part of fixed flange	①	
			Lower part of fixed flange	②	
			Upper lid	③	This portion is mounted remotely. Its sealing needs to be verified.
			Container	④	As long as the container is aligned, it moves only in the vertical direction at a fixed position and hence it is determined to have a lower priority.
Upper lid	➢ It is connected to the movable flange and forms the boundary. ➢ It is connected to the lower lid and plays the role of providing a dual lid.	None	Movable flange	③	This portion is mounted remotely. Its sealing needs to be verified.
			Lower lid	⑤	This portion is joined remotely. Its sealing needs to be verified.
Lower lid	➢ It is connected to the upper lid and plays the role of providing a dual lid. ➢ It is connected to the container. It prevents spread of contamination and shields against dose from the structures.	Present	Upper lid	⑤	
			Container	⑥	This portion is mounted remotely. Its sealing needs to be verified.
Container	➢ It is connected to the movable flange and forms the boundary. ➢ It is connected to the lower lid and the secondary lid and plays the role of an on-site transport container.	Present	Movable flange	④	As long as the container is aligned, it moves only in the vertical direction at a fixed position and hence it is determined to have a lower priority.
			Lower lid	⑥	This portion is joined remotely. Its sealing needs to be verified.
			Secondary lid	⑦	This part is relevant to the secondary lid and falls within the scope of verification on the container side.
Secondary lid	It is connected to the container and serves as the sealing boundary during transportation.	Present	Container	⑦	
Safety lid	It is connected to the fixed flange and forms the boundary during normal conditions.	Present (Equivalent to expanded building)	Fixed flange	⑧	The connection is within the green zone and hence it is determined to have a lower priority.

Conceptual study will be conducted for the parts that do not undergo a sealing verification test.

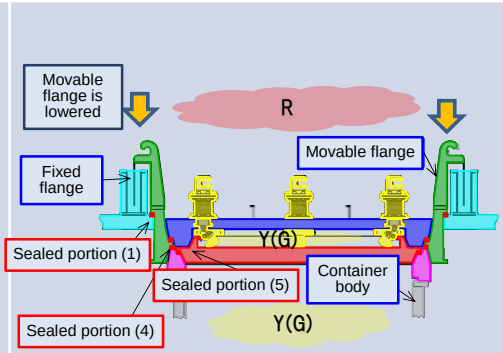
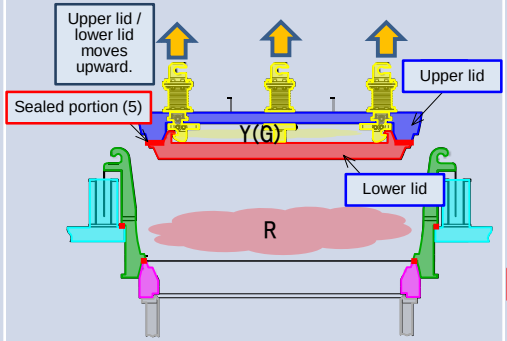
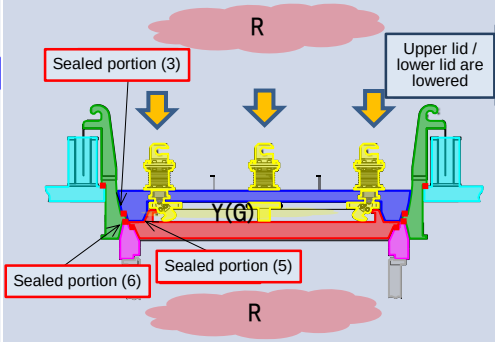
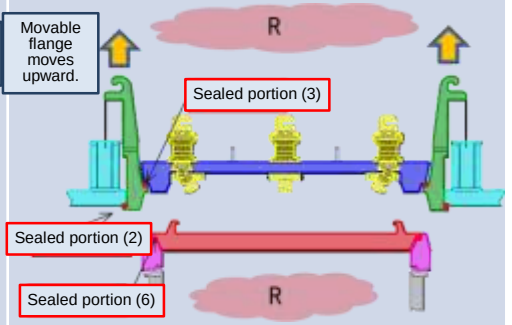
6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

[Issues in the operation of the dedicated transportation container lid (1/2)]



[Notes]
R: Red (high contamination) zone
Y: Yellow (moderate contamination) zone
G: Green (low contamination) zone

	1. Carrying-in and connecting the container	2. Opening the container	3. Closing the container	4. Separating the container
Step diagram				
Details	➢ The container body to which the lower lid is connected is carried in and aligned so that it is positioned directly below the movable flange. ➢ The movable flange is lowered, and connected to the container body. (Upper and lower lids are connected as well)	➢ The upper and lower lids are lifted up in a coupled state to open the container.	➢ The upper and lower lids are lowered in a coupled state after the structure is enclosed in the container. ➢ The upper and lower lids are decoupled, the lower lid is mounted on the container body and upper lid is mounted on the movable flange.	➢ The movable flange moves upward, and the container is separated.
Major issues	① Method of carrying-in the container ② Method of determining the container location ③ Lid opening and closing mechanism (Connection of upper and lower lid) ④ Method of verifying the connection (connection between the movable flange and container body, and the upper and lower lids) ⑤ Sealing of the sealed portions (①④⑤)	① Air-tightness of sealed portion ⑤ when raised	① Lid opening and closing mechanism (Attachment and detachment of upper and lower lid) ② Method of verifying the connection (connection between the lower lid and container body, and the upper lid and movable flange) ③ Sealing of the sealed portions (③⑥)	① Criteria for determining whether the container can be separated ② Sealing of the sealed portion (②)

1) Development of an air-tight mechanism for large transfer containers

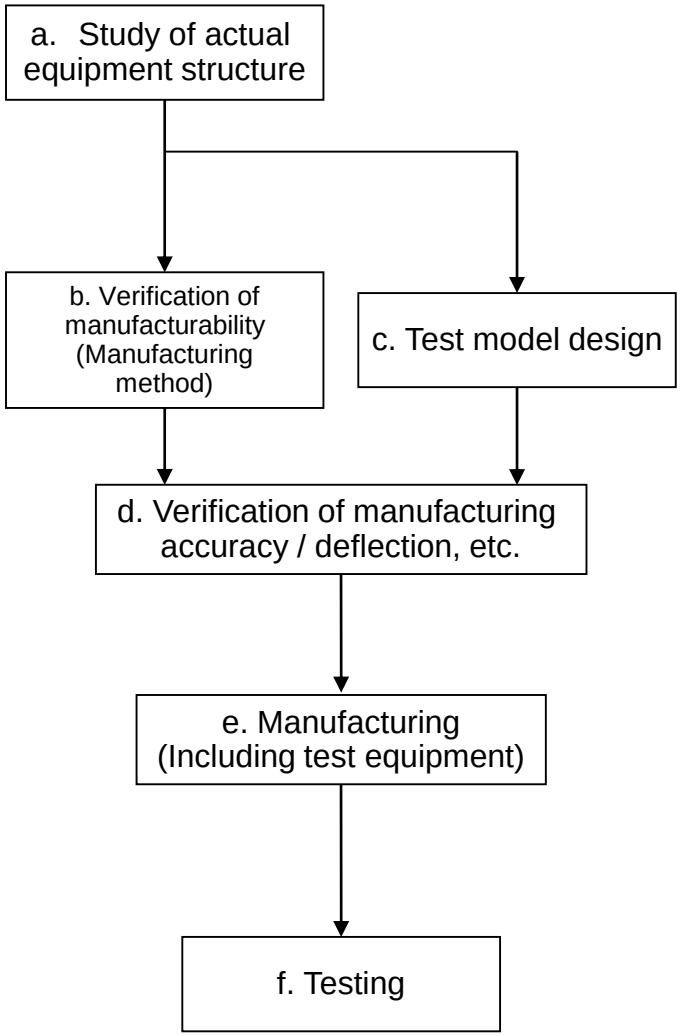
[Issues in the operation of the dedicated transportation container lid (2/2)]

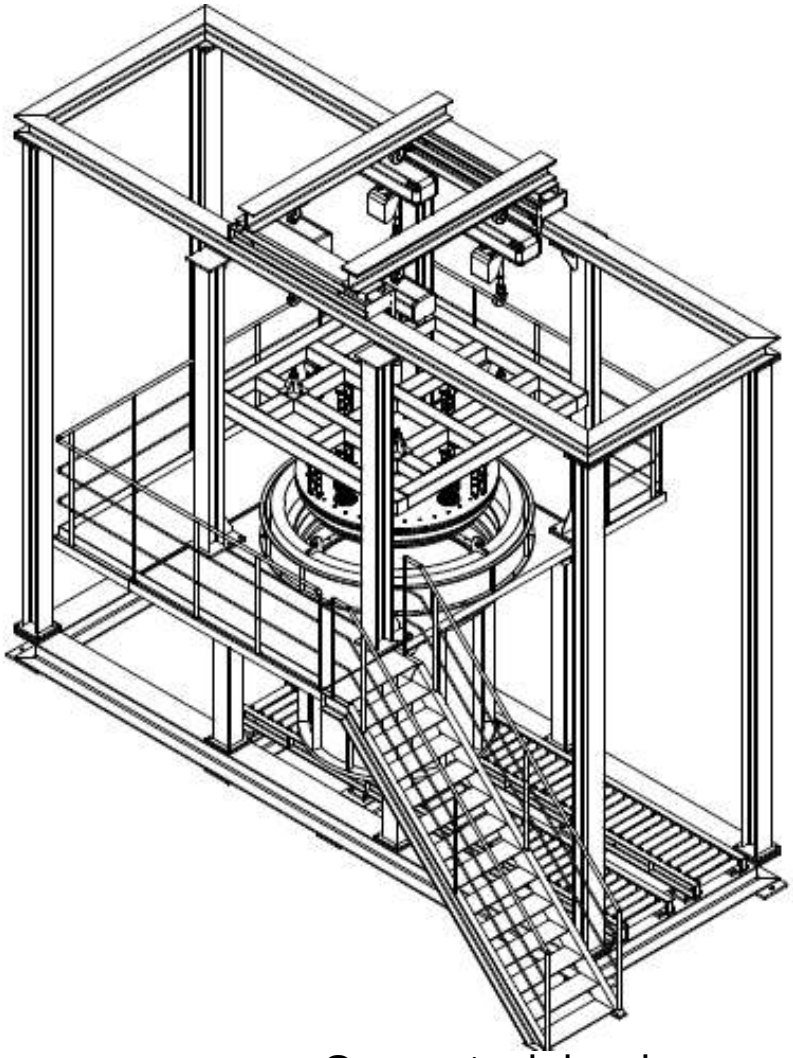
No.	Issues	Details	Examination	Test	Remarks
1	Method of carrying-in the container	The plan is to carry-in the container by mounting it on a vehicle. The method for doing this will be studied.	○	-	Application of existing technologies
2	Method of positioning the container	As the alignment of the container position is difficult if it is mounted on a vehicle, installing a position adjustment mechanism between the vehicle and the container will be considered.	○	-	Application of existing technologies
3	Lid opening/closing mechanism	The method for connecting and attaching/detaching the upper lid and lower lid will be studied, and its feasibility will be verified through elemental tests.	○	○	
4	Method of confirming connection	The method for remotely confirming the connection will be studied and verified through elemental tests. ⇒Proposal: Marking the connection part and checking it by means of a fixed point camera, etc. [This method can be used for the following:] Connection between the upper lid and lower lid, the lower lid and container body, and the upper lid and movable flange	○	○	
5	Sealing of the sealed portion	The sealing method will be studied, and sealing performance will be verified through elemental tests. The following 3 locations that are related to the upper lid and lower lid that are mounted remotely, will be tested. ・Sealed portion ③: Between movable flange and upper lid ・Sealed portion ⑤: Between upper lid and lower lid ・Sealed portion ⑥: Between lower lid and container	○	○	
6	Air-tightness of sealed portion ⑤ (between the upper lid and lower lid) when raised	A sealing method with which the air-tightness of the sealed portion can be maintained when the upper lid and lower lid are lifted as a whole, will be studied. ⇒ Lifting the lower lid is being considered. In that case, as long as the air-tightness of sealed portion ⑤ is maintained before lifting, it is believed that there will be no problem during lifting either. Hence tests will not be conducted.	○	-	Replace with above-mentioned No. 5
7	Criteria for determining whether the container can be separated	Criteria for determining whether the container can be separated and transferred will be studied and their validity will be verified through elemental tests.	○	○	

⇒ Elemental tests will be conducted for No.3 to 5 and 7.

1) Development of an air-tight mechanism for large transfer containers

[Test procedures]





Conceptual drawing

1) Development of an air-tight mechanism for large transfer containers

[Test plan]

No.	Items	Details	Items to be monitored, measured and recorded	Criteria
1	Validity of the lid opening/closing mechanism	● Verification of the movement of the lid opening/closing mechanism by operating the hook ● Verification of the connection between the upper lid and lower lid when the lower lid is installed and the upper lid is lifted up by means of the hook, and verification of the gap, etc.	➢ Abnormal noise, rattling, etc. ➢ Connecting portion between the upper and lower lid ➢ Gap (Extent to which the O-ring is flattened)	➢ Moves normally. ➢ As per the dimensions. ➢ Meets the O-ring specifications and is within the design range
2	Verification of the connection confirmation method	● Remotely confirming the connections between the upper lid and lower lid, the lower lid and container body, and the upper lid and movable flange	➢ Gap (Extent to which the O-ring is flattened)	➢ Meets the O-ring specifications and is within the design range
3	Air-tightness performance	● Verification of the air-tightness at each step ● The sealed portion ③: between movable flange and upper lid, sealed portion ⑤: between upper lid and lower lid and sealed portion ⑥: between lower lid and container will be verified.	➢ Gap (Extent to which the O ring is flattened) ➢ Pressure	➢ Meets the O-ring specifications and is within the design range ➢ Leak rate is ○○ or less (Being considered)
4	Confirmation of reproducibility	● Tests will be conducted multiple times to verify whether the items to be monitored reappear.	Same as items 1 to 3 above	—
5	Criteria for determining whether the container can be separated	● The validity of the criteria being studied will be verified.	(Separately established after studying the structures)	

(Remarks)
・This plan is likely to change depending on the progress in designing.
・Reference leak rate (Unit 3 spent fuel transport cask): 9×10^{-1} ref cm^3/s

6. Implementation Items of This Project

1) Development of an air-tight mechanism for large transfer containers

For development and test manufacturing

[Equipment configuration (comparison with actual equipment)]

No.	Equipment	Actual equipment specifications [mm] (approximate dimensions)*	Mock-up specifications (approximate dimensions)*
①	Movable flange	➢ Diameter 9300, height 1600, weight 150 ton	➢ Under consideration
②	Fixed flange	➢ Diameter 11100, thickness 375, weight 170 ton	➢ Under consideration
③	Upper lid	➢ Diameter 6800, height 800, weight 100 ton	➢ Same as actual equipment (part of it simplified)
④	Lower lid	➢ Diameter 6800, thickness 280, weight 100 ton	➢ Same as actual equipment
⑤	Container	➢ Diameter 7500, thickness 280, height 7500, weight 390 ton	–
⑥	Lifting hook	➢ Diameter 500, height 1500	➢ Under consideration
⑦	Test container	–	➢ Under consideration

*Dimensions are approximate.

[Illustration of the equipment*]

① Movable flange

③ Upper lid ⑥ Lifting hook

⑤ Container

② Fixed flange

④ Lower lid

*The actual equipment specifications, mock-up specifications and equipment image are all from the planning stage and are likely to change.

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

With regard to new access apparatus (access tunnel, cell, etc.) to be installed the /B, development issues for the structure of connection parts, methods, inspection, maintenance, etc. is studied and examined to develop technologies for ensuring the confinement function in the parts connected with the existing structures including PCV. Elemental tests including the following items are conducted to verify the feasibility.

① Technology for connecting heavy structures to accessing PCV

In order to install the new access equipment on to the PCV connection part（equipment hatch, etc.), heavy structures weighing hundreds of tons need to be transferred into the R/B, and their positions need to be adjusted to match the PCV connection part with precision, and in doing so the exposure needs to be reduced and work safety needs to be ensured.

Hence, technology (position adjustment and installation) for connecting heavy structures needs to be developed, which would make it possible to carry out installation while taking into consideration various factors such as not exceeding the R/B floor load limit, moving, turning and position adjustment of heavy structures while avoiding existing structures and equipment in the R/B, and carrying out remote operations so that workers do not have to enter the site as far as possible since the radiation levels inside the R/B are high.

Technical studies of bridges, plants, etc. will be included in the examination and applicable technology for connecting heavy structures will be developed.

And, mock-up elemental tests will be conducted by simulating the actual weight of the equipment to verify on-site applicability.

② Confinement structure for the connection parts

The new access equipment to be connected to the PCV needs to be equipped with the function of absorbing displacements in the event of an earthquake in addition to a confinement function for the connection parts.

The displacement absorption structure of the PCV connection parts for the heavy structures to be installed in R/B will be developed considering the options of combining or improving on existing technologies and the feasibility will be evaluated by conducting elemental tests.

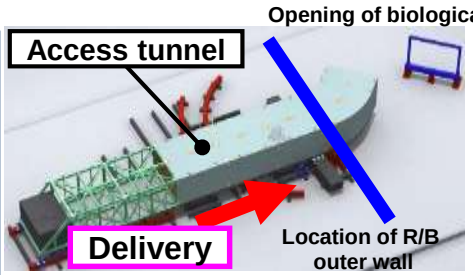
6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

Approach & Systems Upgrade (implemented in FY2017-18)

[Verification of the feasibility of the method (conducting shape, dimensions, scale related elemental tests)]

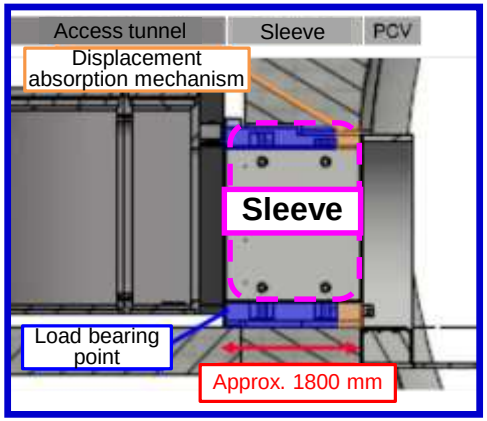
- Delivery of the tunnel parts
- Delivery of the curved surface tunnel through the narrow opening
- Remote work monitoring, positioning accuracy

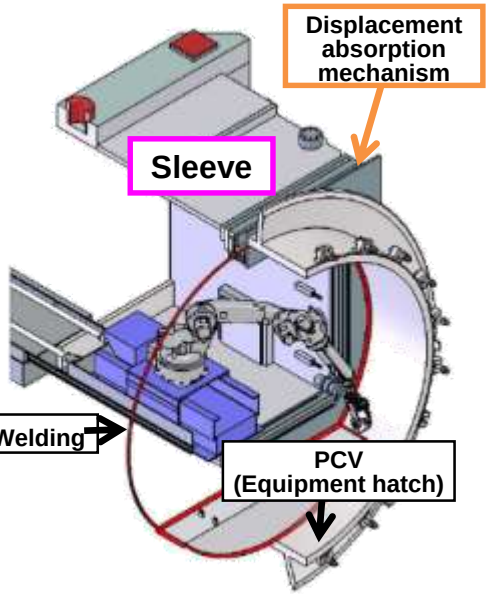


Further increasing the scale of retrieval (implemented in FY2019- 20)

[Verification of the connection method]

- Study of issues identified above
- Method of connecting with the BSW (sleeve welding test)
- Study of sleeve (displacement absorption mechanism) structure

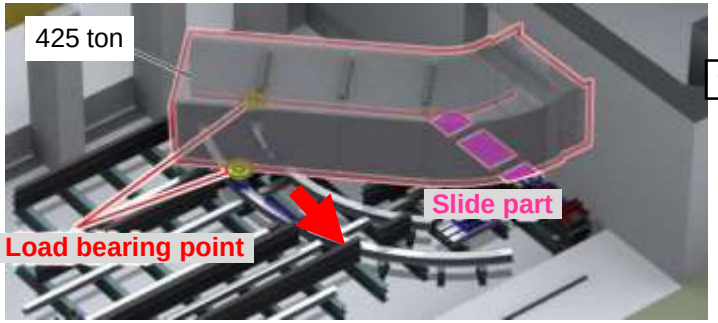




Implemented in this project

[Verification of feasibility through testing]

- Delivery of heavy objects (simulated mass)
- Displacement absorption mechanism (air-tight function)



Items to be studied in future

- Study of the method of remotely installing and welding the sleeve, etc.

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures used to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

[Issues]

- Prospects of feasibility of the work of remotely delivering the access tunnel were obtained through elemental tests conducted by simulating the shape and dimensions.
- However, due to space limitations within the building, the technology for rotating the tunnel during its delivery is an issue.

[Implementation Details]

- The structure of the rotating part (slide part) of the access tunnel will be studied considering the impact of the load.
- In order to verify the feasibility of the slide part considered, an elemental test plan will be formulated for testing by simulating the load of the slide part (simulating the access tunnel unit actual mass at the time of rotation).
- Elemental tests will be conducted to verify the feasibility of the slide part that was considered. (The plan is to track the movement of the sliding surface to the tunnel body in order to verify feasibility)

[Expected outcome]

- An access tunnel slide part structure that considers the impact of the load will be presented.

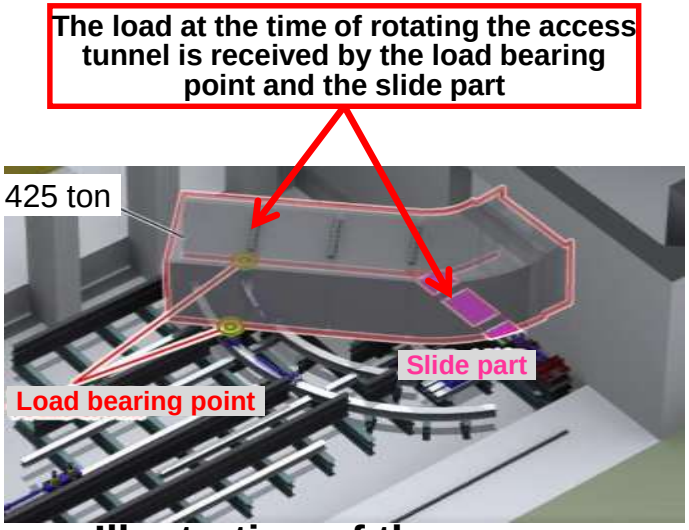


Illustration of the access tunnel slide part

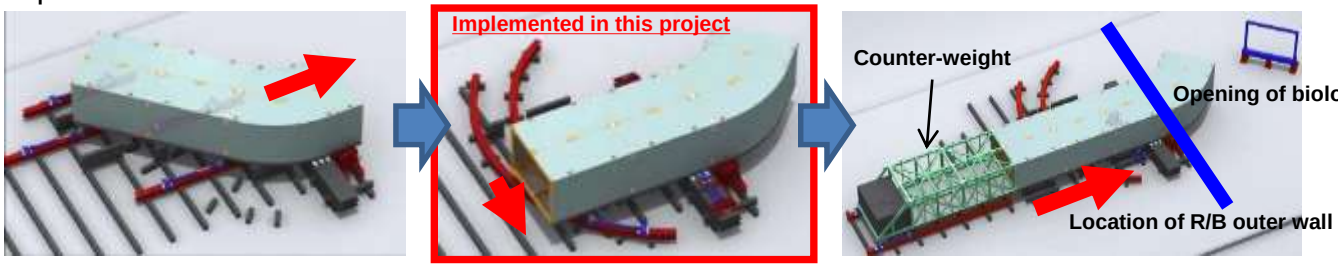


Illustration of access tunnel installation

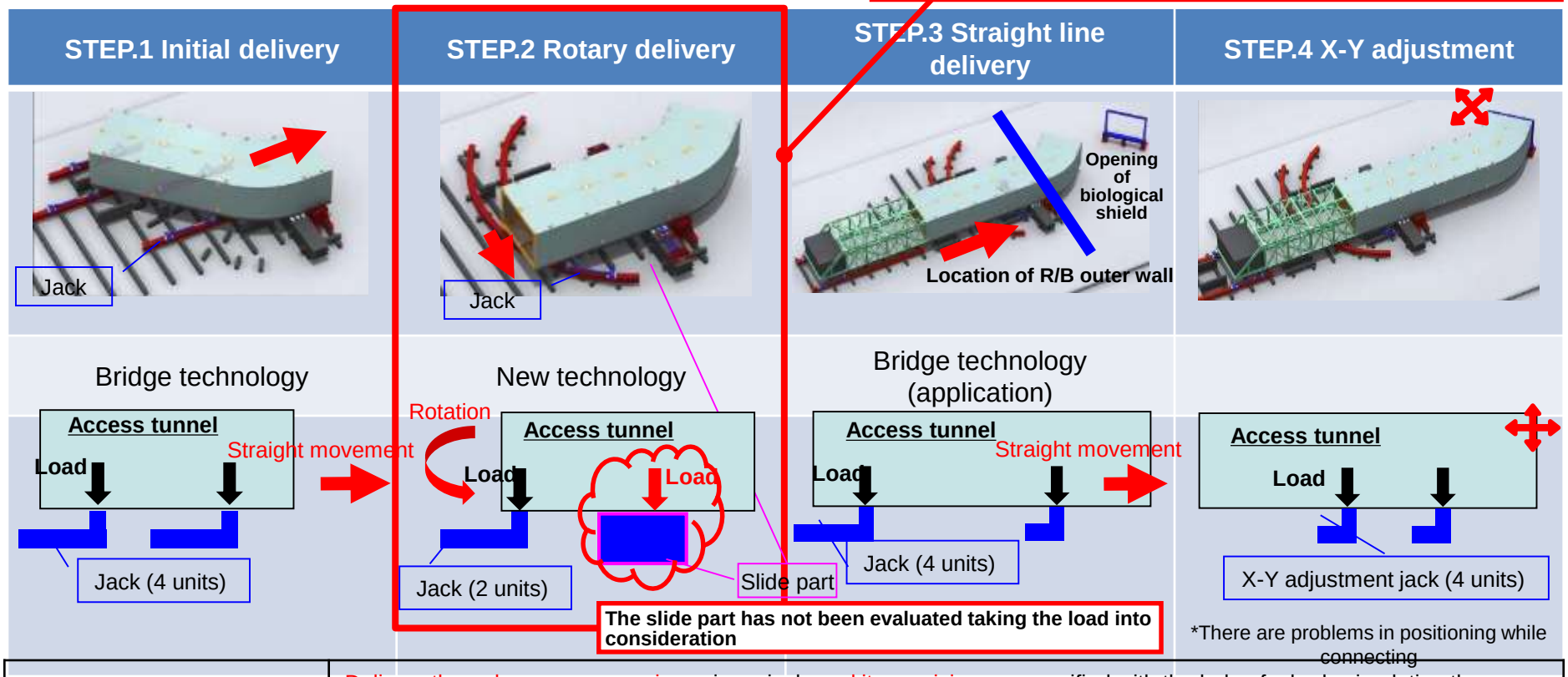
6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

[The reason why the rotating part (slide part) needs to be developed]

Slide part: Slides the access tunnel when the block receives the load and the access tunnel is rotated by the jack.



Results up to FY2018 (Approach & Systems Upgrade)	Delivery through a narrow opening using a jack, and its precision were verified with the help of a body simulating the shape. ・Since the jack used was of the same capacity as the actual device, there will be no problem even with the actual mass. ・As the body simulating the shape was light in weight, the slide part has not been evaluated.
This project	Verification of the function of the slide part with the help of a body simulating the mass (STEP 2)

*In STEP 2, 4 jacks cannot be installed like it is done in other STEPS, due to installation space limitations.

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

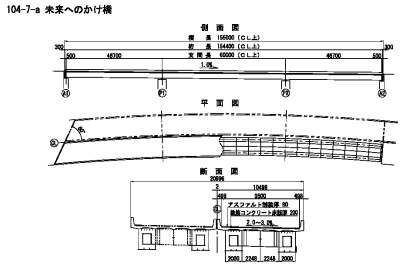
① Technology for connecting heavy structures to accessing PCV

[Comparison with a method that has a proven track record with respect to bridges]

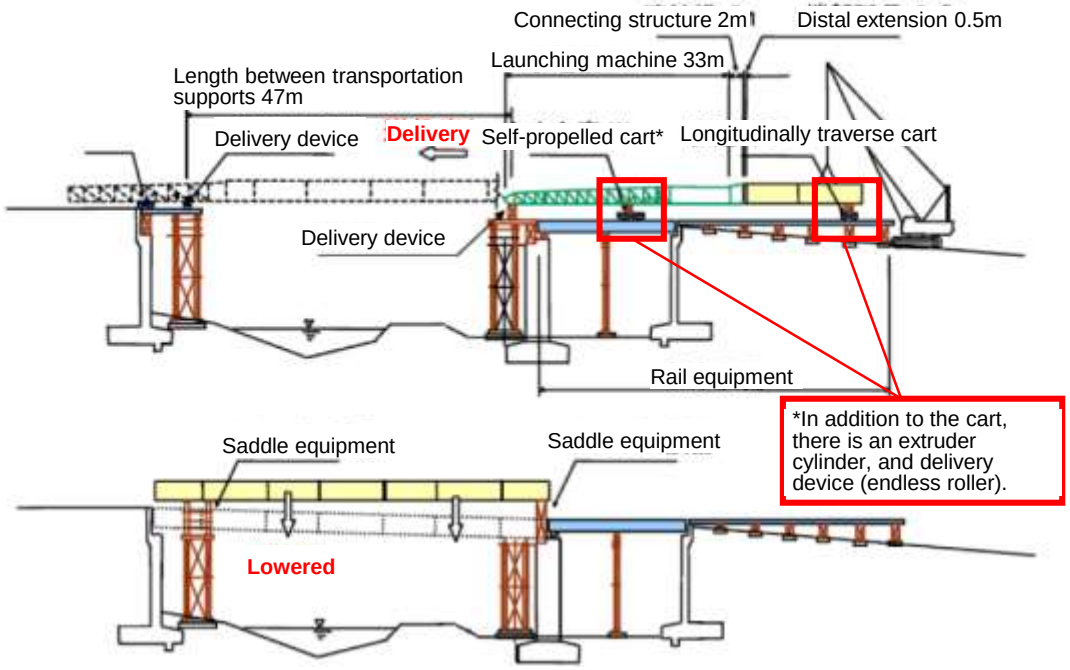
- In bridges, generally the delivery is in a straight line. However, depending on the environment, there are times when a R is provided for delivery as shown in the figure below.
- As sufficient work space is secured most of the times, the jacks are installed (4 or more) in front and at the rear for delivery. Thus, there is no sliding.
- The structures being delivered sometimes have curved contours as well, but as the bend radius is large and quite similar to a straight line, it does not result in offset load that affects the construction method.

⇒ **This time the work space is small and the objects are supposed to be delivered (passes through) to a narrow part, sliding is required.**

Example of a bent delivery rail



Example of structures with curved contours



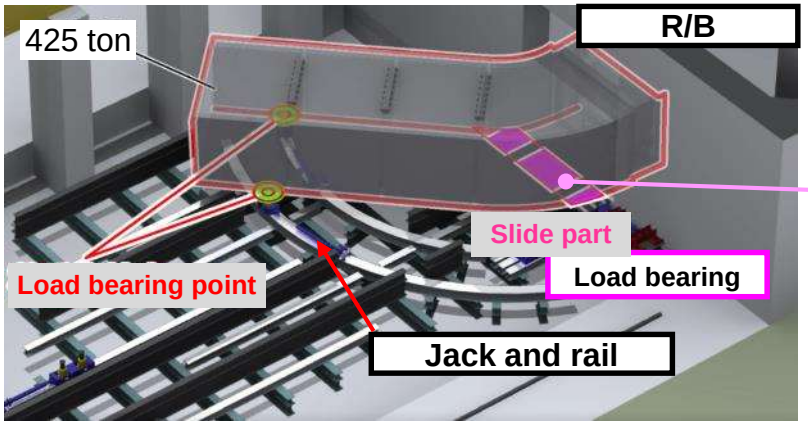
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

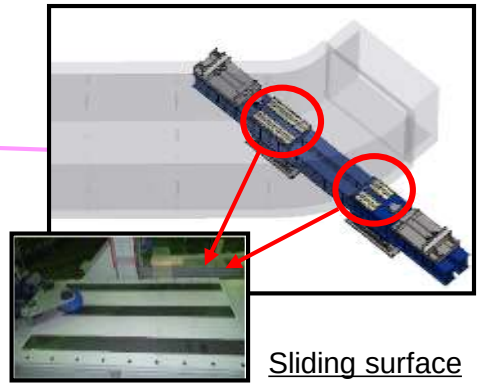
① Technology for connecting heavy structures to accessing PCV

Results up to FY2018 (Shape simulation)

- Verification of delivery feasibility
- Verification of delivery feasibility of the curved shaped tunnel through the narrow opening
- Remote work monitoring (remote installation)
- Verification of positioning accuracy (±50mm)

[Access tunnel slide part]





・The plan is to install the access tunnel without removing existing pillars so as to minimize the load on the damaged R/B.

For that, the access tunnel needs to be rotated in the vicinity of the R/B.

・The rear part of the access tunnel can be rotated on the rail by means of a jack, but there is no space to lay rails for rotating the front part. Hence the access tunnel will be rotated (slid) by the slide part while bearing the load.

⇒ The feasibility of the access tunnel delivery was verified until FY2018 using simulated shape.

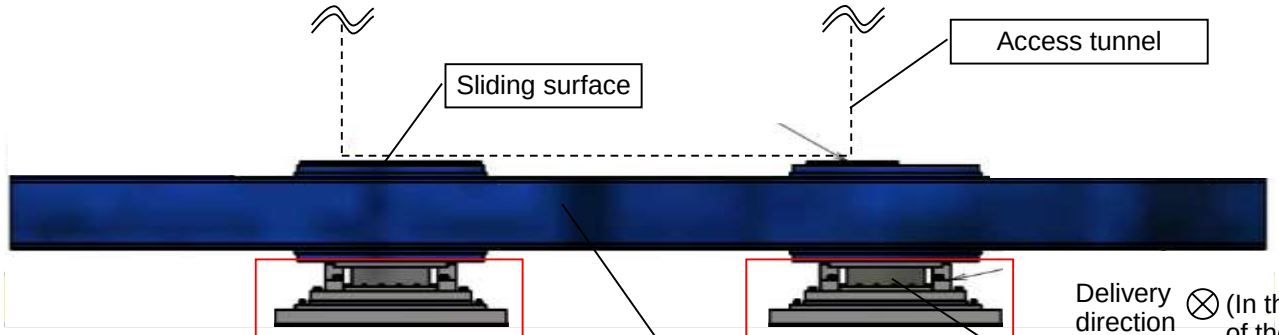
The rotation of the access tunnel was tested as well, but as it was tested using a body simulating the shape and not the mass, this time verification will be carried out by means of simulated mass.

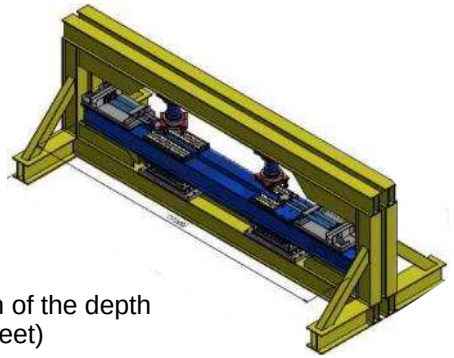
6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

[Configuration of the slide part]





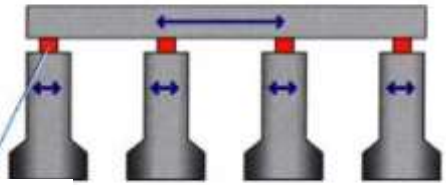
Delivery direction ⊗ (In the direction of the depth of the paper sheet)

[Usage examples of bearings]

Used for dispersing the horizontal force in the event of an earthquake to multiple lower structures of the bridge (expansion/contraction).

Rubber

Dispersion of horizontal force



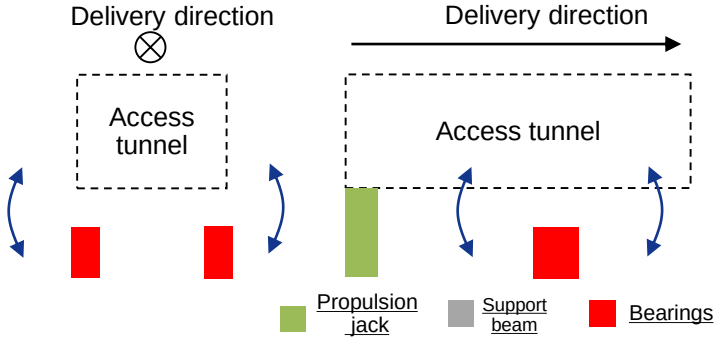
Rubber bearings for dispersion

Horizontal force dispersion structure

Rubber bearings (example of a bridge)

The technology concerning bridge bearings will be applied so that the sliding surface follows the lower surface of the access tunnel to keep the surface pressure as uniform as possible.

(Eccentric load + shift in center of gravity)



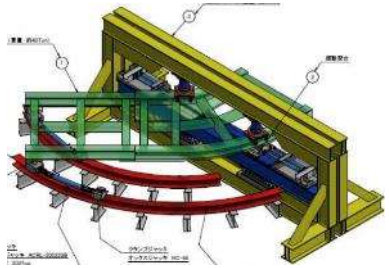
Example of access tunnel

6. Implementation Items of This Project

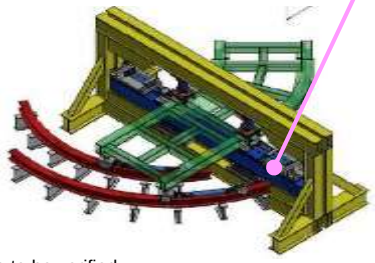
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

Implementation items of this project
Rotated 45° simulating the mass

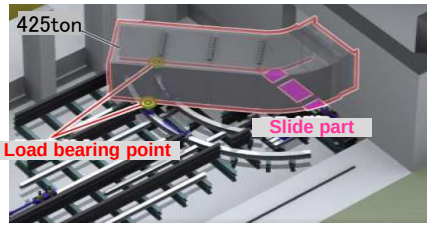


Slide part



Items to be verified

- Ability of the sliding surface to follow the tunnel body
- Sliding surface friction data
- Impact assessment of the weight and center of gravity



Slide part

[Overview of implementation details submitted a request for proposal]

・Although it is desirable to manufacture a simulated body with the mass of the actual equipment and conduct testing, simulated bodies with partial simulation will be manufactured.

・Load will be simulated by imposing a force using a jack and data related to the slide part will be acquired.

(Acquired data: Ability of the sliding surface to forl ow the tunnel body, sliding surface friction data, and impact assessment of the weight and center of gravity, etc.)

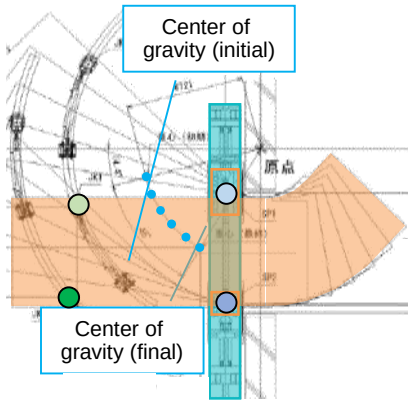
・The test conditions for load simulation will be finalized based on the following studies.

・ Change in the center of gravity along with the rotation of the access tunnel

・ Load analysis ⇒ configuration of the pushing force towards the jack

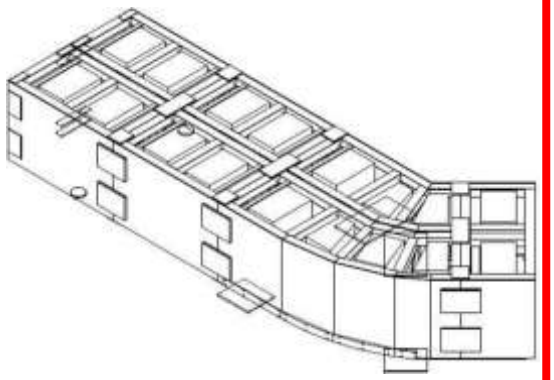
The simulated mass method is revised by incorporating the design progress and opinions of experts

→ Will be implemented based on the Actual Equipment Mass Simulation Proposal 2



Proposal 1 Pushing the center of gravity with a jack

*The shape of the actual equipment simulated body will continue to be studied.



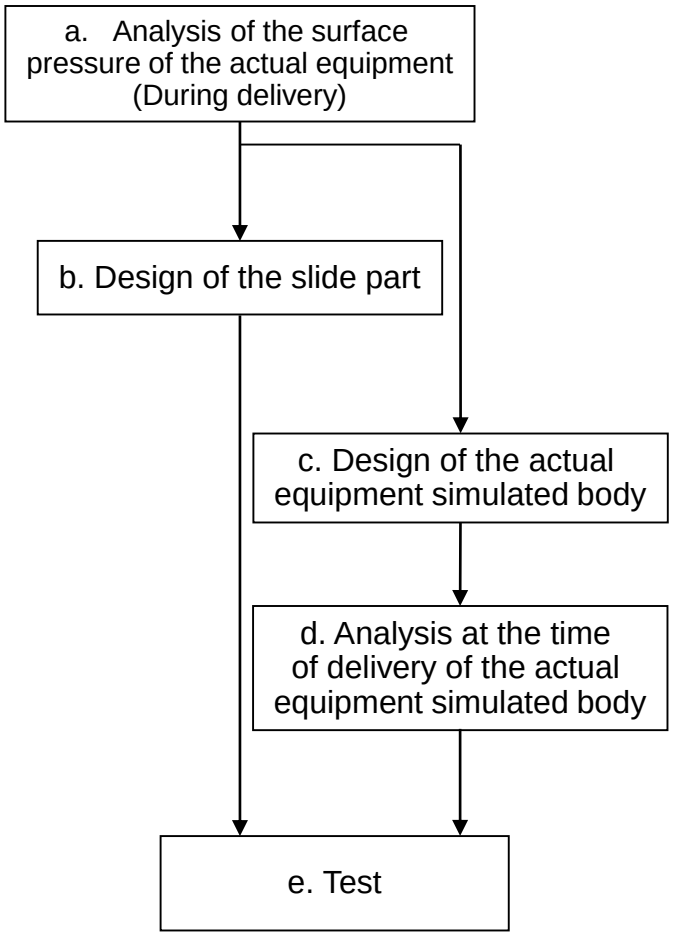
Proposal 2 Simulating the mass of the actual equipment

6. Implementation Items of This Project

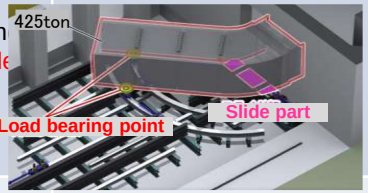
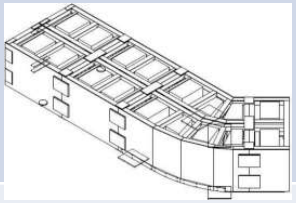
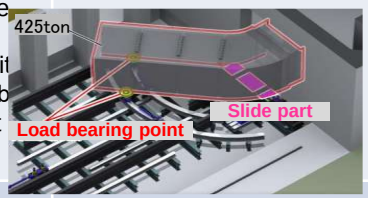
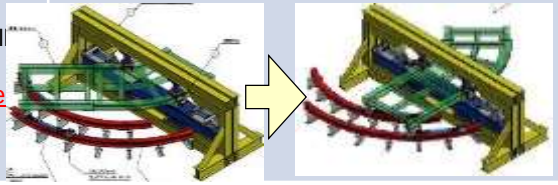
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

[Test procedures]



* Comparison with 'a' before the test and with 'e' after the test will be considered

	Details	Illustration
a.	The load (surface pressure) applied to the slide part durin delivery will be analyzed using the actual equipment mode A model of the bearing (rubber) will be made using a spring.	 Analysis: Actual equipment model
b.	The slide part structure (material, etc.) will be designed (developed) using the actual equipment analysis results. (Multiple designs will be developed and used as test parameters)	
c.	Actual equipment simulated body will be designed. (It is planned to have a simple shape as shown in the figure on the right)	
d.	The shape of the actual equipment simulated body will be analyzed. The surface pressure or deflection will be verified. It will be compared with 'a' before the test and wit 'e' after the test. (It will be made sure that validation can b carried out based on only the analysis, even if the weight changes)	 Analysis: Actual equipment simulated body
e.	Friction coefficient will be calculated based on the load conditions and the pushing force of the rotation jack. It wil be confirmed that this value is within the scope of application of the sliding surface (sliding plate), or that the rotation jack propulsive force is within the scope of its ability.	

* The image will be updated in future.

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

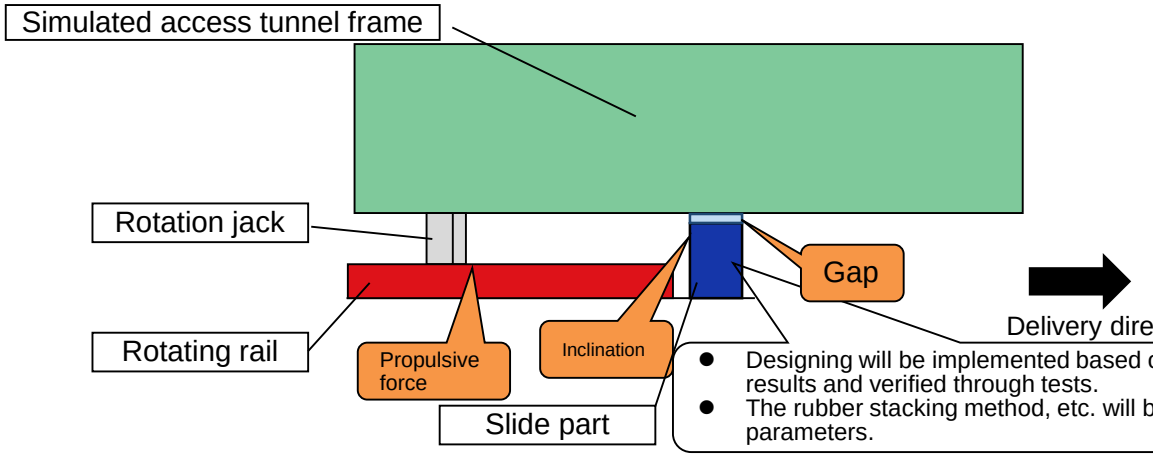
① Technology for connecting heavy structures to accessing PCV

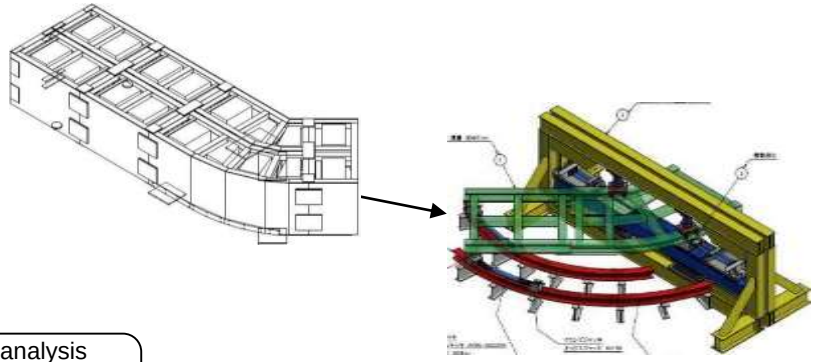
[Test plan]

Purpose of development: Applicable delivery system by using rotation jack → with surface pressure in accordance with the design → and the bearing part functioning

No.	Items	Details	Items to be monitored, measured and recorded	Criteria
1	Delivery of actual equipment simulated body	● Delivery of actual equipment simulated body will be tested. ● Will be rotated from 0 - 45° with a 5° angle movement each time.	➤Rotation jack propulsive force	Can be delivered. (Rotation jack propulsive force ≦50 ton/unit)
2	Frictional resistance of sliding surface	● The friction coefficient of the sliding surface (sliding plate) will be verified based on the rotation jack propulsive force.	➤Calculation of the friction coefficient (Comparison with the specifications)	Is within the range of specifications of the sliding surface. (Friction coefficient: 0.04 to 0.2)
3	Ability of the sliding surface to follow the tunnel body	● Measurement points will be set up, and the gap between the sliding surface and bottom plate of the simulated access tunnel frame as well as the inclination of the slide part will be measured before and after delivery.	➤Gap between the sliding surface and the access tunnel frame ➤Inclination of the slide part	—
4	Confirmation of reproducibility	● Tests will be conducted multiple times to verify whether the items to be monitored reappear.	Same as items 1 to 3 above	—

(Remarks) This plan is likely to change depending on the progress in designing.





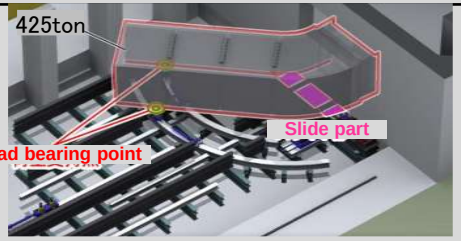
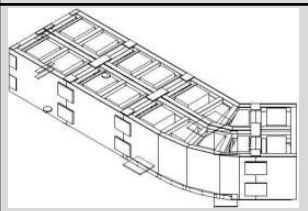
6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Technology for connecting heavy structures to accessing PCV

For development and test manufacturing

[Equipment configuration (comparison with actual equipment)]

No.	Equipment	Actual equipment specifications*	Mock-up specifications*
①	**Access tunnel body**	➢ Cross-sectional dimensions: width 4.5 x height 3.1 (m) ➢ Shielding thickness: 300 mm (base 110 mm) ➢ Rotating unit: (Access tunnel 1 to 5 units) ➢ Weight: 425 ton ➢ Sliding surface: Stainless polishing	➢ Cross-sectional dimensions: width 4.5 (m) *Height is being considered ➢ Shielding thickness: not considered (frame structure) ➢ Rotating unit: (Access tunnel 1 to 5 units) ➢ Weight: Actual equipment mass will be simulated by means of weight ➢ Sliding surface: Stainless polishing
②	**Slide part**	➢ Sliding surface: Sliding plate ➢ Allowable surface pressure: 49Mpa (500kgf/cm^2) ➢ Allowable speed: 100m/min ➢ Operating temperature: -200°C to +260°C ➢ Friction coefficient: 0.04 to 0.2	Same as actual equipment specifications
③	**Test equipment**	—	(Under examination)
④	**Delivery mechanism**	➢ Rotation jack: Capability (pushing) approx. 50 ton x 2 units ➢ Rotation jack: Stroke 1000 (mm) ➢ Vertical jack: Capability approx. 200 ton ➢ Vertical jack: Stroke approx. 230 (mm)	Same as actual equipment specifications
Illustration			 Illustration of the simulated body  Bearing part

*The actual equipment specifications and the mock-up specifications are all from the planning stage and are likely to change.

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts

[Issues]

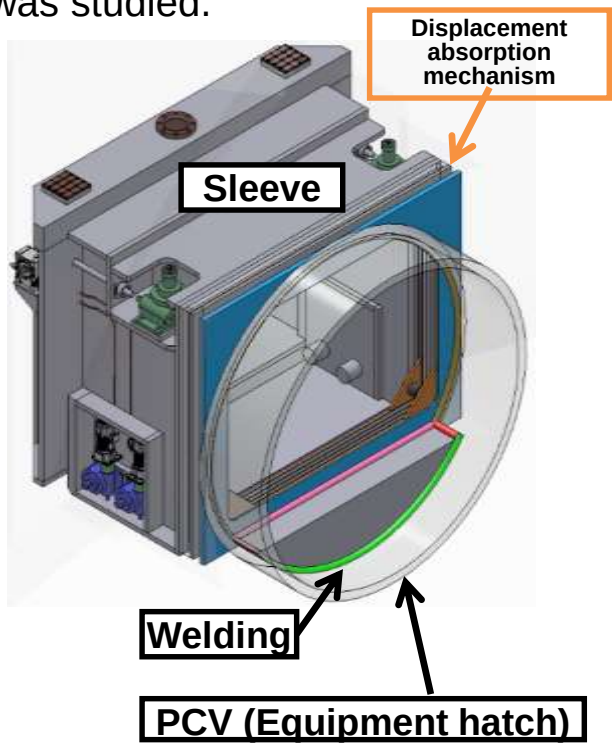
- Embodiment of the access tunnel connection part that retains the confinement function and is able to absorb the displacement in the event of an earthquake, etc.
- Feasibility verification of the displacement absorption mechanism that was studied.

[Implementation Details]

- The displacement absorption mechanism to be installed at the connection part that connects the access tunnel with the PCV, which absorbs the displacement caused in the event of an earthquake, etc. and takes the confinement function (airtight structure) into consideration, will be embodied.
- An elemental test plan required for verifying the feasibility of the displacement absorption mechanism that was studied, will be formulated.
- Elemental tests will be conducted to verify the feasibility of the displacement absorption mechanism that was studied.
  (The plan is to implement movement verification and air-tightness verification in order to verify feasibility)

[Expected outcome]

- An access tunnel connection part structure (displacement absorption mechanism) that retains the confinement function and is able to absorb the displacement in the event of an earthquake, etc. will be presented.

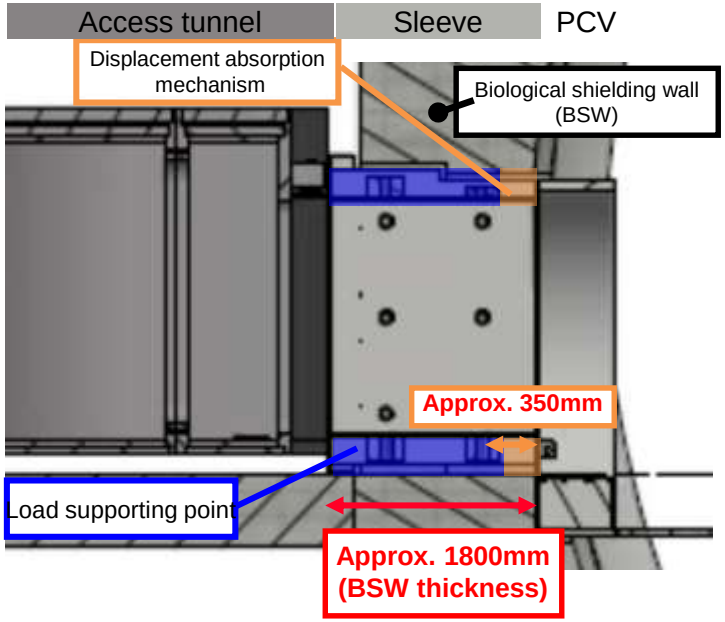


An example of the connection part structure

6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts



[Overview of the displacement absorption mechanism]

・A sleeve will be installed for connecting the PCV and access tunnel.
・As the sleeve and the tunnel are fixed and move together with the R/B as a whole in the event of an earthquake, the displacement absorption mechanism will be installed on the PCV side of the sleeve.

(A maximum of ±12.5 mm of displacement is expected*)

・As the sleeve needs to bear the load of the tunnel as well, load bearing and displacement absorption are required within the approx. 1800 mm thickness of the biological shielding wall
⇒ Considering load bearing, approx. 350 mm of this can be used for the displacement absorption mechanism.
If the displacement of ±12.5mm was to be absorbed only by means of bellows, it would require 1000 mm or more and hence a new mechanism needs to be developed.

Estimation of displacement (mm)*	
Horizontal	±12.5
Vertical	±0.2

Distance between surfaces (mm)
Approx. 350

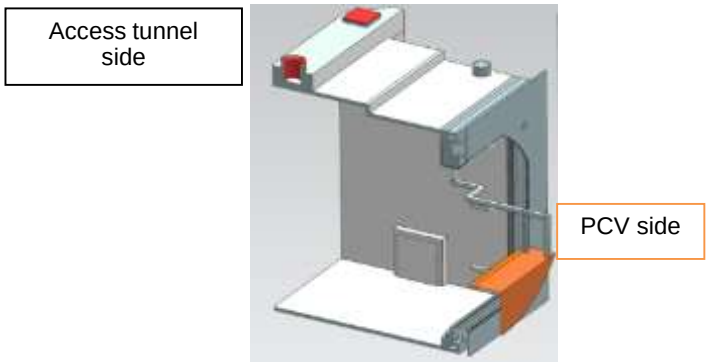


Illustration of the sleeve

The displacement absorption mechanism installation location has dimensional constraints, has high radiation levels and is narrow. Based on the results of the studies conducted as part of the FY2019 Subsidized Project, the displacement absorption mechanism, including the maintenance method after it has been installed, will be studied and test manufactured.

*Set up based on the contents of the report on Subsidy Project of Decommissioning and Contaminated Water Management in the FY2015 Supplementary Budgets "Development of Assessment Method for Seismic Resistance and Impact of Pressure Vessel and Containment Vessel" (Refueling floor additional equipment: 6100 ton, Seismic motion: 900Gal)

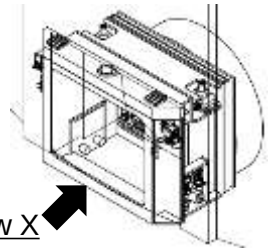
6. Implementation Items of This Project

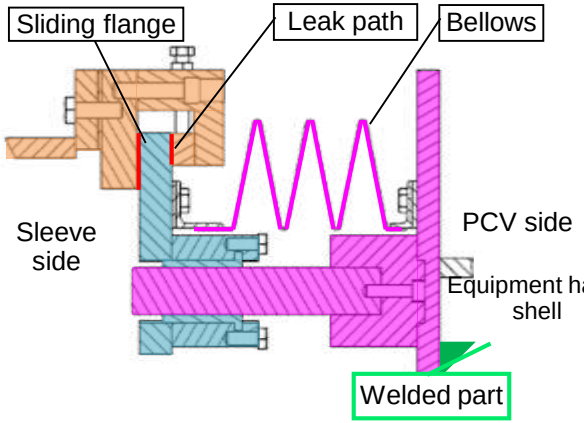
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts

[Structure of the AT sleeve]

- Displacement absorption mechanism: Absorbs displacement in the event of an earthquake
- Reaction force jack: Adjusts the reaction force after connecting the access tunnel
- Positioning jack: Adjusts the position while installing the sleeve

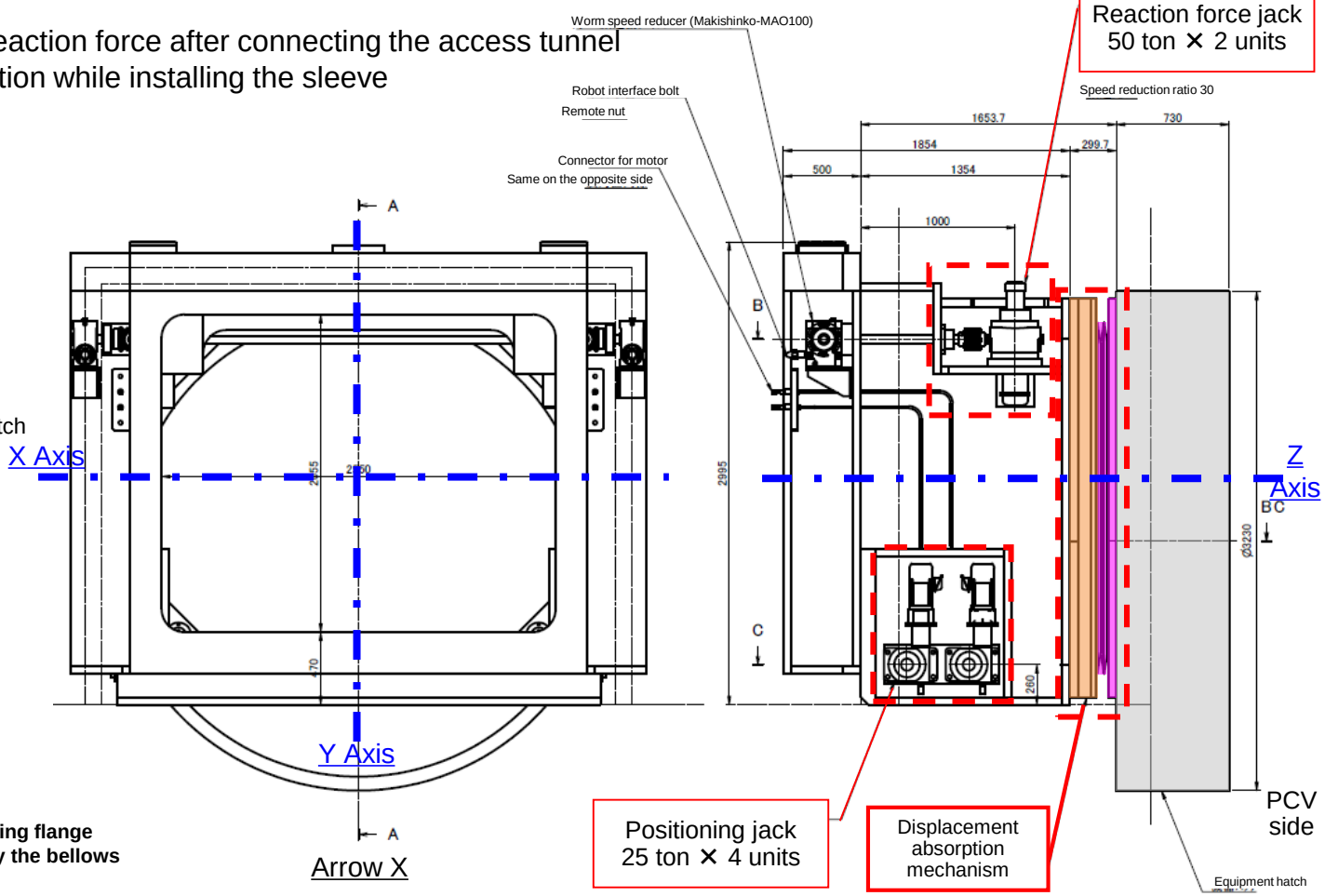




Details of the displacement absorption mechanism

Displacement plane	Response
XY	Sliding flange
YZ	Bellows
ZX	Bellows

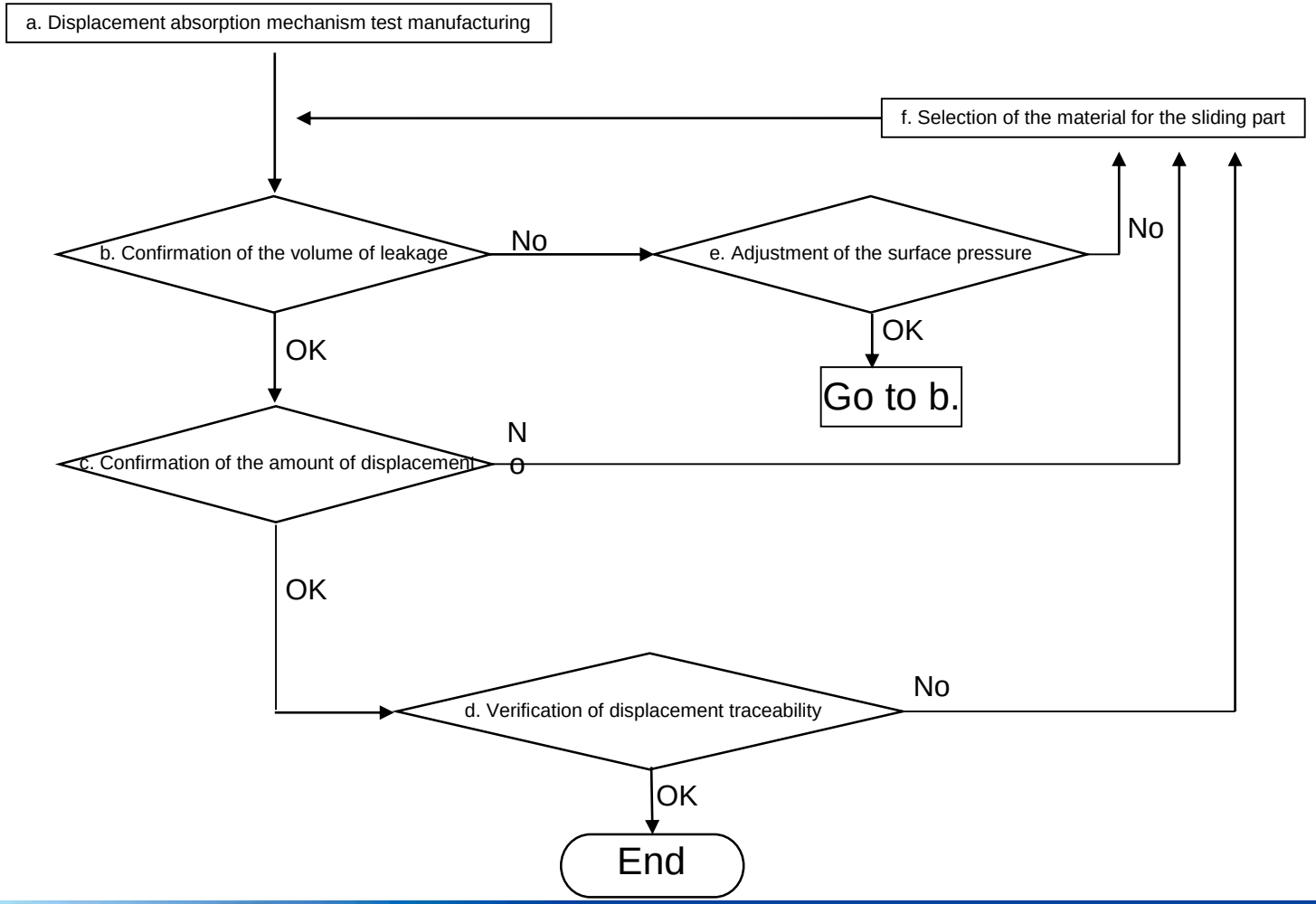
- **The displacement on the XY plane is dealt with by the sliding flange**
- **The displacement on the YZ and ZX planes is dealt with by the bellows**



2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts

[Test procedures]



6. Implementation Items of This Project

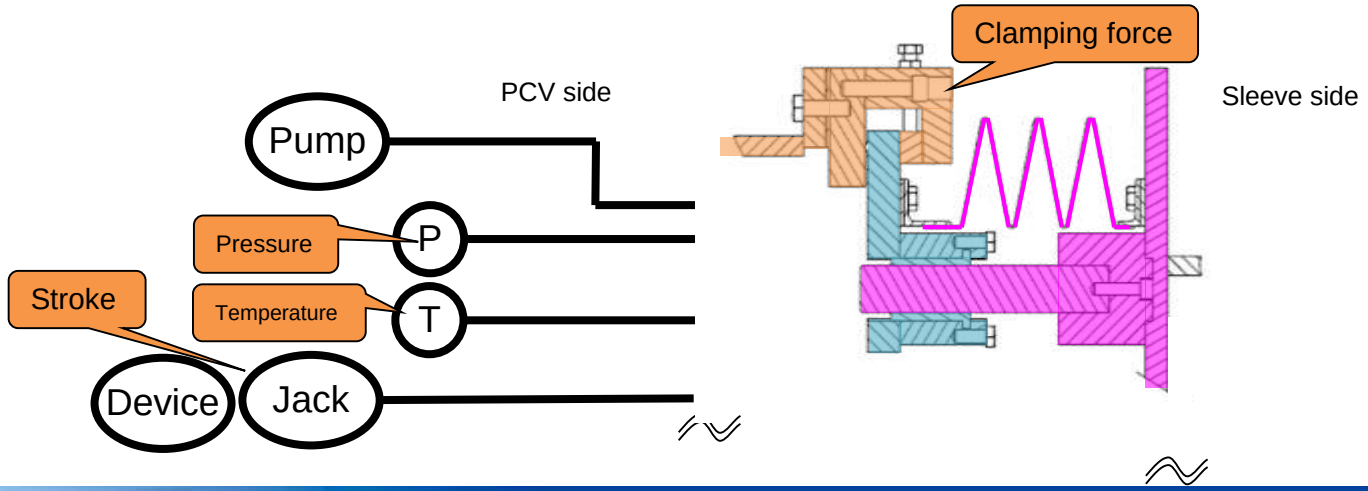
2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts

[Test plan]

No.	Items (Note)	Details	Items to be monitored, measured and recorded	Criteria
1	Volume of leakage (Test procedure (b))	● The pressure fluctuations before and after the operation of the displacement absorption mechanism shall be within the reference value.	➢ Pressure ➢ Temperature ➢ Surface pressure	Is within the prescribed range. Leak rate ○○ or less (under examination)
2	Amount of displacement (Test procedure (c))	● It will be verified whether or not the amount of displacement is met. Displacement will be brought about using a jack, etc. for verification. ● The displacement takes place in the X, Y, Z, Θ directions.	➢ The stroke of the test jack used for changing the amount of displacement	Prescribed amount of displacement is achieved. Horizontal ±12.5 mm or more Vertical ±0.2 mm or more
3	Displacement traceability (Test procedure (d))	● The displacement traceability will be verified by increasing and decreasing the assumed speed. After the operation, the leak rate will be verified. *A simple device (jack, etc.) will be used rather than an excitation device. A displacement of ±12.5 mm is assumed.	➢ Outer appearance (occurrence of damaging scratches) ➢ Sound during operation	Is within the prescribed range. Leak rate ○○ or less (under examination)

(Remarks) This plan is likely to change depending on the progress in designing.
(Note) The “Items” listed correspond to the “test procedures” mentioned on the previous slide.



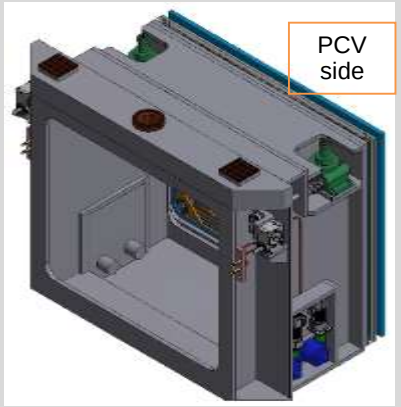
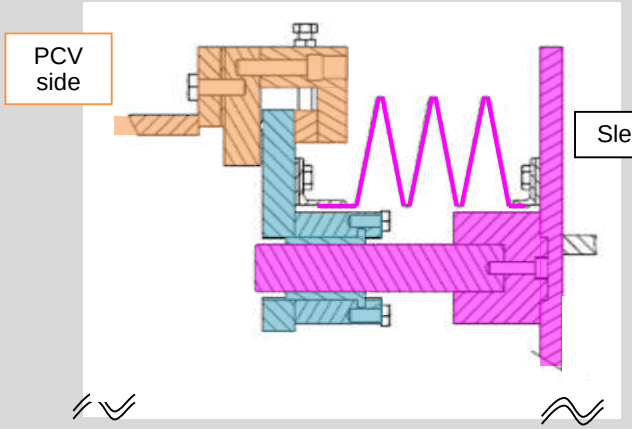
6. Implementation Items of This Project

2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

② Confinement structure for the connection parts

[Equipment configuration (comparison with actual equipment)]

For development and test manufacturing

No.	Equipment	Actual equipment specifications*	Mock-up specifications*
①	**Sleeve**	➢ Shape: W3730 × D2200 × H2995mm [mm] ➢ Weight: approx. 25 ton ➢ Reaction force jack: 50 ton x 2 units (operated by means of trapezoidal screw thread / robot) ➢ Positioning jack: 25 ton x 4 units (motor operated cylinder)	–
②	**Displacement absorption mechanism**	➢ Mechanism: Bellows (axial direction) + sliding flange ➢ Amount of displacement: horizontal 12.5 mm, vertical 0.2 mm (Note) ➢ Displacement direction: X, Y, Z, Θ ➢ Sliding flange material quality: (the outcome of this project will be reflected)	➢ Mechanism: Bellows (axial direction) + sliding flange ➢ Amount of displacement: horizontal 12.5 mm, vertical 0.2 mm (Note) ➢ Displacement direction: X, Y, Z, Θ ➢ Sliding flange material quality: under examination
Illustration		 *Sleeve included	 *Only the displacement absorption mechanism

***The actual equipment specifications and the mock-up specifications are all from the planning stage and are likely to change.**

(Note) Set up based on the contents of the report on Subsidy Project of Decommissioning and Contaminated Water Management in the FY2015 Supplementary Budgets "Development of Assessment Method for Seismic Resistance and Impact of Pressure Vessel and Containment Vessel" (Refueling floor additional equipment: 6100 ton, Seismic motion: 900Gal)

7. Summary

(1) Development of an air-tight mechanism for large transfer containers

- **The air-tight mechanism of the lid part of large transfer containers required for transferring large structures, which have a function for preventing the spread of contamination and a shielding function against high radiation items stored in them, was studied.**
- **The elemental test plan related to the air-tight mechanism of the lid part of large transfer containers is being formulated. In future, the feasibility of the mechanism will be verified through elemental tests. In addition, the criticality control method for the duration from after collection of the structures until they are stored, will be studied.**

(2) Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts

① Development of technology for connecting heavy structures to accessing PCV

- **Technology for remotely connecting the access tunnel, which is a heavy structure, to the PCV is being studied.**
- **The elemental test plan related to the technology for connecting heavy structures is being formulated. With regards to the method for simulated mass, rather than the method of imposing a force using a jack that was initially being considered, the method of manufacturing a body simulating the mass of the actual equipment is being considered. In future, the feasibility of the mechanism will be verified through elemental tests.**

② Development of the confinement structure for the connection parts

- **The displacement absorption mechanism to be installed onto the part connecting the access tunnel and the PCV is being embodied.**
- **The elemental test plan related to the displacement absorption mechanism is being formulated. In future, the feasibility of the mechanism will be verified through elemental tests.**

8. Specific goals for achieving the purpose of the project

(1) Development of an air-tight mechanism for large transfer containers	To study large transfer containers used in the top access method as containers having the function of preventing spread of contamination and the shielding function against high radiation items stored in them, and upon considering the pre-conditions for the large transfer containers and the required development items, to verify the feasibility of the technology through elemental tests related to the air-tight structure of the lid part of the large transfer containers. And, to present a criticality control method for the period from after collection of the structures until they are stored. (Target TRL at completion: Level 3)
(2)Development of technology for connecting heavy structures to accessing PCV and the confinement structure for the connection parts	① Technology for connecting heavy structures to accessing PCV To indicate the feasibility of the technology for remotely connecting heavy structures such as the new access equipment (access tunnel) to be installed in the R/B, while taking remote operation into consideration for minimizing the dose of the workers, through elemental tests. (Target TRL at completion: Level 3)
	② Confinement structure for the connection parts To indicate the feasibility of the displacement absorption structure for the part connecting the access tunnel and the existing structures such as PCV, etc., which absorbs the displacement in the event of an earthquake, while ensuring the confinement function, through elemental tests. (Target TRL at completion: Level 4)

TRL level	Explanation	Phase
TRL7	Stage at which implementation is complete.	For practical use
TRL6	Stage at which field verification is conducted.	Field verification
TRL5	Stage at which a prototype is manufactured based on the actual equipment and verified in a simulated environment at the plant, etc.	Simulated verification
TRL4	Stage at which functional tests are implemented at the test manufacturing level as a development and engineering process.	Research for practical use
TRL3	Stage at which development and engineering are being carried out by applying or combining past experiences. Or, stage at which development and engineering are being carried out based on fundamental data in domains in which there is no prior experience.	Applied research
TRL2	Stage at which development and engineering are being carried out in domains in which there is almost no applicable prior experience, and the required specifications are being defined.	Applied research
TRL1	Stage at which specific details pertaining to the development and engineering targets are clarified.	Basic research