Implementation Status of the Fukushima Daiichi Nuclear Power Station Unit 1 Primary Containment Vessel Internal Investigation (ROV-A2) (work conducted between March 14~16)

< Reference Material >
March 24, 2022
Tokyo Electric Power Company Holdings, Inc.
Fukushima Daiichi D&D Engineering Company

- In order to deliberate equipment and methods for recovering deposits from inside the primary containment vessel (hereinafter referred to as, “PCV”), internal investigations of the PCV shall be conducted to obtain information, such as the amount and origins of such deposits. Going forward, separately developed remotely operated vehicles (hereinafter referred to as, “submersible ROV”) will be used to perform a detailed visual investigation of the inside and the outside of the pedestal※1, measure the thickness of deposits, detect deposit debris, sample debris, and create 3-D maps of the deposits. In preparation for these investigations, we used submersible ROV-A to install guide rings ※2 inside the PCV between February 8~10.
  （Announced prior to February 10 ）

- In preparation for the detailed visual inspection of the outside perimeter of the pedestal using submersible ROV-A2, we leveraged the knowledge we gained through work using submersible ROV-A, such as shutting off the noise propagation line from other equipment as much as possible. And, on March 10, we turned on the power to each piece of equipment in the same order, and under the same conditions, as the actual investigation, and inserted submersible ROV-A2 into the PCV side. There were no abnormalities and each piece of equipment performed correctly.

- As preparations had been completed, submersible ROV-A2 was inserted through the X-2 penetration ※3 on March 14. In addition to checking the conditions of existing structures and the extent to which debris has been dispersed around the perimeter of the pedestal, we will also measure neutrons in order to narrow down the scope of the deposit debris detection (nuclide analysis/neutron measurement) investigation that will be conducted using submersible ROV-D.
  （Already announced on March 14）

- Between March 14~16, the conditions of existing structures in the PCV and the distribution of deposits in the area in red on slide 4 were examined. The following information was gathered.
  - ① Existing structures, such as the primary loop recirculation system (hereinafter referred to as, "PLR") (B) pipes/pump and jet deflectors ※4, and pedestal foundation, showed no visual signs of extensive damage (refer to slides 5-10).
  - ② Clump-like deposits were found at the bottom of the lead wool mats ※5 near the PLR (B) inlet valve and also near jet deflector (F) (refer to photo 3 on slide 5, and photo 2 on slide number 10).
  - ③ Deposits were found behind jet deflectors H, G, and F (suppression chamber side) (refer to slides 6, 8, and the 9).
  - ④ A continuous stream of bubbles was seen coming from the vent pipe connected to the suppression chamber behind jet deflector F (suppression chamber side) (Refer to photo 2 on slide 9).
  - ⑤ Obstructions were found near jet deflector G (refer to slides 7 and 8)
- This information shall be analyzed going forward and additional investigations of these areas may be performed as necessary using ROV's B, C, D, and E during investigations planned for the future.
- This investigation was performed after constructing boundaries※6 to prevent gases inside the PCV from leaking to the outside, and there have been no significant fluctuations in data from monitoring post or dust monitors, or with plant parameters from before the investigation to the present, so there have been no radiological impact on the surrounding environment.

- In the wake of the earthquake that occurred off the coast of Fukushima Prefecture on March 16, performance checks of equipment in the remote operations room and in the field (in front of the X-2 penetration/field headquarters) on March 17 were conducted while confirming the safety of workers, and it was verified that all equipment is operating normally.
- Furthermore, visual inspections performed using a submersible ROV on March 18 and March 22 found the water in the PCV to be murky and that the water level in the PCV is decreasing very slowly (Calculations estimate a drop of approximately 20cm between March 16~17th, and then another drop of approximately 20cm by March 22)
- In light of these circumstances, reactor cooling water was added ($3.5m^3/h \rightarrow 5.5m^3/h$) yesterday (March 23) at 12:03PM to ensure that the water level in the PCV is high enough to use the submersible ROV for further investigations.
- Furthermore, in order to reduce the exposure dose of the submersible ROV, it was temporarily removed from the inside to the outside of the PCV yesterday (March 23), and the isolation valve was closed at 3:26 PM.
- Reactor cooling water has continually been injected prior to and after the earthquake, and the cooling of fuel debris has continued without problem. Plant parameter monitoring has also confirmed that there are no abnormalities.
- Going forward, after we have confirmed that water levels in the PCV required to conduct an investigation using the submersible ROV are stable, we shall insert the submersible ROV into the PCV to examine the murkiness of the water and determine when we will be able to recommence detailed visual investigations. We will continue to prioritize safety and carefully conduct these investigations.

※1 Pedestal: Work space and platform below the primary containment vessel
※2 Guide ring: Ring installed to prevent the cables attached to the submersible ROV from getting twisted.
※3 X-2 penetration: Hole used by workers to enter the PCV
※4 Jet deflector: Disk-shaped steel material installed on the PCV side of pipes connecting the PCV and the pressure suppression chamber.
※5 Lead wool mat: Lead and lead-containing cloth used for shielding
※6 Boundary: PCV containment function

Location of the detailed visual inspection of the perimeter of the pedestal and inspection schedule

＜ Main targets of the investigation ＞

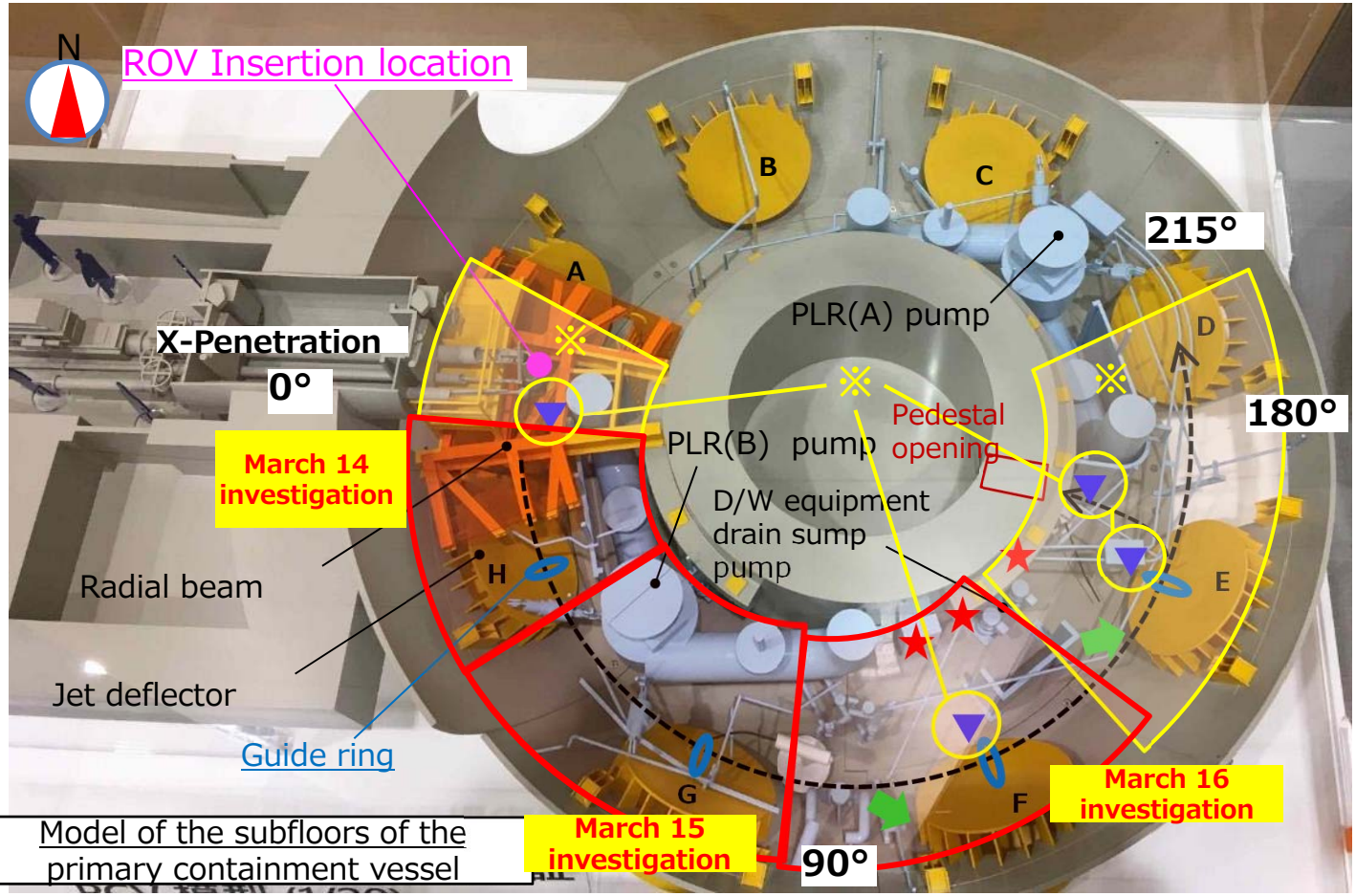
■Examine the condition of existing structures

■Examine the extent of dispersal of debris, debris height, and slope

■Examine the conditions around the pedestal opening and also the condition of the concrete wall near the pedestal opening（★Location）

■Condition of deposits around the jet deflectors（⬇Location）

■Measure neutron flux above deposits（▼ Location）

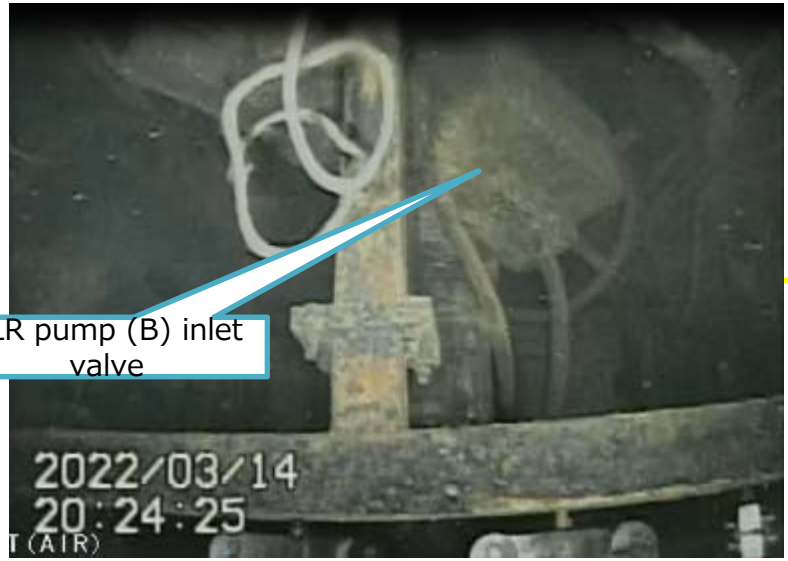


Model of the subfloors of the primary containment vessel

※Investigation schedule under revision

Source : International Research Institute for Nuclear Decommissioning (IRID)

Conditions near PLR Pump (B) and jet deflector (H) (from March 14 investigation①)



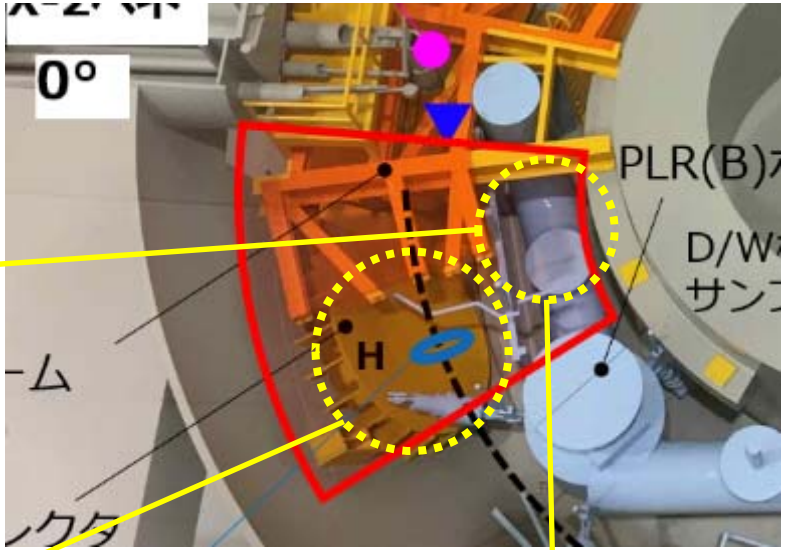


Photo 1. Conditions near the PLR pump (B) inlet valve

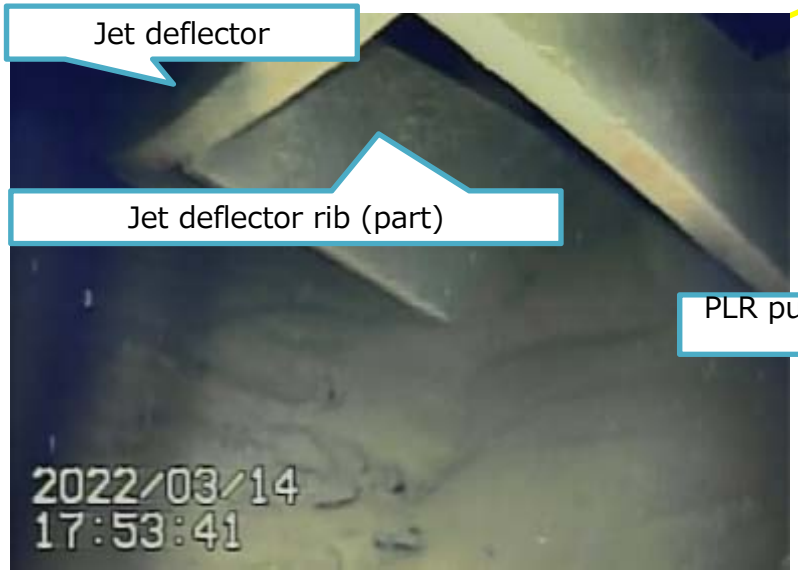


Photo 2. Conditions at bottom of jet deflector (H)

Photo 3. Conditions near PLR pump (B) inlet valve

Conditions neat jet deflector (H) (from March 14 investigation ②)

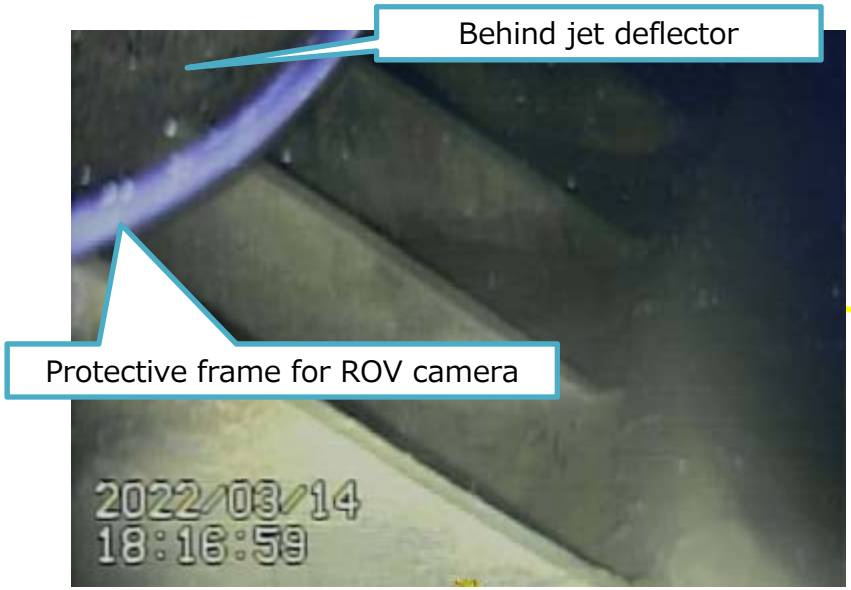


Photo 1. Conditions behind jet deflector (H) ①

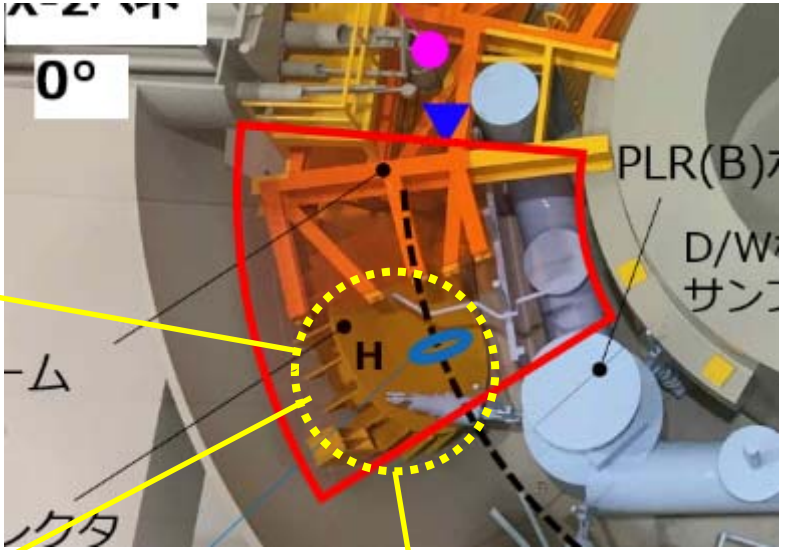


Photo 2. Conditions behind jet deflector (H) ②

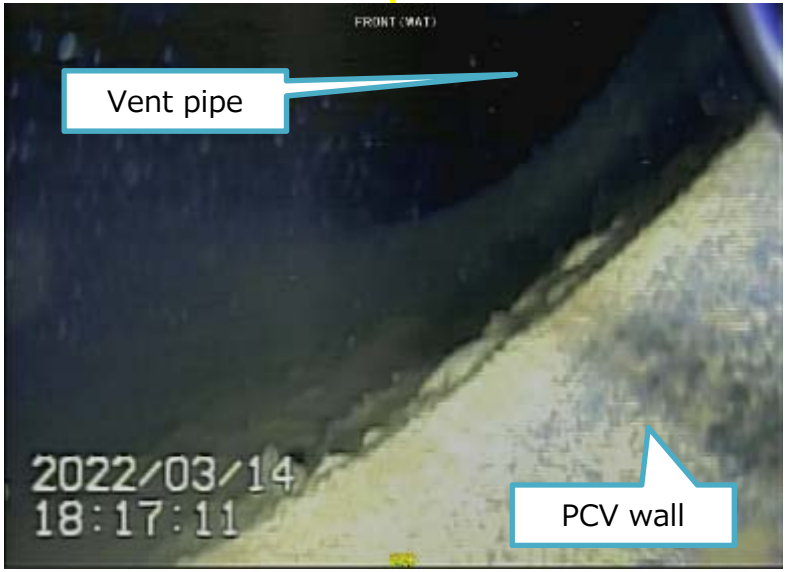


Photo 3. Conditions behind jet deflector (H) ③

Conditions near jet deflector (G) (From March 15 investigation①)

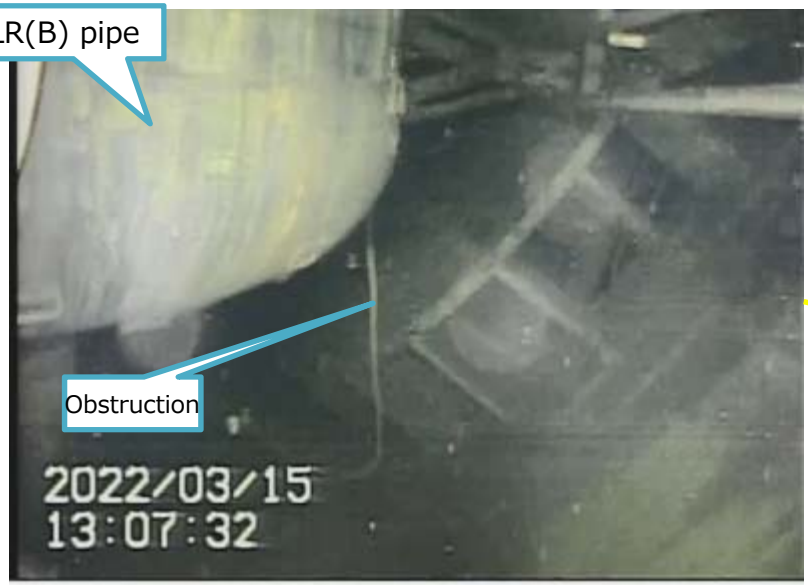


Photo 1. Looking down on jet deflector (G)

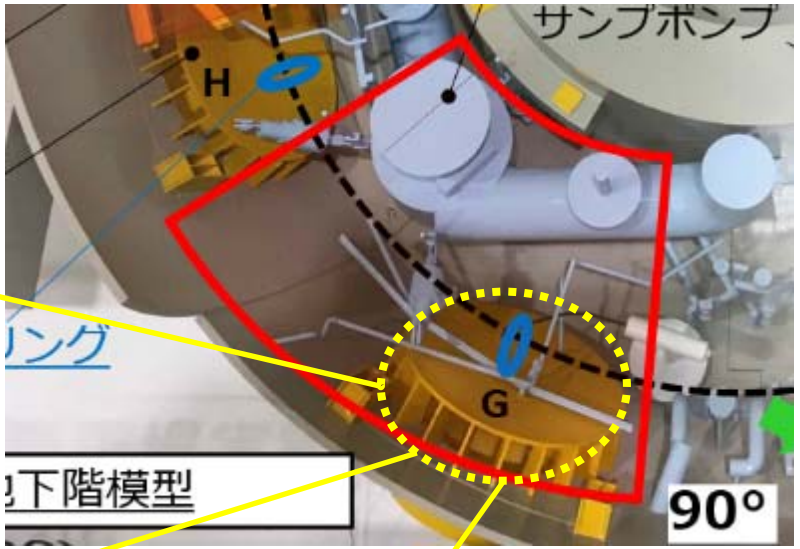
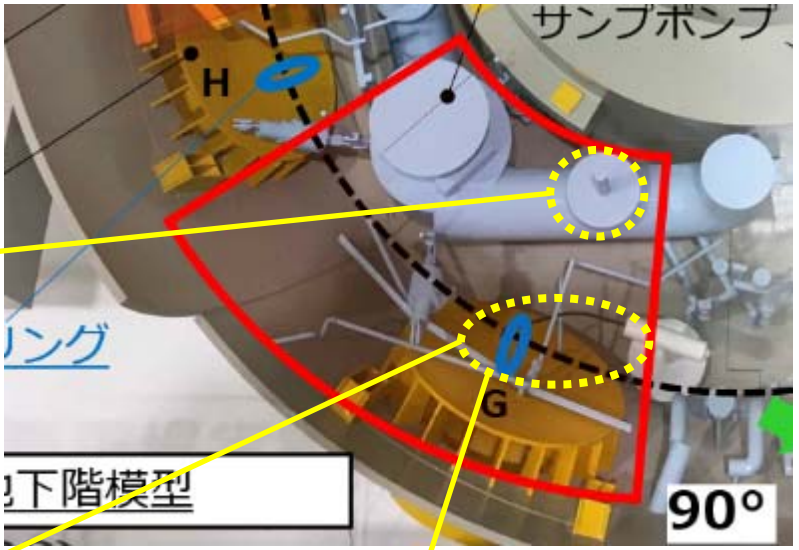


Photo 2. Conditions near jet deflector (G)

Photo 3. Conditions behind jet deflector (G)

Conditions near PLR pump (B) and jet deflector (G) (from March 15 investigation②)

Photo 1. Conditions near PLR pump (B) outlet valve



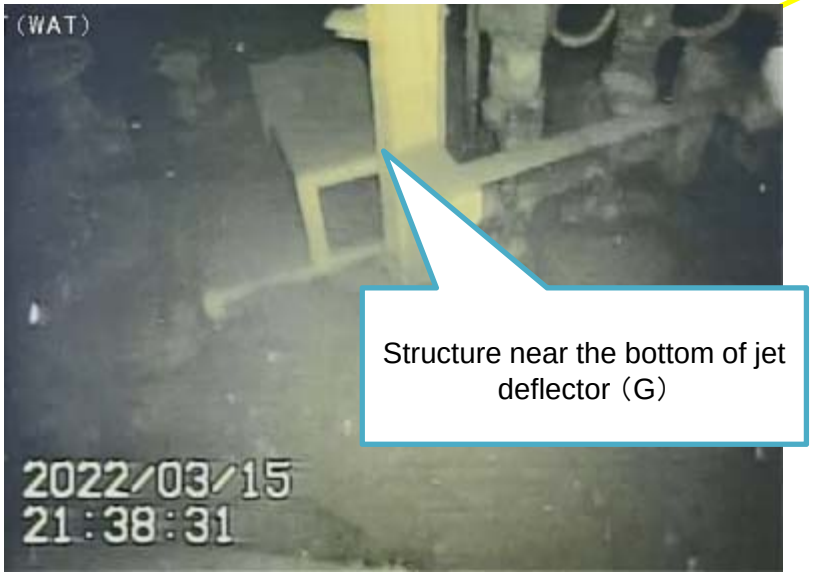


Photo 2. Conditions near the bottom of jet deflector (G)①

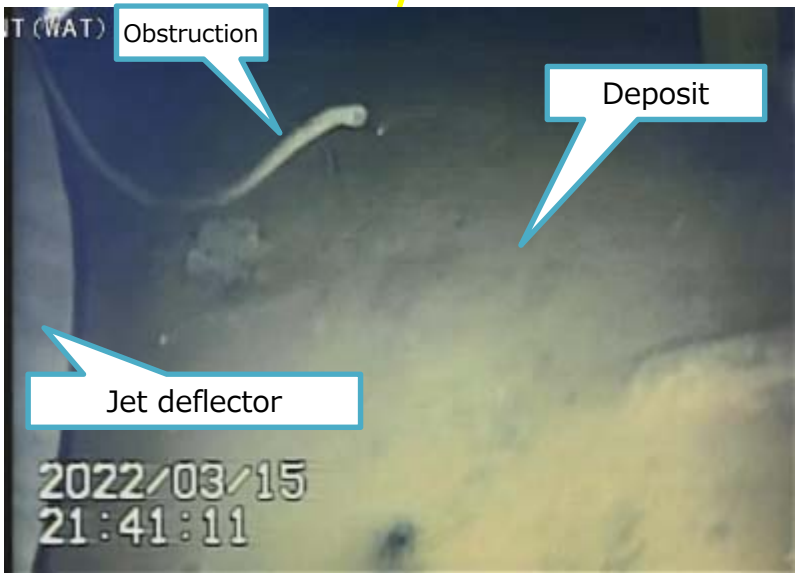


Photo 3. Conditions near the bottom of jet deflector (G) ②

Conditions near jet deflector (F) (from March 16 investigation①)

Photo 1. Looking down on jet deflector (F)

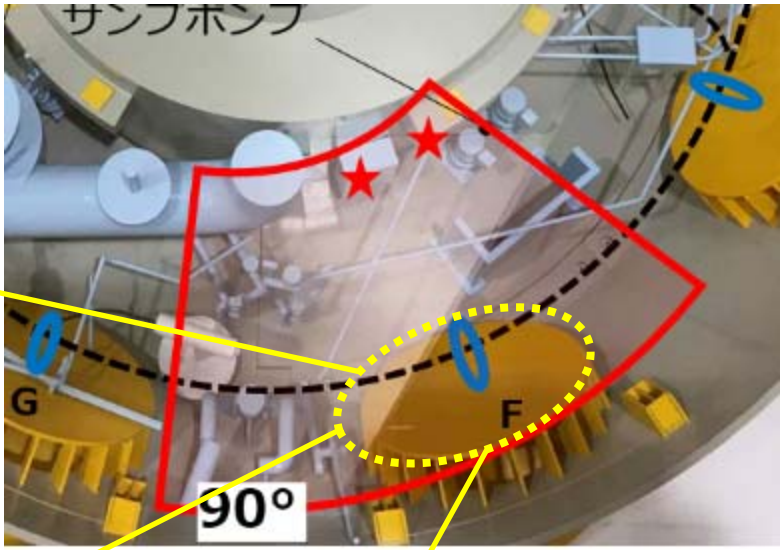


Photo 2. Conditions behind jet deflector (F) ①

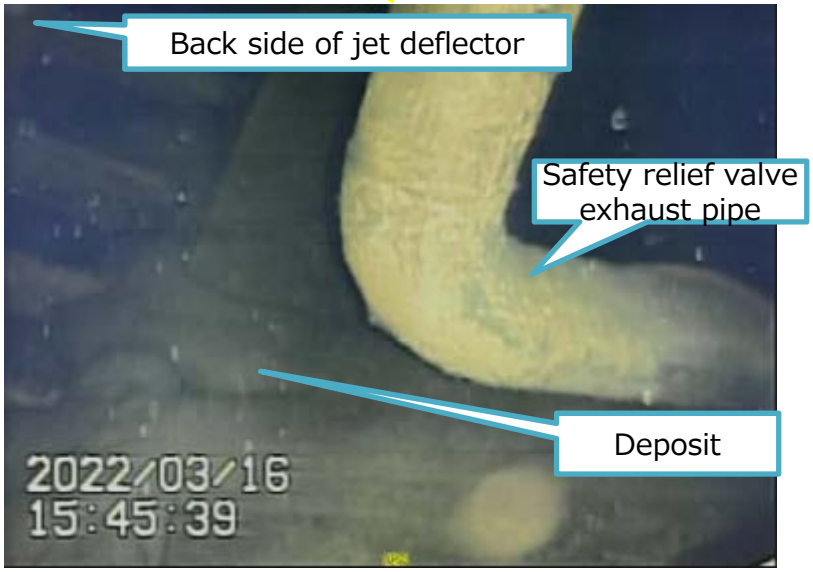


Photo 3. Conditions behind jet deflector (F) ②

Conditions near pedestal and jet deflector (F) (from March 16 investigation ②)

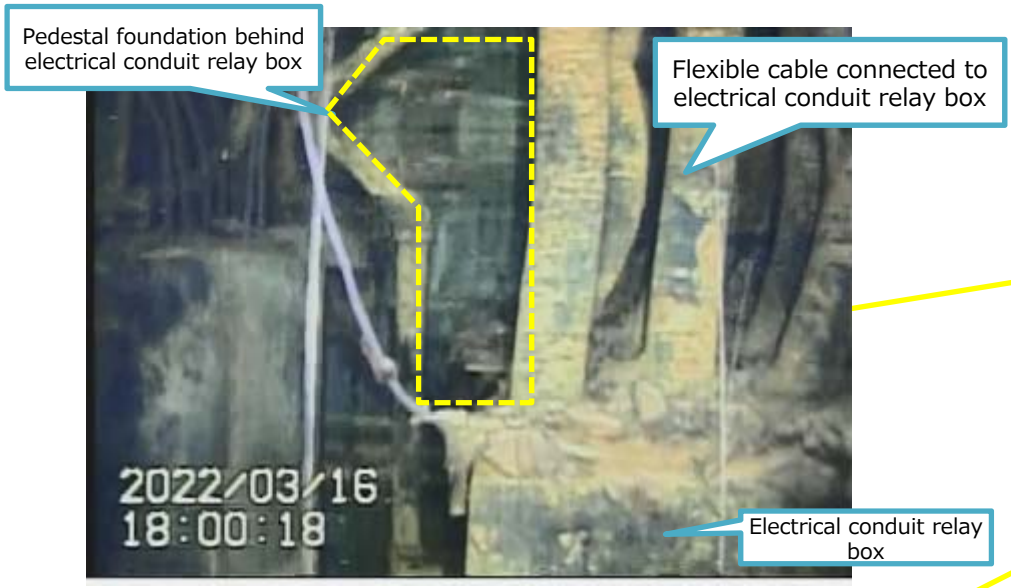


Photo 1. Conditions near pedestal foundation①

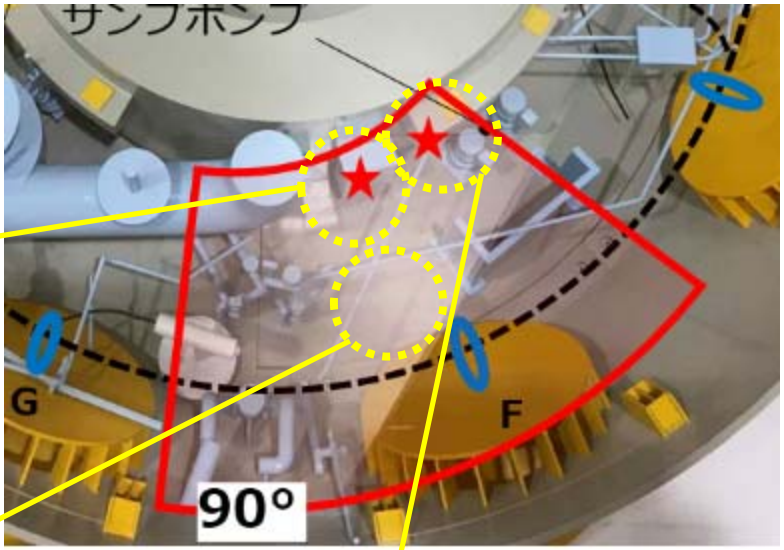


Photo 2. Conditions near jet deflector (F)

Photo 3. Conditions near pedestal foundation②

Sequence of events (March 14~16)

【March 14】

10:05 AM　PCV internal investigation preparations begin　(Power is turned on for each piece of equipment)

10:58 AM　It is confirmed that dose data built-in to the submersible ROV-A2 and the timestamp on submersible ROV camera monitors are displaying correctly

11:13 AM　**PCV internal investigation (ROV-A2) commences**　(Isolation valve on the X-2 penetration is opened)

2:36 PM　Submersible ROV-A2 arrives at the surface of the water inside the PCV

4:06 PM - 4:21 PM　Operations check of submersible ROV-A2 conducted (No abnormalities)

4:43 PM - 10:21 PM　Detailed visual investigation by submersible ROV-A2 conducted

【March 15】

9:49 AM　PCV internal investigation preparations begin　(Power is turned on for each piece of equipment)

10:53 AM – 11:19 AM　Operations check of submersible ROV-A2 conducted (No abnormalities)

11:24 AM - 10:36 PM　Detailed visual investigation by submersible ROV-A2 conducted

【March 16】

10:01 AM　PCV internal investigation preparations begin　(Power is turned on for each piece of equipment)

10:51 AM – 11:11 AM　Operations check of submersible ROV-A2 conducted (No abnormalities)

11:22 AM - 10:23 PM　Detailed visual investigation by submersible ROV-A2 conducted

Work structure (March 14~16)

■ Staff allocation

Area in front of the outside of the PCV (X-2 penetration): 6 teams each comprised of 8 people

Field headquarters: approx. 10 people mainly supervisors

Remote control room: 4 teams comprised of 4 operators each (1 team leader, 3 member operators) + approx. 18 supervisors

■ Equipment

Area in front of the outside of the PCV (X-2 penetration): R gear (i.e., Anorak, coveralls, full face mask, helmet, cotton gloves, 3 sets of rubber gloves, 3 pairs of socks, shoe covers, R shoes)

Field headquarters: Y gear (i.e., coveralls, full face mask, helmet, cotton gloves, 2 sets of rubber gloves, 2 pairs of socks, Y shoes)

■ Dose

Planned dose : 3mSv/day per person

APD set value : 1.5mSv

Actual dose (maximum value for an individual) : Gamma: 0.57mSv, Beta: 0mSv (on March 14)

Gamma: 0.12mSv, Beta: 0mSv (on March 15)

Gamma: 0.15mSv, Beta: 0mSv (on March 16)

【Reference】 Internal investigation of the Unit 1 PCV (March 14)

Photo 1. Work in the remote operations room

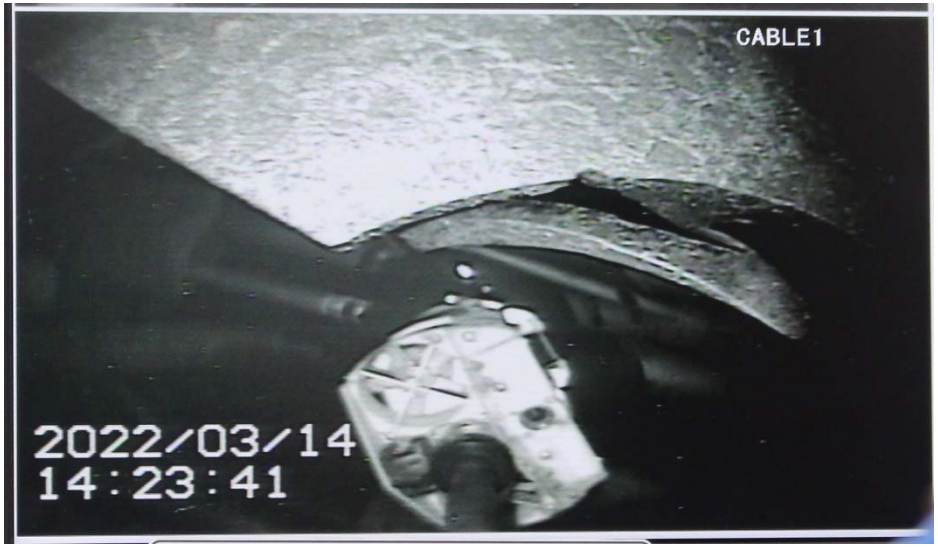


Photo 2. Lowering the submersible ROV

Photo 3. ROV arrives at the surface of the water at the bottom of the PCV

Photo 4. Conditions at the point of lowering

【Reference】
Performance checks prior to the Unit 1 PCV internal investigation

■ Date/Time
12:59 PM~8:56 PM, March 10

■ Objective
- In preparation for the Unit 1 PCV internal investigation (detailed visual inspection of the outside perimeter of the pedestal using submersible ROV-A2), submersible ROV-A2 was inserted into the area between the interior and exterior doors of the X-2 penetration upon checking the welds between the cable drum and the seal box, and also between the isolation valve and the glovebox, in order to confirm that the PCV is sealed, and it was confirmed that all pieces of equipment to be used during the investigation are operating normally.

■ Results
- Power was turned onto each piece of equipment in the same order, and under the same conditions, as the actual investigation, and it was confirmed that there are no abnormalities with equipment, such as dosimeter data and monitoring monitors, etc., and that all equipment is performing normally.
- When the B10 detector (neutron detector) was started up while in between the interior and exterior doors of the X-2 penetration in order to conduct a performance check, the detector indicated a maximum value of 10 counts per minute (cpm). Since nothing was detected outside the X-2 penetration, it is assumed that the neutron detector is working normally and that neutrons were detected. During past investigations (June 2018), no significant measurements of neutron rays around the X-2 penetration were recorded, but measurements taken this time in March 11 using rem counter, indicated 0.25μSv/h around the exterior door of the X-2 penetration. However, when measurement equipment was moved away from the door, levels fell to 0.00μSv/h so it was determined that the impact on the work environment from neutrons is extremely limited and will not affect workers or the surrounding environment.

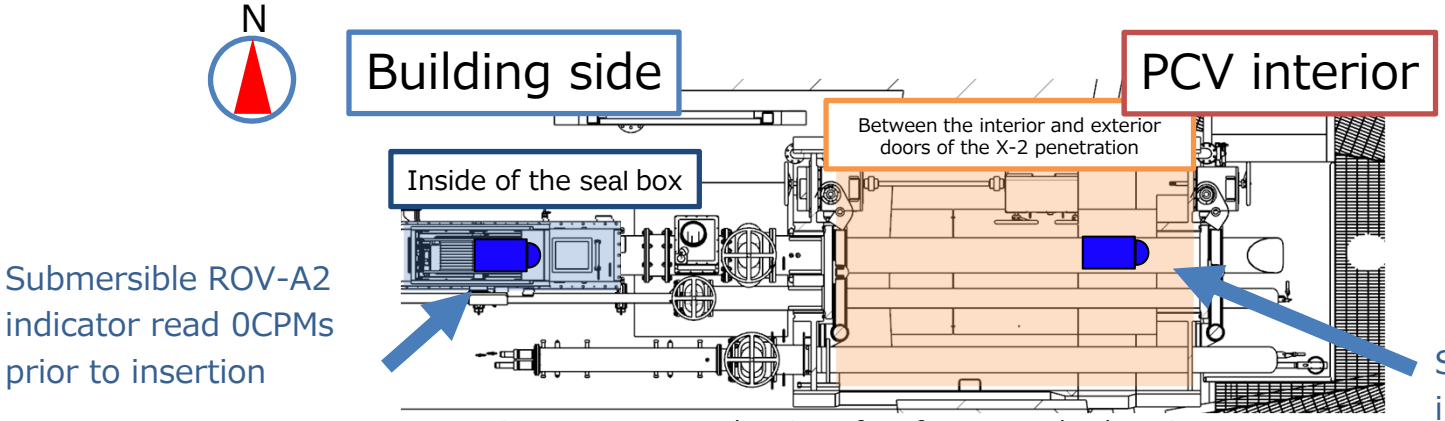


Figure. Concept a drawing of performance checks prior to PCV internal investigation

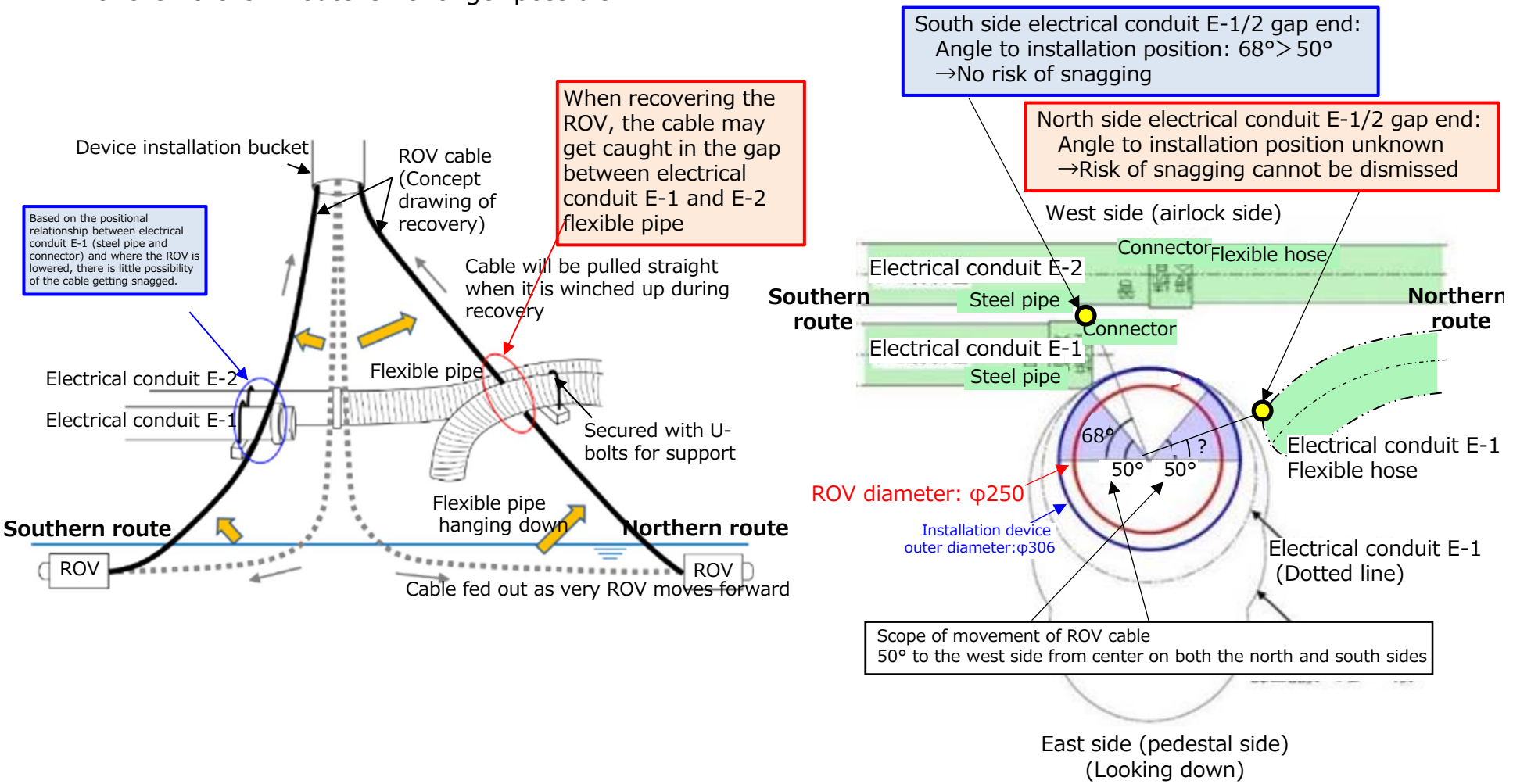
【Reference】Foreseen risks and countermeasures（1/5）

Issue	Risk	Countermeasures
PCV temperature rise	Change in cooling status of fuel debris in conjunction with the swimming movement of the submersible ROV	The investigation will be immediately terminated if overall temperatures inside the PCV start to rise
Drop in PCV pressure	When the isolation valve is opened, an abnormality with the boundary outside the isolation valve may allow gasses inside the PCV to escape into the building.	The investigation will be immediately terminated if a significant decrease in PCV pressure is seen※
Dust concentration increase	Dust concentrations may increase due to changes in the behavior of dust inside the PCV caused by the swimming motion of the submersible ROV	The investigation will be immediately terminated if significant increases in dust concentrations inside the PCV are seen
Snagging of the submersible ROV	Refer to Foreseen risks and countermeasures（2/5~5/5）	

※ When the isolation valve is open, personnel are always on standby ready to immediately close the isolation valve and quickly recover the ROV in the event of an emergency

【Reference】Foreseen risks and countermeasures（2/5）

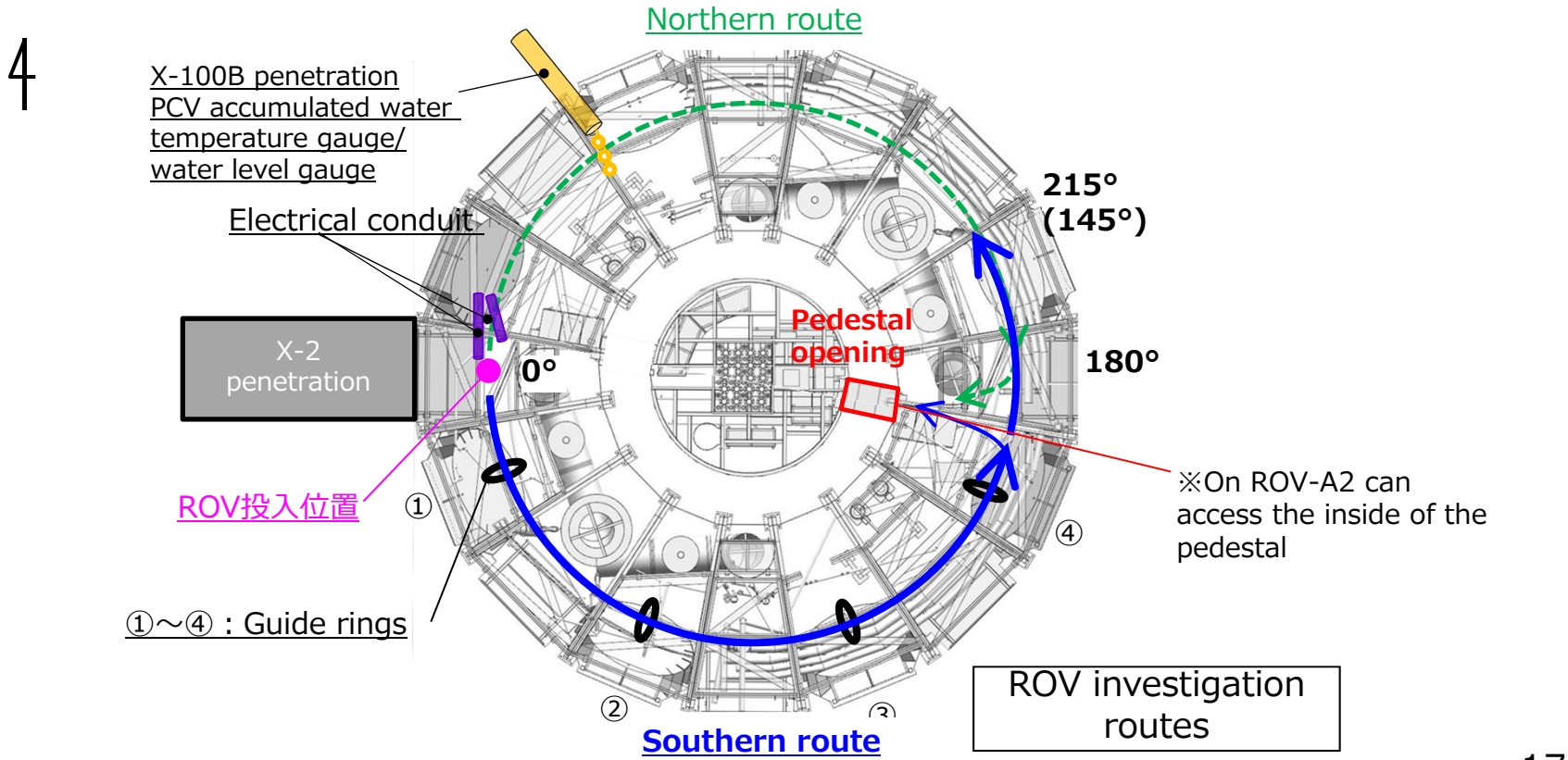
- During preparations to insert PCV internal investigation equipment, an electrical conduit that is obstructing the path was seen, and there is the risk that the submersible ROV cable will get snagged when investigating the northern route.
- If the ROV cable gets snagged, it will be impossible to recover the ROV and insert other ROV's, so investigation of the northern route is no longer possible.



Source: International Research Institute for Nuclear Decommissioning（IRID）

【Reference】Foreseen risks and countermeasures（3/5）

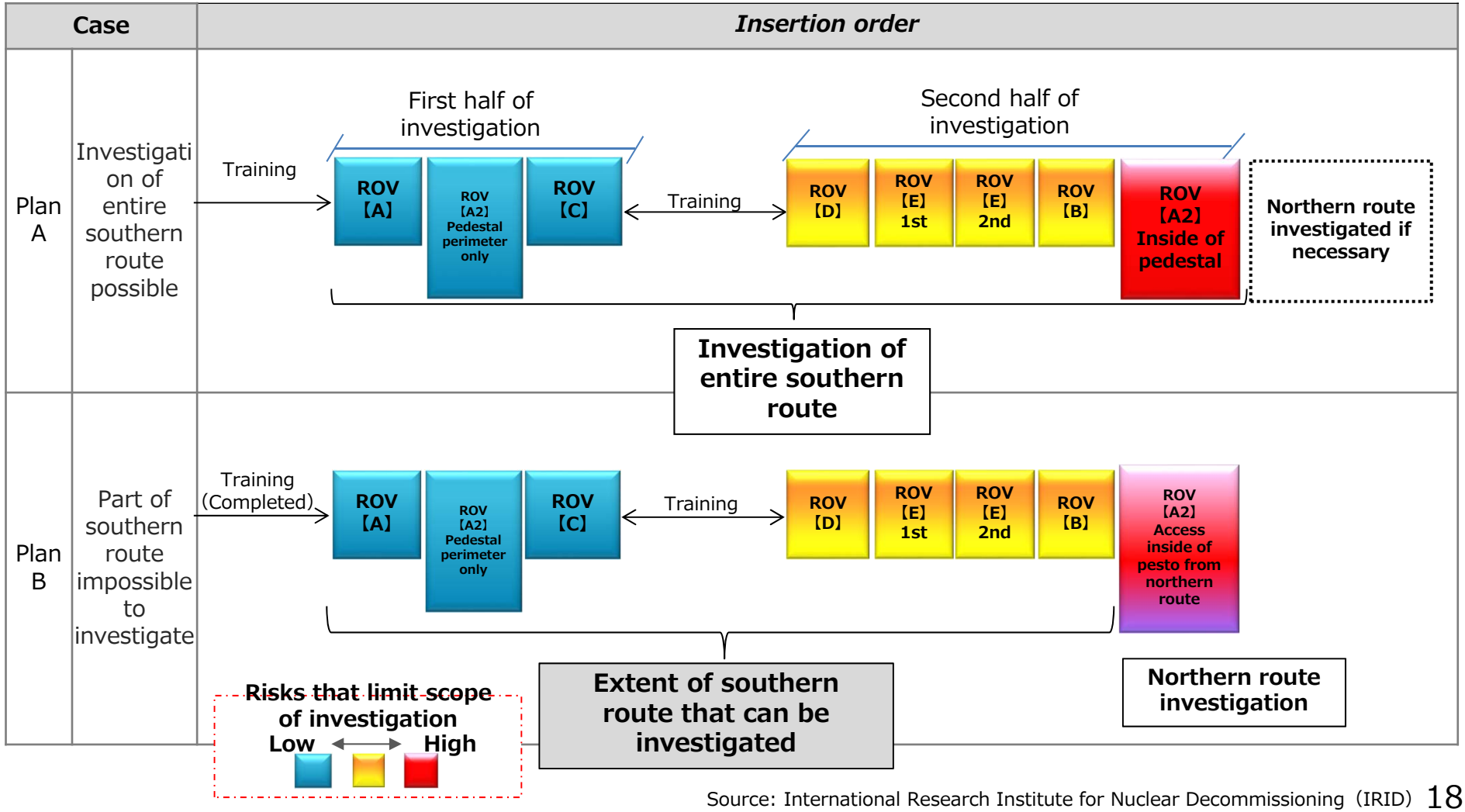
- The investigation will be performed along the southern route in order to avoid the risk of getting the ROV cable snagged on the northern route.
- The scope of the southern route investigation will be approximately 0°~215°, so if all information can be obtained, it should be analogous to the northern route.
- If the pedestal cannot be accessed from the southern route, an investigation of the inside of the pedestal (ROV-A2) will be conducted from the northern route.
- The feasibility of an investigation from the northern route shall be quickly determined as the southern route investigation is performed.



Source: International Research Institute for Nuclear Decommissioning（IRID）

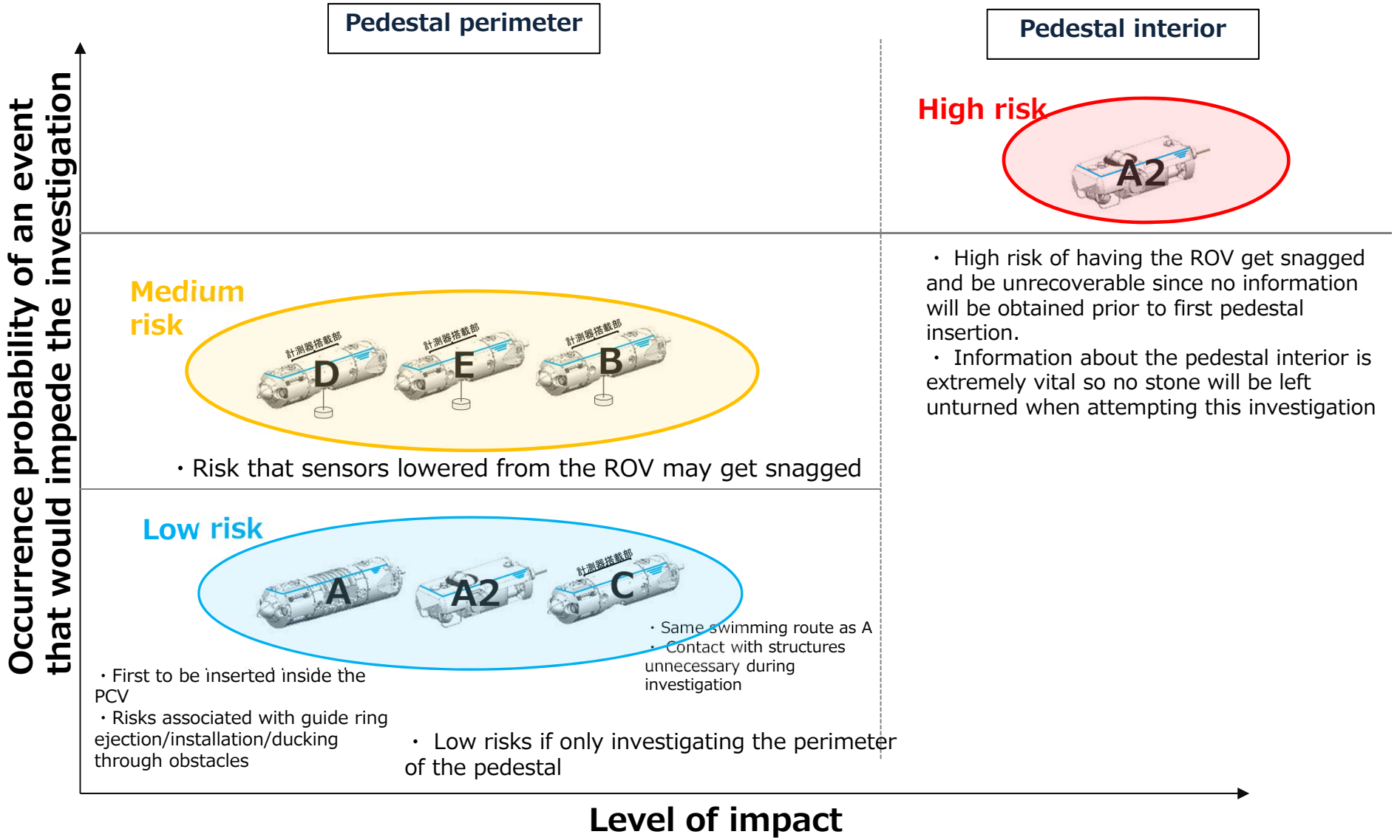
【Reference】Foreseen risks and countermeasures（4/5）

- The PCV internal investigation shall be twofold, and prior to inserting the ROV's during the first half and second half of the investigation, effective training shall be conducted in order to prevent ROV operating errors.
- Low-risk investigation equipment with limited scopes of investigation shall be inserted first in order to prioritize the acquisition of as much information as possible. (The investigation of the inside of the pedestal shall be performed last since it is the most risky)



Source: International Research Institute for Nuclear Decommissioning（IRID）

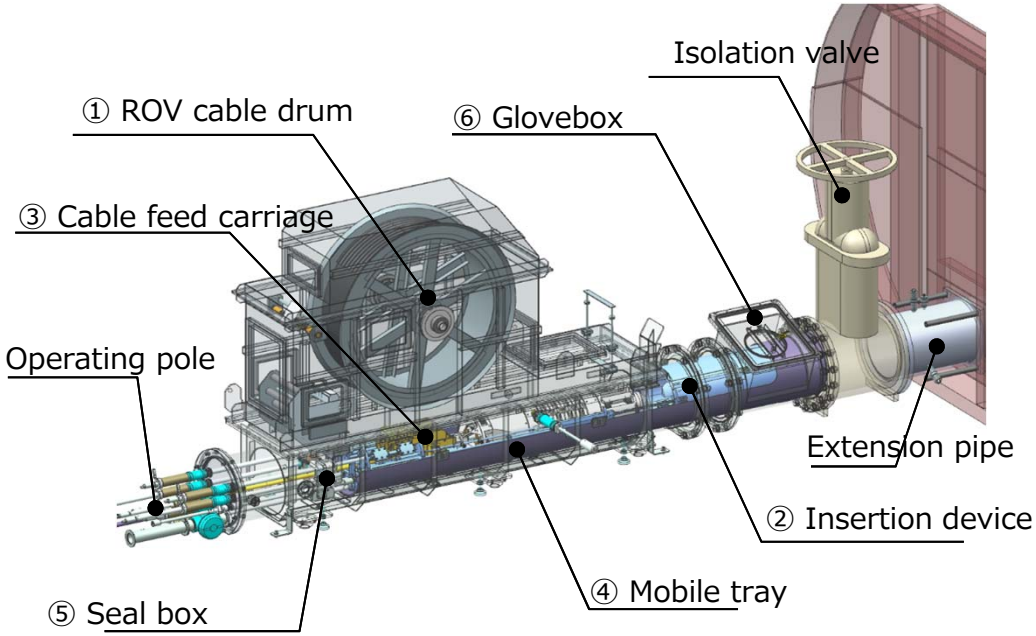
【Reference】Foreseen risks and countermeasures（5/5）

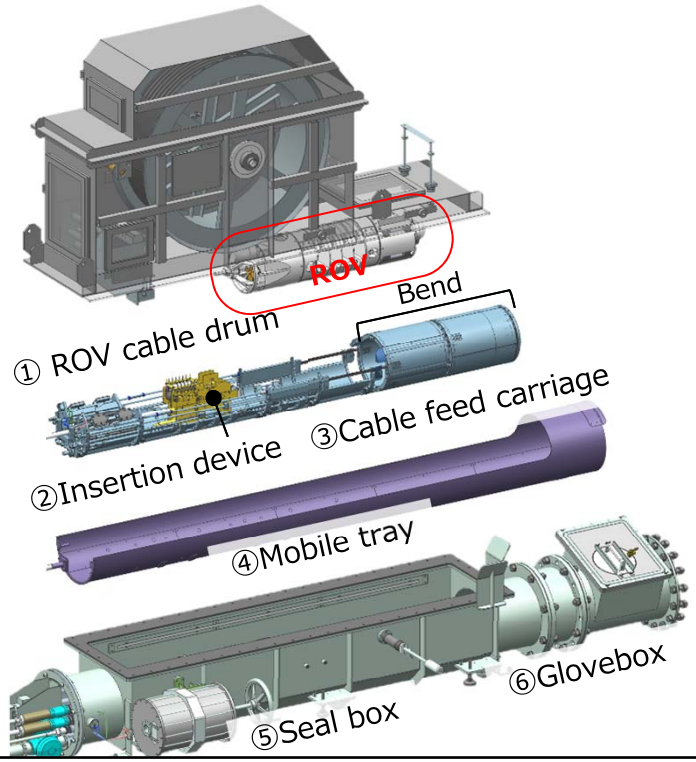


Source: International Research Institute for Nuclear Decommissioning（IRID）

【Reference】 Investigation device details
Seal box and other equipment

Inserts/extracts the ROV into/from the PCV.
Creates a PCV boundary along with the ROV cable drum.



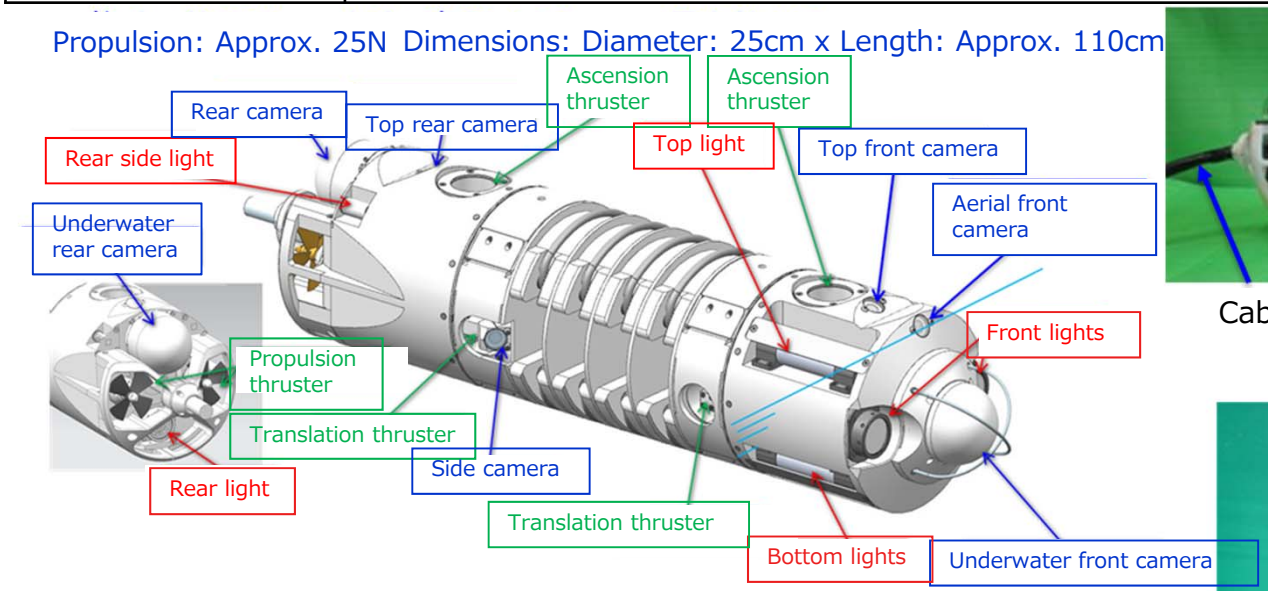


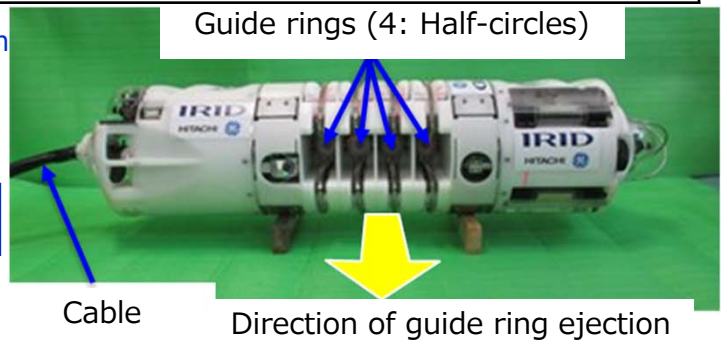
Name of component		Role
①	ROV Cable drum	Part of the ROV that feeds and retracts the ROV cable.
②	Insertion device	Inserts the ROV into the PCV via guide rings and bends to stand the ROV vertically once inside.
③	Cable feed carriage	Works in tandem with the cable drum to assist with the cable.
④	Mobile tray	Device for carrying the insertion device up to the guide pipe.
⑤	Seal box	Houses the ROV cable drum and constitutes a boundary.
⑥	Glovebox	Used to set the cable fee carriage and to cut the cable in the event of an emergency.

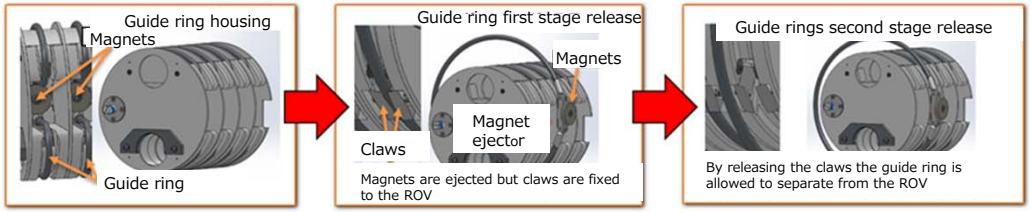
Source: International Research Institute for Nuclear Decommissioning (IRID)

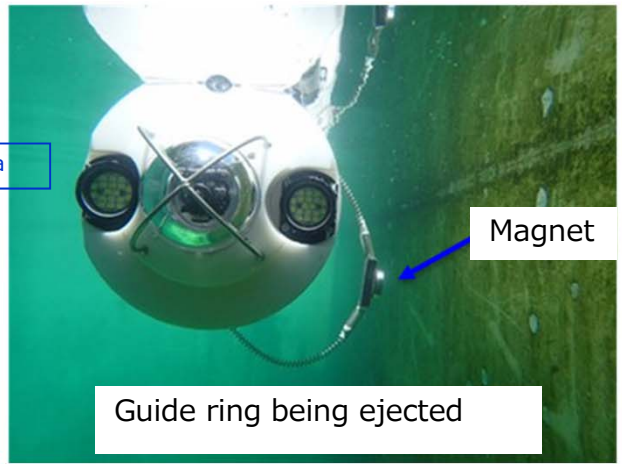
【Reference】 Investigation device details
ROV-A guide ring installation device

Investigation device	Instruments	Details
ROV-A Guide ring installation	ROV protection （Fiber-optic γ-ray dosimeter※） ※ : Same as that used for the external investigation of the pedestal	Guide rings (internal diameter: 300mm (design value)) are attached to the jet deflectors to prevent structures from interfering with the cable
	Quantity: 1 for the north and 1 for the south; Cruising time: Approx. 80 hours/unit　Since this is the first ROV to be inserted, low-friction and relatively hard polyethylene cables (φ24mm) will be employed	







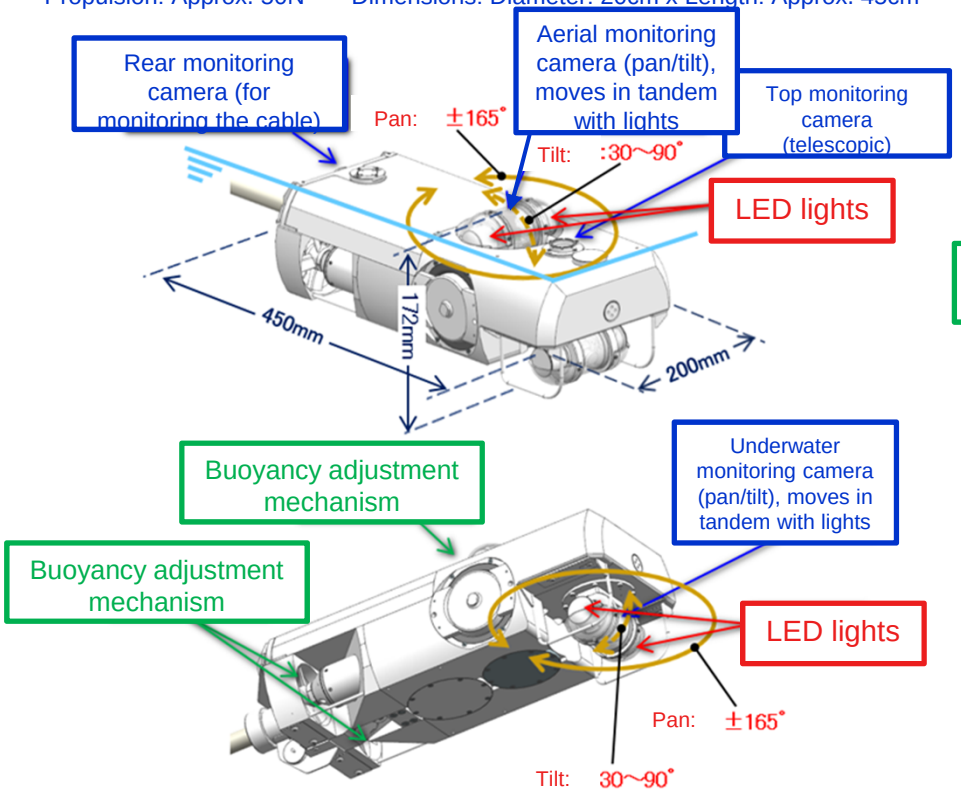


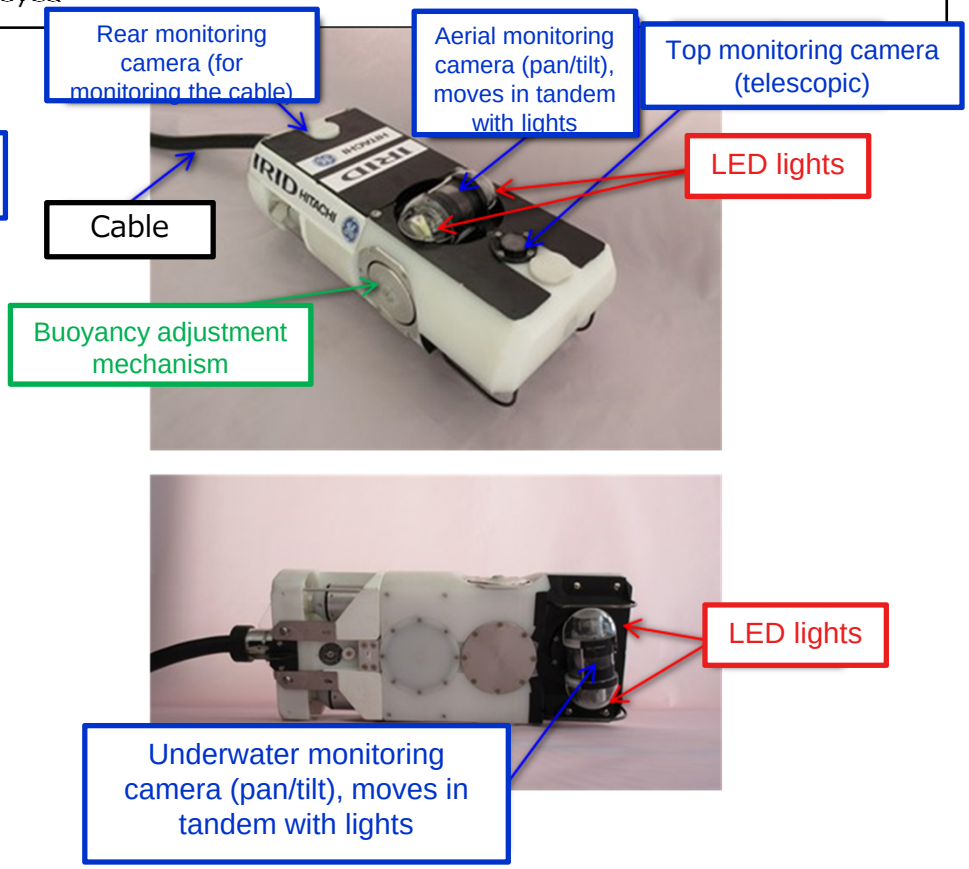
Source: International Research Institute for Nuclear Decommissioning (IRID)

【Reference】 Investigation device details
ROV-A2 For detailed visual investigation

Investigation device	Instruments	Details
ROV-A2 Detailed visual investigation	ROV protection（Fiber-optic γ-ray dosimeter※, Improved mini B10 detector) ※ : Same as that used for the external investigation of the pedestal	Uses cameras to perform a visual investigation of the extensive basement area and of the status of the detached CRD housing inside the pedestal （※） （※If it can be accessed）
	Quantity: 2 units; Cruising time: Approx. 80 hours/unit Since the units need to be agile for the investigation flexible PVC cables (φ23mm) will be employed	

Propulsion: Approx. 50N　Dimensions: Diameter: 20cm x Length: Approx. 45cm

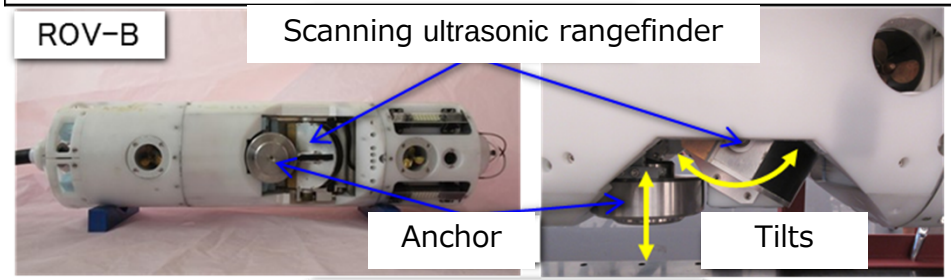


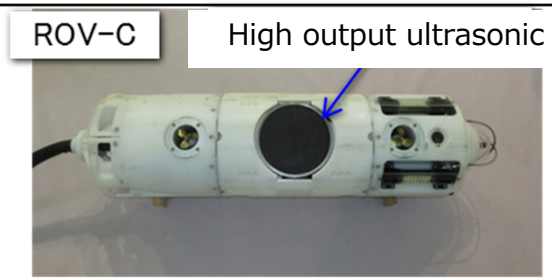


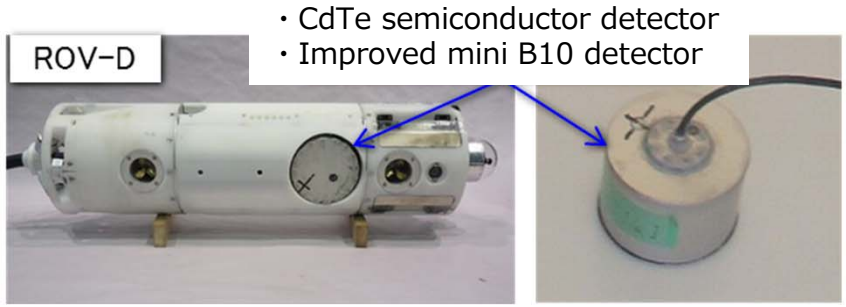
Source: International Research Institute for Nuclear Decommissioning (IRID)

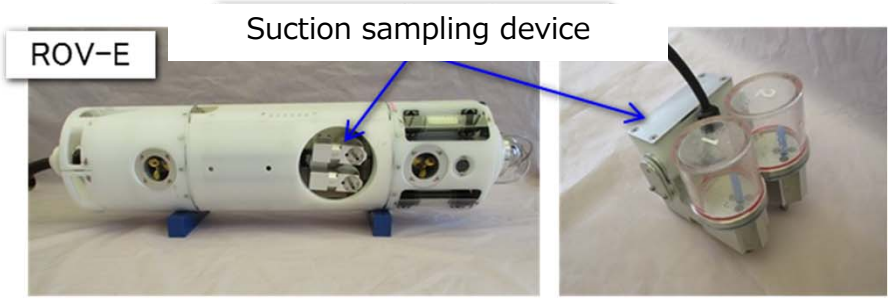
【Reference】 Investigation device details
ROV-B~E for different investigations

Investigation device	Instruments	Details
ROV-B 3-D mapping of deposits	・Scanning ultrasonic rangefinder ・Water temperature gauge	Scanning ultrasonic rangefinder used to examine the height distribution of deposits.
ROV-C Deposit thickness measurements	・High output ultrasonic sensor ・Water temperature gauge	High output ultrasonic sensor used to measure the height of deposits and examine objects underneath them in order to estimate debris height and distribution.
ROV-D Deposit debris detection	・CdTe semiconductor detector ・Improved mini B10 detector	Debris detection sensors will be dropped on the surface of the deposits to analyze nuclides and measure neutron flux in order to examine if debris exists inside the deposits.
ROV-E Deposit sampling	・Suction sampling device	The deposit sampling device will be dropped on the surface of the deposits to take samples from the surface of the deposits.
Quantity: 2 each; Cruising time: Approx. 80 hours/unit Since the units need to be agile for the investigations flexible PVC cables (ROV-B : φ33mm、ROV-C : φ30mm、ROV-D : φ30mm、ROV-E : φ30mm) will be employed		









Source: International Research Institute for Nuclear Decommissioning (IRID)