Fukushima Daiichi Nuclear Power Station
Unit 3 PCV Internal Investigation
(non-submerged area) using Micro-drones

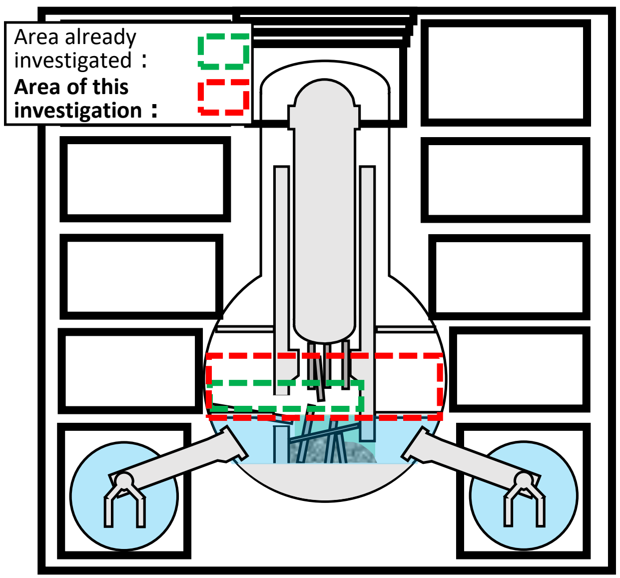
February 26, 2026

TEPCO

Tokyo Electric Power Company Holdings, Inc.

1. Summary

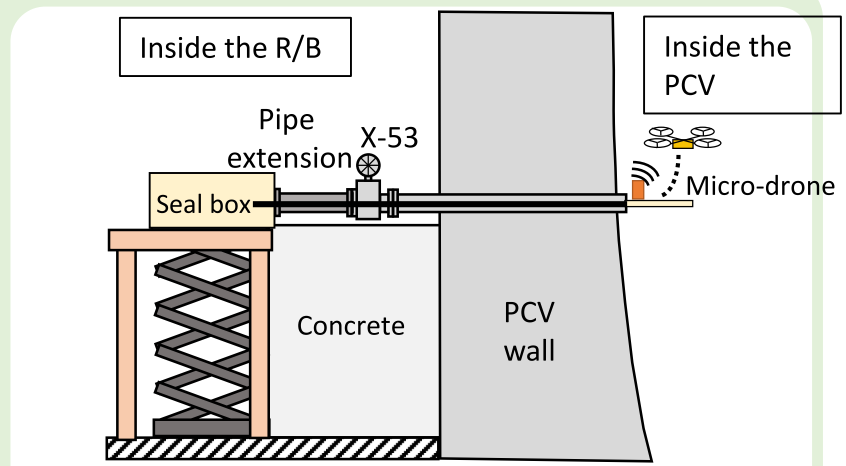
- In July 2025 we announced that we were deliberating design plans for the retrieval of fuel debris from Unit 3, and **that more information needs to be gathered about the inside of the PCV as we prepare for full-scale debris retrieval**.
- However, the water level inside the PCV has remained high since the accident and the penetrations we can use are limited with the **small X-53 penetration (Diameter: Approximately 140mm) being the only penetration currently available for access.**
- Therefore, the investigation devices that have proved successful at other units cannot be used and a new larger diameter access route must be constructed. However, this would require time so **our current plan is to conduct a PCV internal investigation using a small "micro-drone."**
- During this investigation, we plan to investigate the **as of yet unexamined first floor of the D/W and also perform a more meticulous investigation of the inside of the pedestal** that was investigated in 2017 using a submersible ROV.



Cross-sectional diagram of the Unit 3 PCV internal investigation area

Micro-drone

Use: Photography (2.7K)
Dimensions: 130×120×40[mm]
Weight:95[g](Including battery)
Flight time: Approx. 13min. (Investigation is planned to take 10min.)

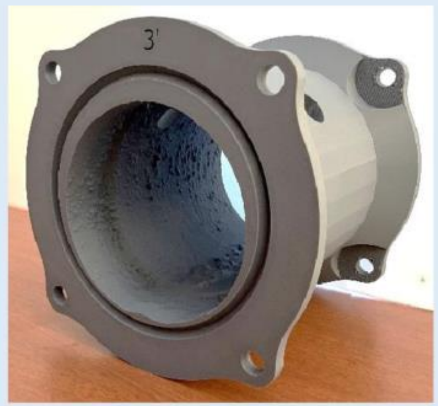


Inserted through the small X-53 penetration (Diameter: Approximately 140mm)

Concept diagram of Unit 3 micro-drone investigation

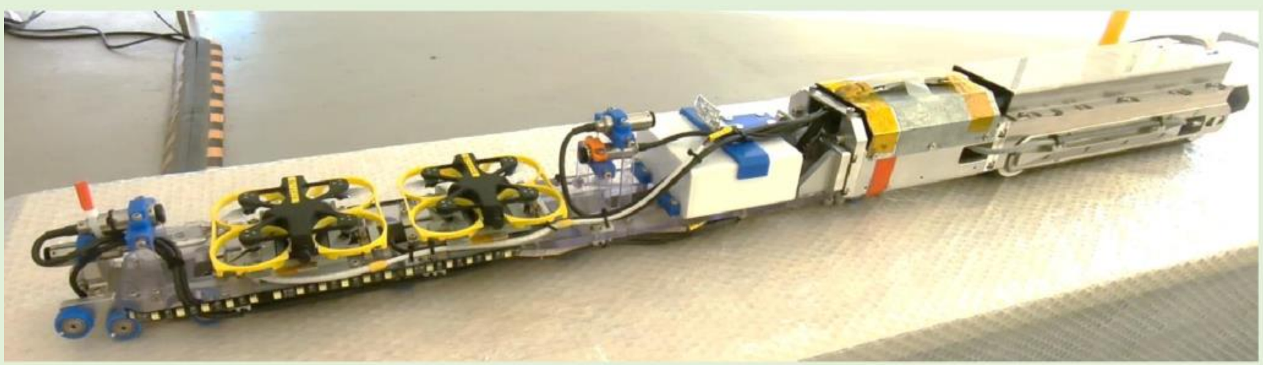
2. The insertion device running tests

- **Running tests of the insertion device were conducted at the off-site mock-up equipment** in order to investigate the reason why the insertion device failed to move forward.
- During this test, we utilized an “insertion pipe model” that simulates the misalignment between the isolation valve connection pipe and the X-53 penetration, which was identified during the insertion piping inspection conducted last December.
- We operated an “insertion device model” with specifications largely equivalent to those of the actual unit through the interior of the installation piping model, and examined the reproduction of the event as well as its potential causes.



New insertion pipe models (Left: acrylic, Right: 3D-printed)

- Two types of insertion pipe models were made, one from acrylic and the other 3D-printed. (Capable of simulating steps, misalignment, etc.)
- Since the acrylic model is transparent piping, the condition of the insertion device during operation can be visually checked. It is primarily used to verify the overall posture of the device and the status of the crawlers.
- Since the 3D-printed model is produced directly from point cloud data of the insertion piping, it can closely replicate the actual internal geometry (including uneven surfaces) of the piping. It is used to examine whether or not the device is catching on anything inside the pipe.



Insertion device model

・The weight, center of gravity, shape, material, size and motor source were replicated (Radio functions were not included since this was not needed for the running tests).

・The methods for wrapping and securing the cables and the location for securing the cables were also replicated to see if any of these were causing the device to snag.

・Since the camera on the front has the same field of view as the actual unit, it allows for comparison with the video footage from when the device was unable to move forward.

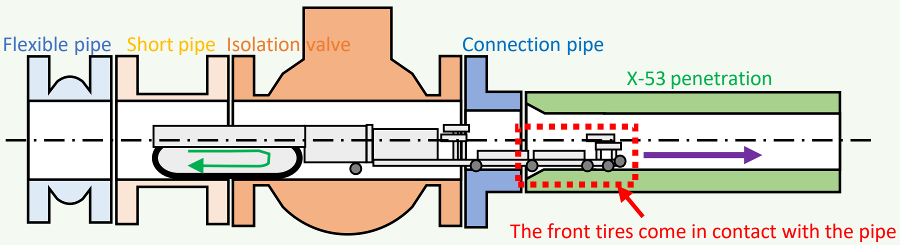
3. Mechanism that prevented the insertion device from moving forward

TEPCO

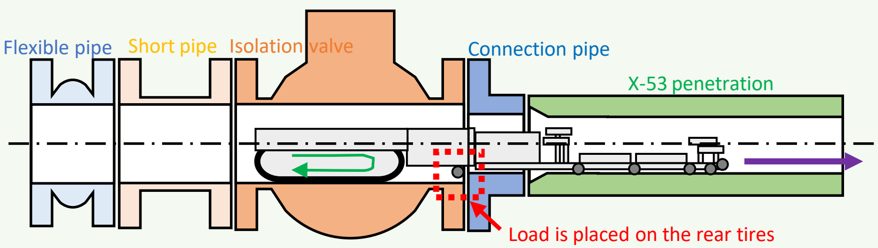
- The results of the insertion device running tests showed that when the connection pipe and the X-53 penetration are misaligned**, the middle tires of the device get caught on the step between the isolation valve and the connection pipe**.
- **This step between the isolation valve and the connection pipe is caused by a difference in the inner diameters of both pipes and we have confirmed that when the connection pipe and the X-53 penetration are aligned correctly, the device can move past this point without issue.**
- However, when there is misalignment between the connection pipe and the X-53 penetration as in the actual insertion pipe, **the front of the insertion device becomes cantilevered** when it reaches the X-53 penetration. As a result, **the load concentrates on the middle tires, preventing the device from overcoming the step and causing it to become caught**. This is considered to have been the cause of the event.

When the connection pipe and X-53 penetration are aligned correctly

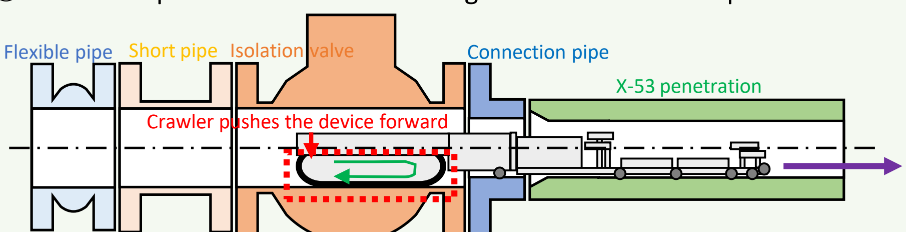
①： Front of the device moves into the X-53 penetration



②： Middle tires hit the aforementioned step

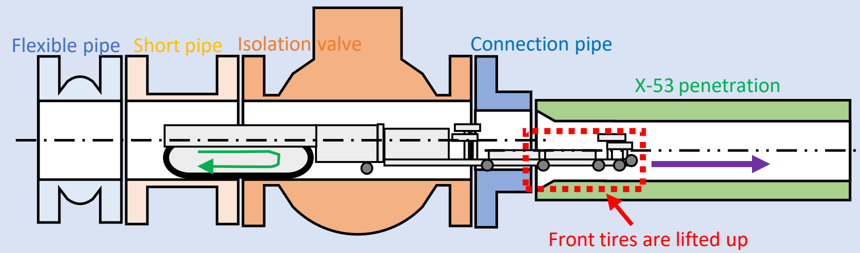


③： Crawler pushes the device enabling it to traverse the step

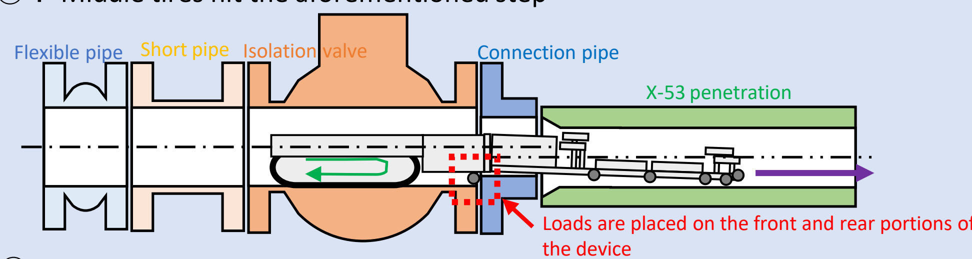


When the connection pipe and X53 penetration are misaligned

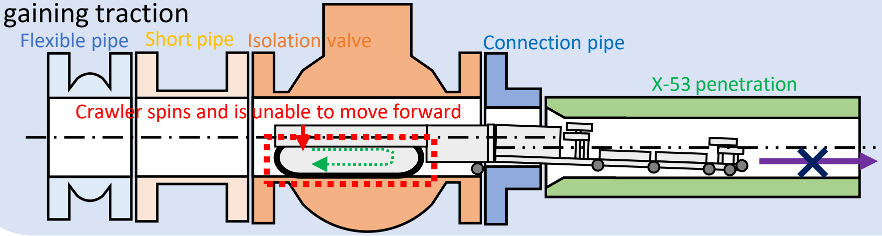
①： Front of the device moves into the X-53 penetration



②： Middle tires hit the aforementioned step



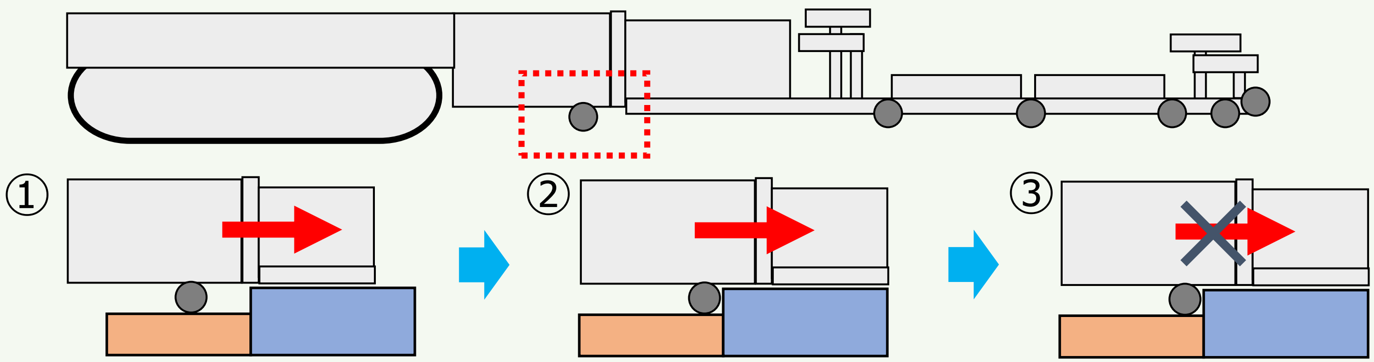
③： The resistance from getting snagged on the step prevents the crawler from gaining traction



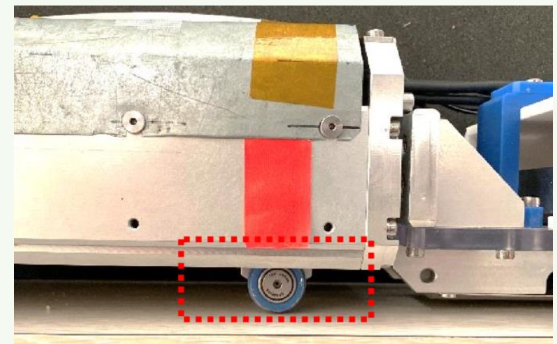
4. Countermeasures

- **The middle tires have been redesigned so as to mitigate the chance of getting caught on the step** between the isolation valve and the connection pipe.
- Five tires have been arranged in an arch to **enable steps to be smoothly overcome and mitigate any impact that this step will have when the device is passing over it.**
- In addition to the countermeasures mentioned above, procedures have been added that call for the **insertion device to be pushed with a rod from the glove box in order to aid with insertion (if the crawler is unable to push the device), and the crawler caterpillar has been improved to improve grip.**
- For this countermeasure, after conducting running tests using the models, **we verified its effectiveness in the actual insertion piping. We confirmed that the forward movement failure issue was resolved and that the device can travel smoothly in both forward and reverse directions without any problems.**

[Prior to improvement] Only two middle tires (one on each side)

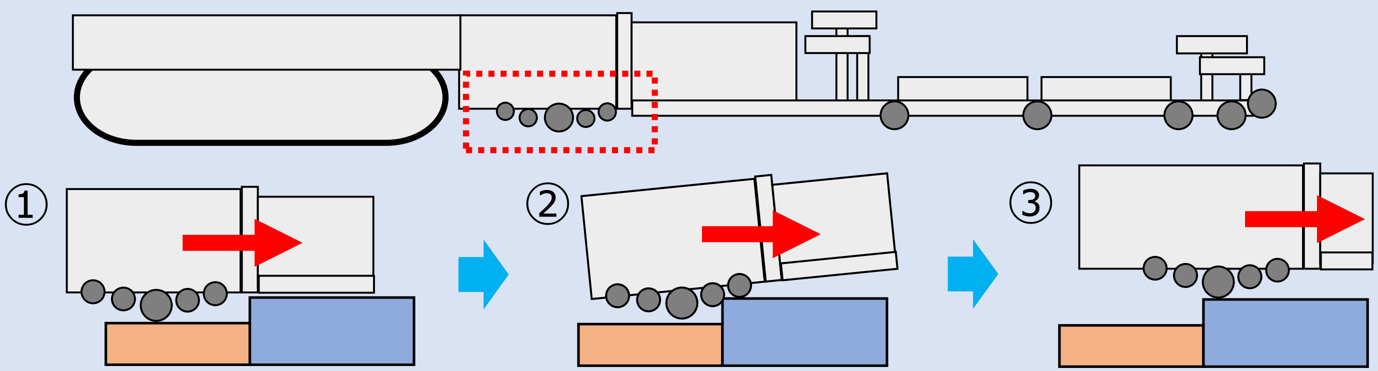


Since the step must be overcome by a single tire, the device is more susceptible to the effects of snagging.

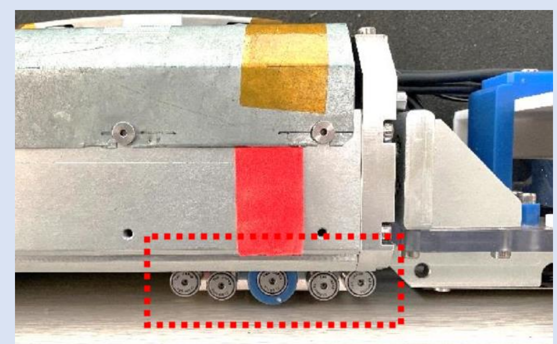


Tires in the mid-section of the device before improvement (Photograph of the model)

[After improvement] There are now 10 middle tires (five on each side)



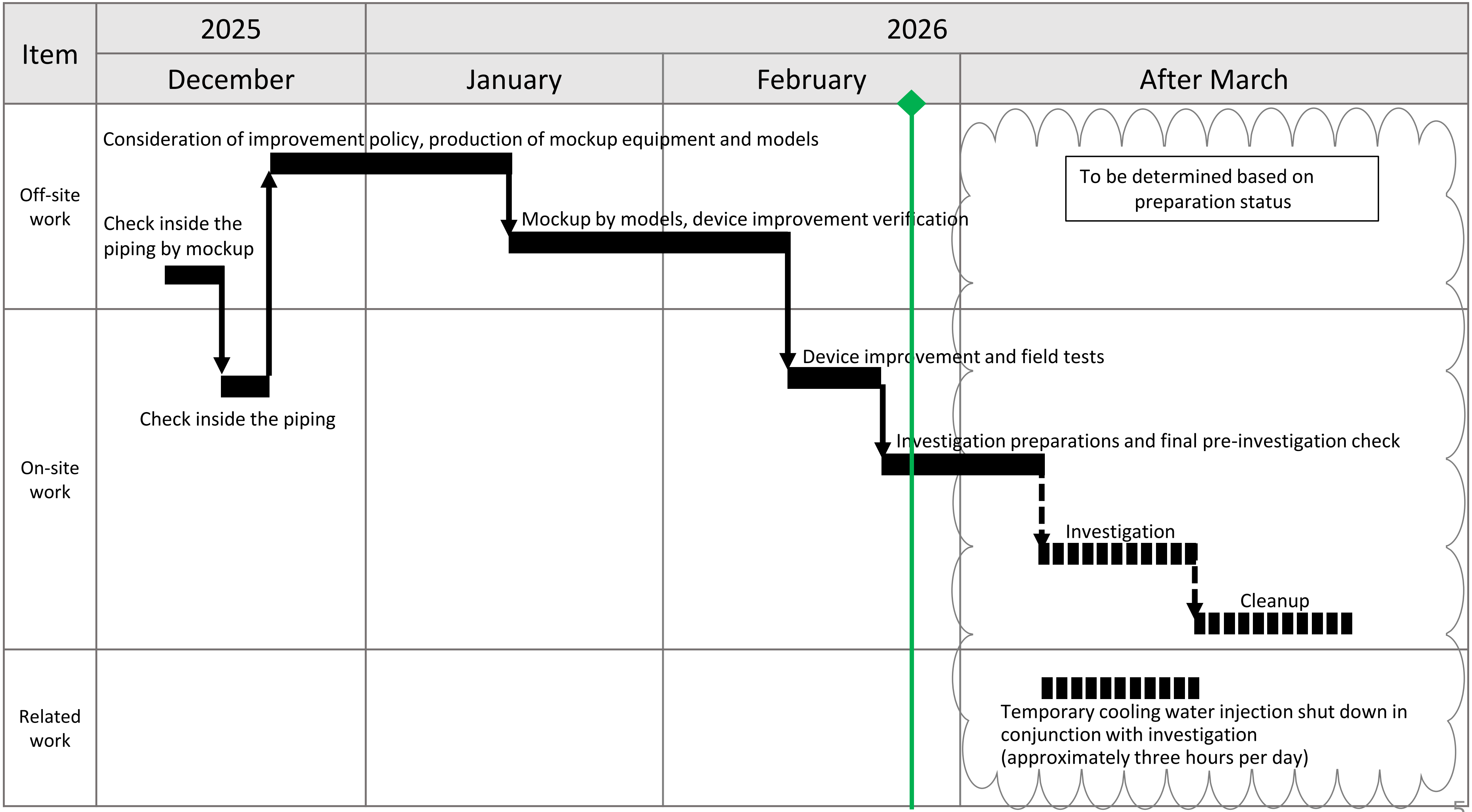
By having multiple tires overcome the step in stages, the effects of snagging are mitigated.



Tires in the mid-section of the device after improvement (Photograph of the model)

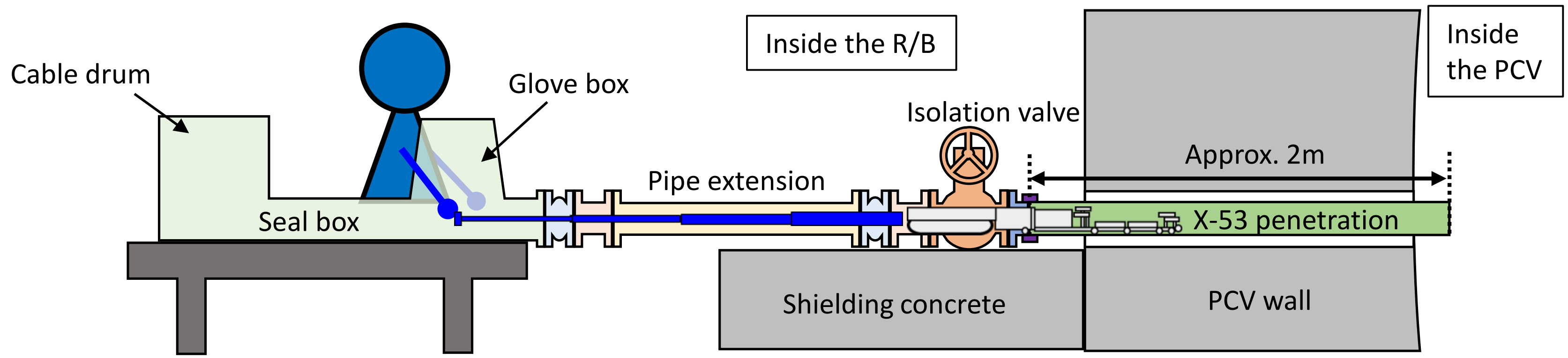
5. Investigation schedule

- The investigation will recommence after preparations have been made and the final pre-investigation check has been completed.



[Reference] Concept diagram of additional countermeasures

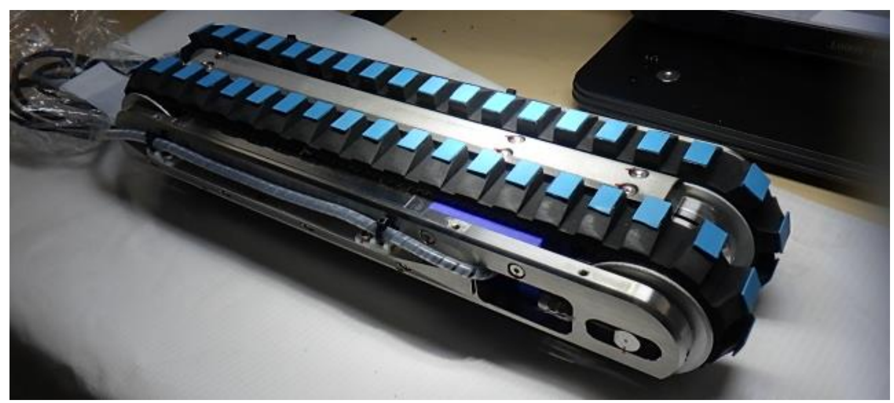
- **Assisting with insertion using a push rod**
  - If the crawler is unable to move on its own a rod housed in the glove box will be used to push the device from the back and alter its position. (done manually)
  - The cable drum will be used to pull the device if it needs assistance moving backwards.



Concept diagram of manual insertion assistance using a push rod

- **Crawler Caterpillar improvement**
  - To prevent idling and maintain grip performance even when snagging occurs, a high grip material was installed on the crawler's contact surface.

Crawler prior to improvement



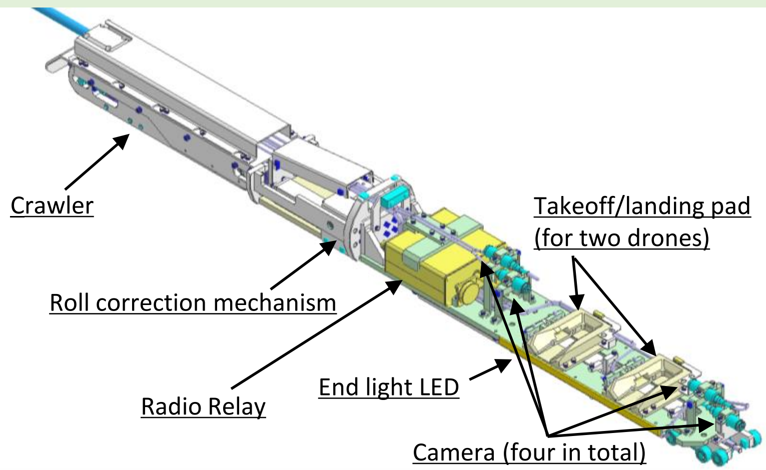
Improved crawler

[Reference] The insertion device unable to move forward

TEPCO

- When conducting function tests of the investigation device **it suddenly became impossible to move the insertion device forward inside the X-53 penetration.**
- Several attempts were made at insertion, but **the device was unable to move forward past a certain point (approximately 50cm into the X-53 penetration).**
- The device could be moved backwards, so **normal procedures for withdrawal were conducted and the insertion device was returned to the seal box** (Since the device was withdrawn to the seal box, the isolation valve, which is the PCV boundary, did not have to be opened or closed).

insertion device



- Two drones can be loaded onto the takeoff and landing pad on the tip
- The device is moved backward and forward by driving the crawler mechanism at the rear
- Drones are carried into the PCV from the seal box
- Dimensions: Approx. 1.3m×Φ130mm
- Weight: Approx. 20kg

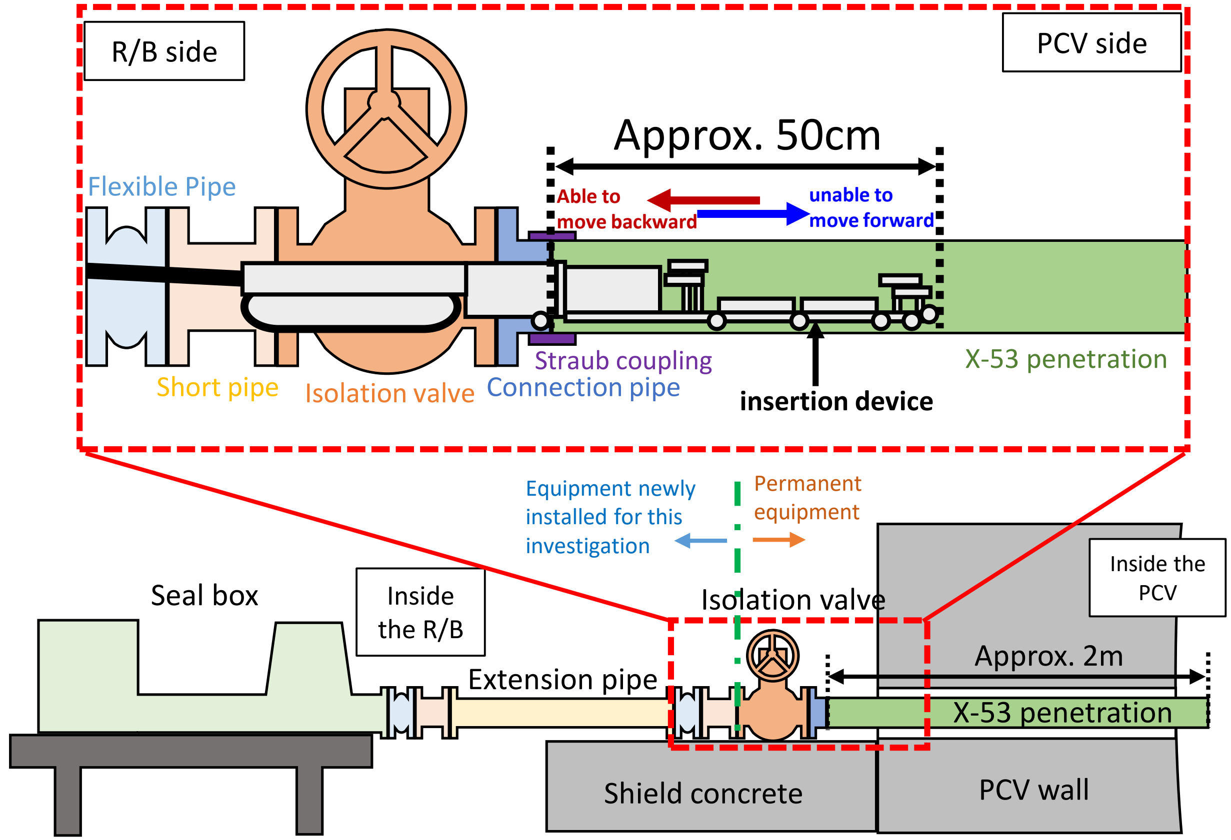
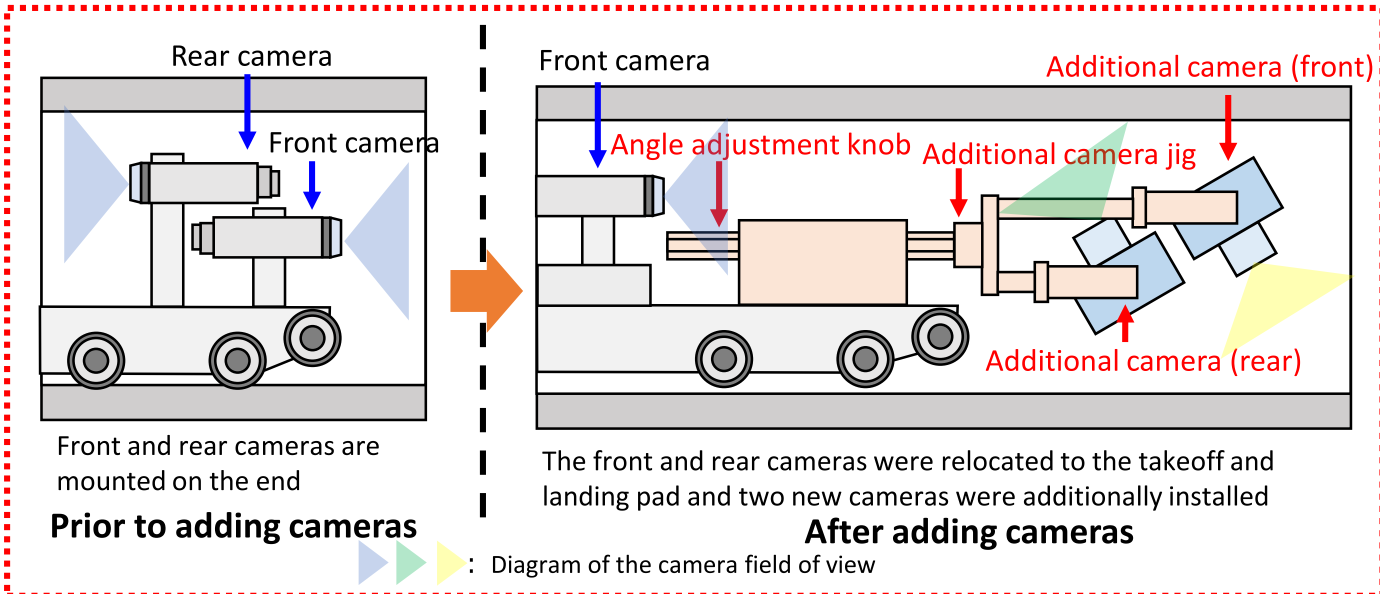


Diagram showing the unable to move the insertion device forward

[Reference] Detailed inspection of the inside of the insertion pipe

- **Two cameras were added to the end of the insertion device** in order to perform a detailed inspection of the inside of the insertion pipe.
- Both cameras are angled slightly forward and to the rear to take photos of the **level difference inside the pipe and the shape of the inner walls of the pipe.**
- The cameras can also rotate along the axis of the pipe, so **turning each of them 90-degrees enables us to acquire footage of the entire inner circumference of the pipe.**



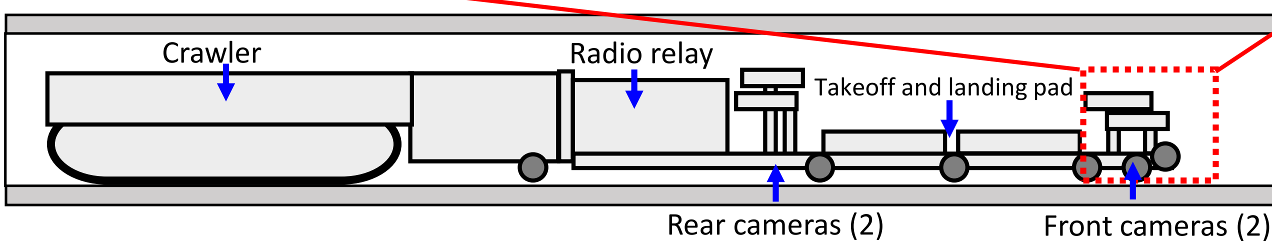


Diagram showing the insertion device (side view)

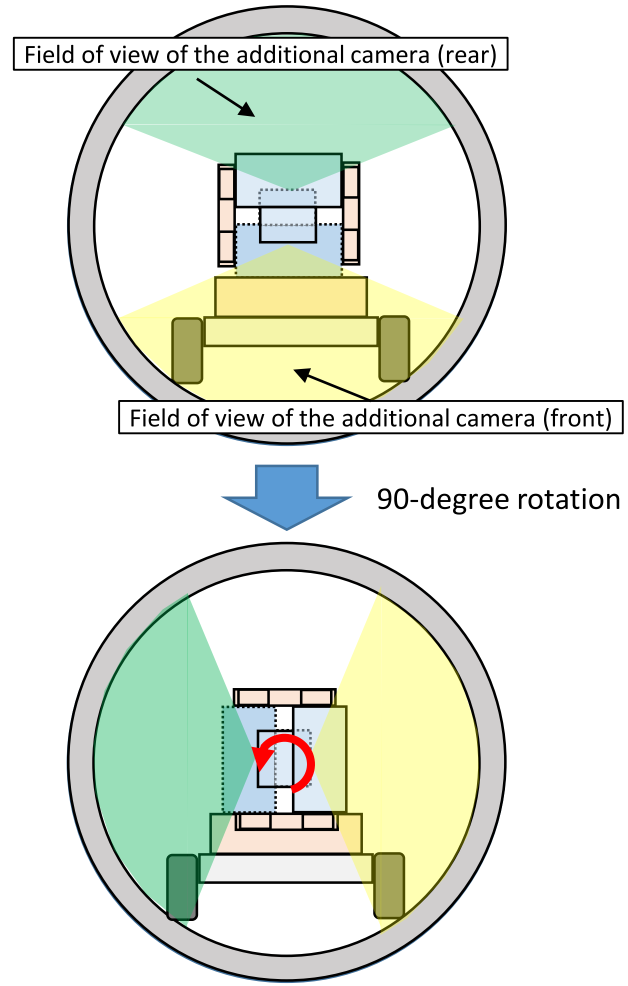
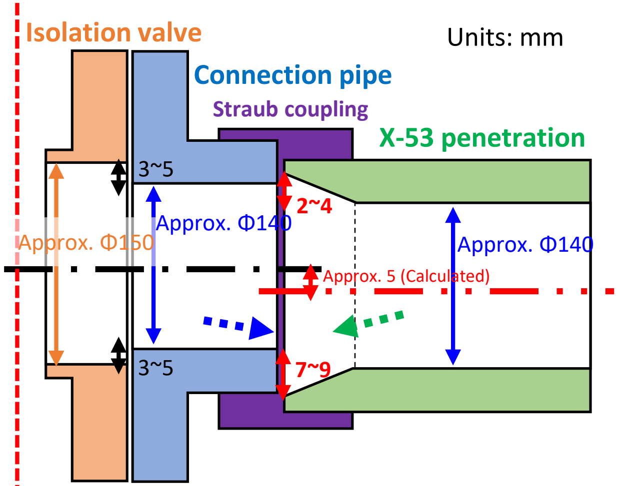


Diagram of additional camera rotation (front view)

[Reference] Confirmed conditions inside the insertion pipe

- Analysis of obtained footage (footage from point grouping) shows that the center axes of the **connection pipe and X-53 penetration are slightly misaligned.**※1
- From these results we assume that the reasons why the insertion device cannot move passed this point is because the **cross-sectional area of the pathway becomes smaller** and **the crawler loses grip**. ※2
- Going forward, the obtained data will be further analyzed in detail and countermeasures deliberated.



※ **The measurements shown above were obtained from point group data** (The amount of misalignment is a calculation). Representative values have been shown since there may be discrepancies due to uneven surfaces caused by rust inside the pipes

Direction of view of camera footage:

Direction of view of camera footage:

- The dimensions of the level difference at the end of X-53 penetration were measured and it was confirmed that there are discrepancies at the top and bottom
- If the center axes of the pipes were aligned, the level difference should be the same around the entire circumference, so it is assumed that the **connection pipe and the X-53 penetration are slightly misaligned (the X-53 penetration is a little bit lower)**

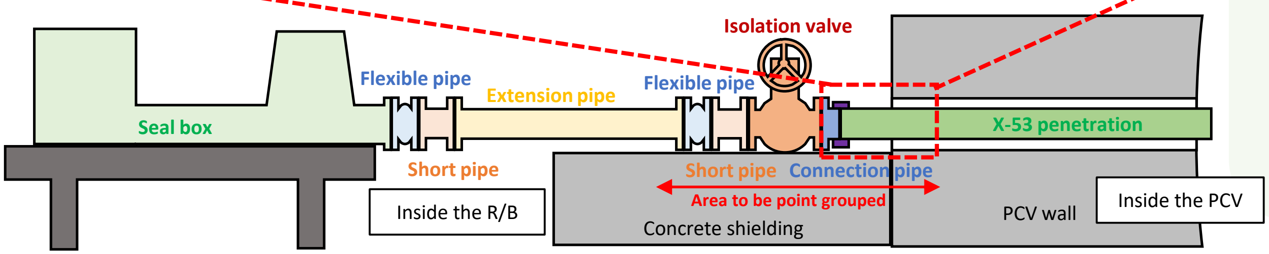
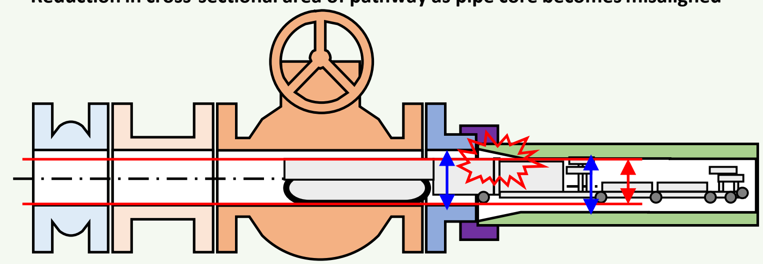


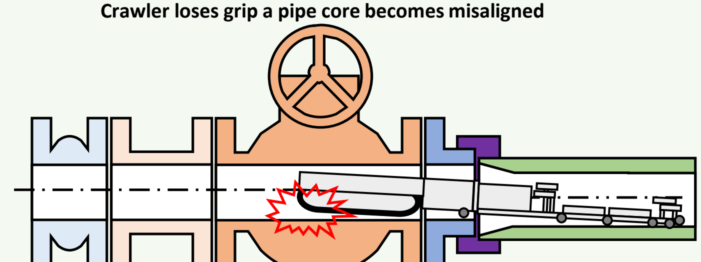
Diagram of confirmed conditions inside the insertion pipe

Reduction in cross-sectional area of pathway as pipe core becomes misaligned



- Reduction in cross-sectional area in longitudinal direction as pipe center axes becomes misaligned (red arrow)
- If the system is designed based on the minimum pipe diameter (blue arrow) then the device will not be able to pass the point where the cross-sectional area becomes narrower

Crawler loses grip a pipe core becomes misaligned



- The entire X-53 penetration is lower, relatively, due to the misalignment
- After the front of the device passes through the X-53 penetration, it tilts downward forcing the crawler to lift and lose grip thereby making it unable to move forward any further

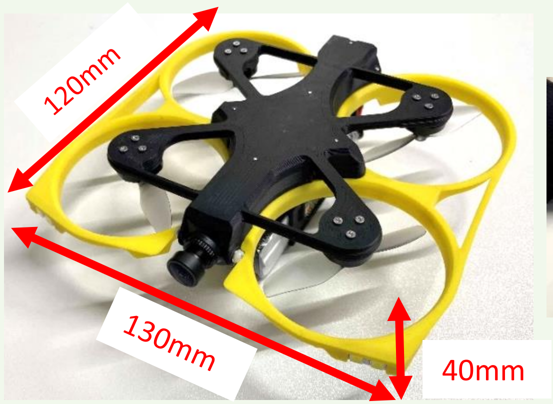
Diagram illustrating why the insertion device cannot be moved forward (assumptions)

※1: There is no current impact on the PCV boundary.
※2: This is just an estimate at this stage, and there are other possibilities.

[Reference] Investigation devices

- Since the area inside the PCV is cramped and dark, an extremely small and highly mobile **"micro-drone"** with photographic capabilities will be installed through the small X-53 penetration.
- As with past investigations**, a seal box will be attached to the X-53 penetration so as to allow the micro-drones to be inserted into the PCV while maintaining PCV isolation**.
- The seal box will contain a total of six drones, and two drones will be able to be inserted inside the PCV simultaneously (how the six drones are to be used will be determined during mockup/training).

Micro-drone



Held in the palm of the hand for size comparison

Use: Photography (2.7K)
Dimensions: 130×120×40[mm]
Weight:95[g](Including battery)
Communications method: Radio
Flight time: Approximately 13 minutes (the investigation is planned to take 10 minutes)
Camera performance: Image quality: 2.7K, frame rate: 60fps
Angle of view: diagonal 140°, Horizontal 135°, vertical 107°
Lights: 2 LEDs on the left and right sides (total: 380lm)
Radiation resistance: 200Gy
Notes: Corresponds to IP52, Two types of cameras: portrait and landscape

Seal box

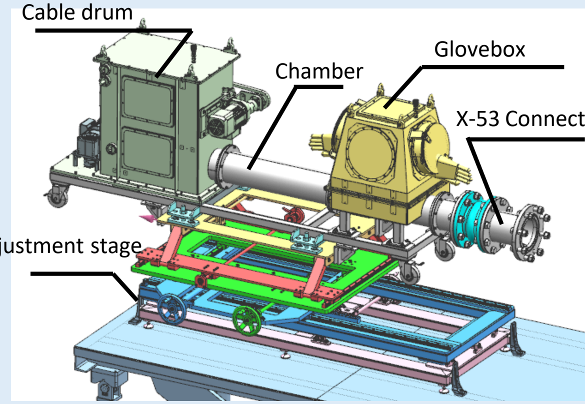


Diagram of seal box

The drones to be installed are housed in the chamber through which they are installed into the PCV.

Standby drones and recharging equipment are inside the glove box so that drones on the liftoff/landing pad can be switched out while maintaining airtightness.

Dimensions: Approx. 2.6m×0.6m×1.1m
Weight: Approx. 315kg

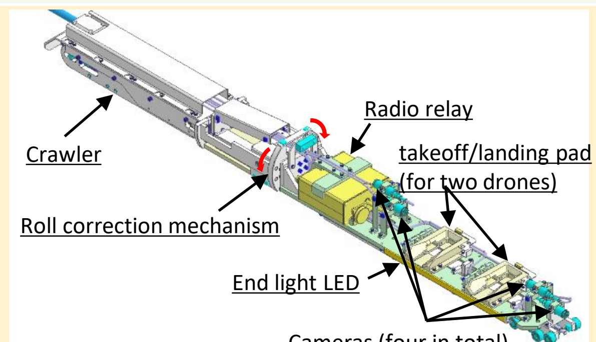


Diagram of insertion device

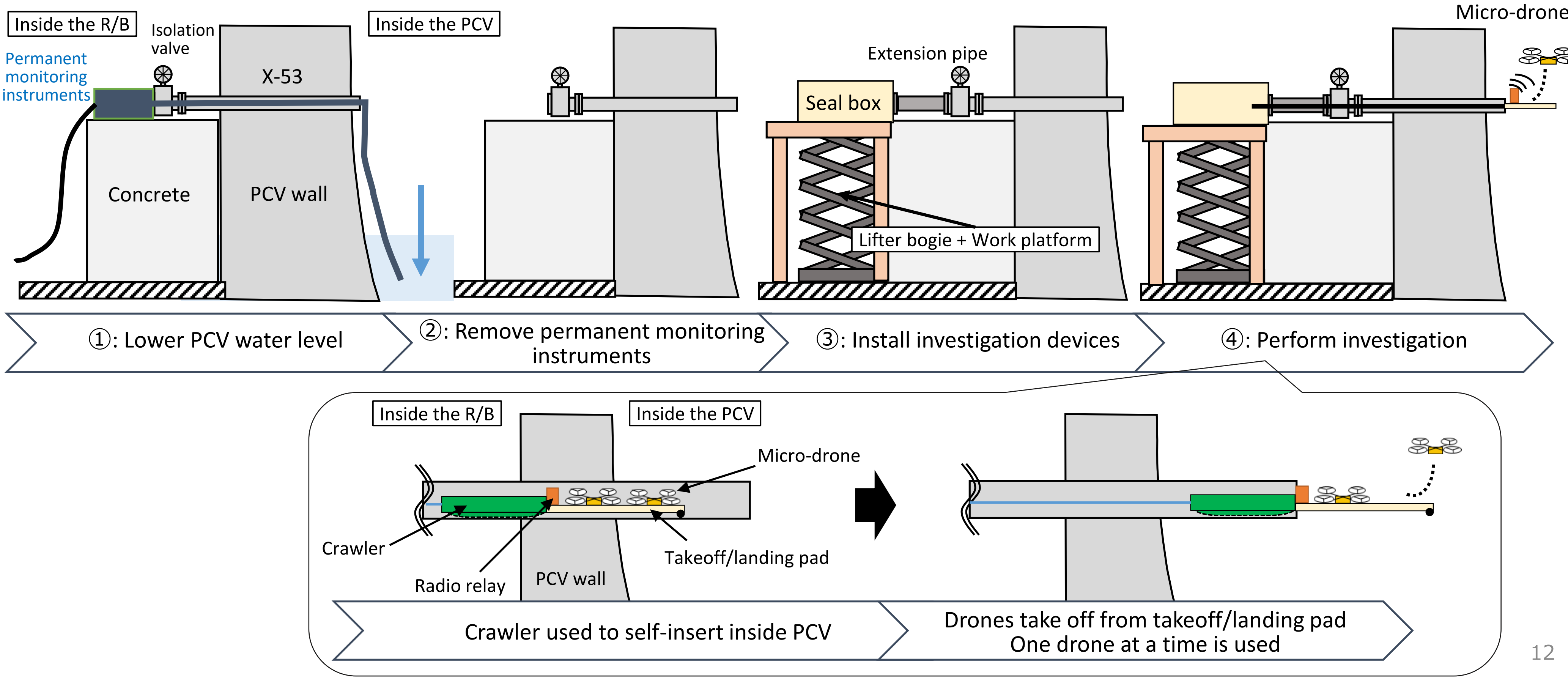
The crawler enables self-insertion thereby reducing worker exposure.

Two drones can be installed simultaneously.

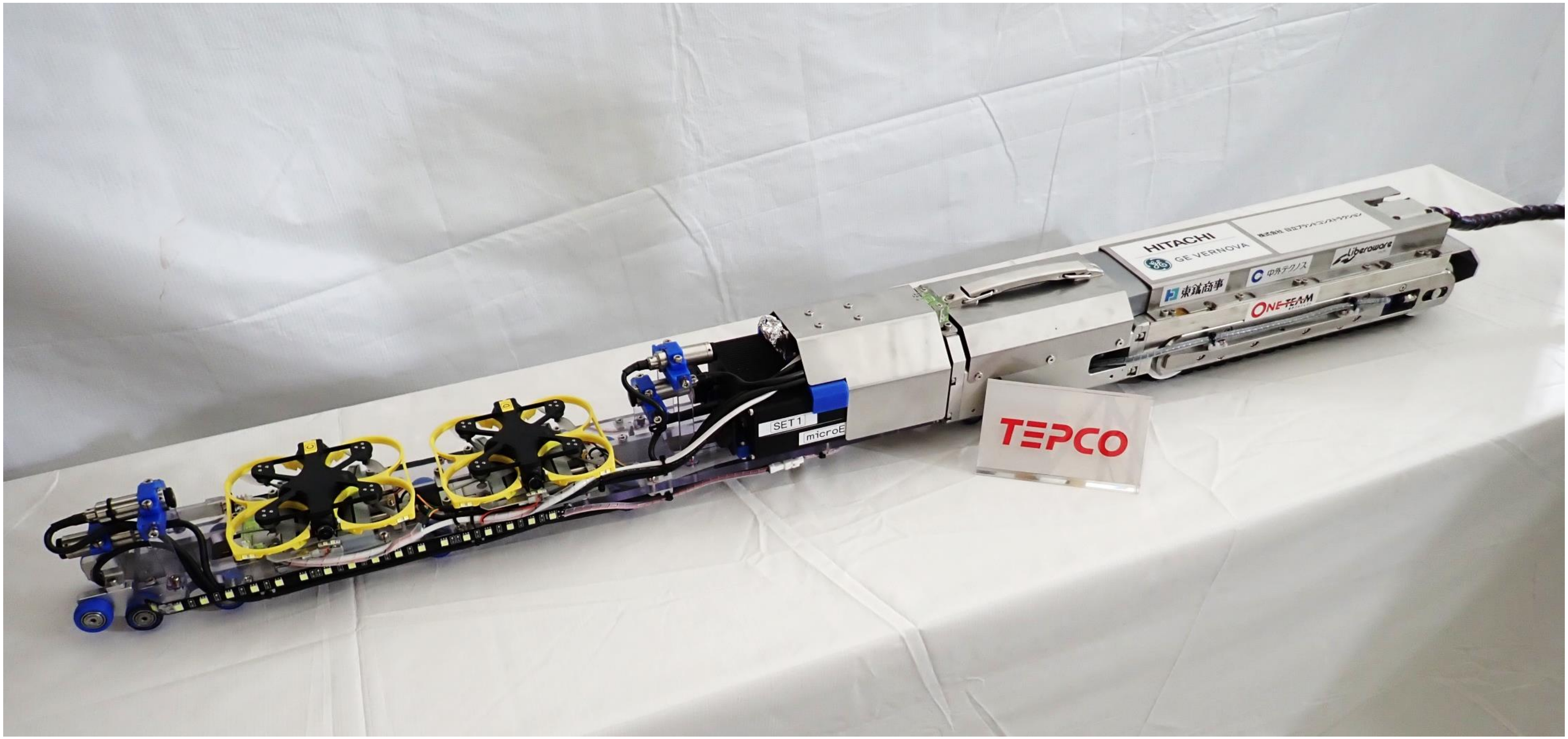
Dimensions: Approx. 1.3m×Φ130mm
Weight: Approx. Approximately 20kg

[Reference] Overall workflow

- Permanent monitoring instruments (water level/temperature gauge) newly installed after the accident are currently inserted through the X-53 penetration.
- And, in order to fly the micro-drones inside the pedestal, the water level inside the PCV must be lowered to the bottom edge of the CRD replacement opening.
- Therefore, as preparations for the investigation, **PCV water level will be lowered, and permanent monitoring instruments will be removed after which the investigation devices will be installed and the investigation performed**.
- After the investigation is completed, the investigation devices will be removed, and the permanent monitoring instruments will be reinstalled.



[Reference] External appearance of insertion device



*Mock-up in 2025