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

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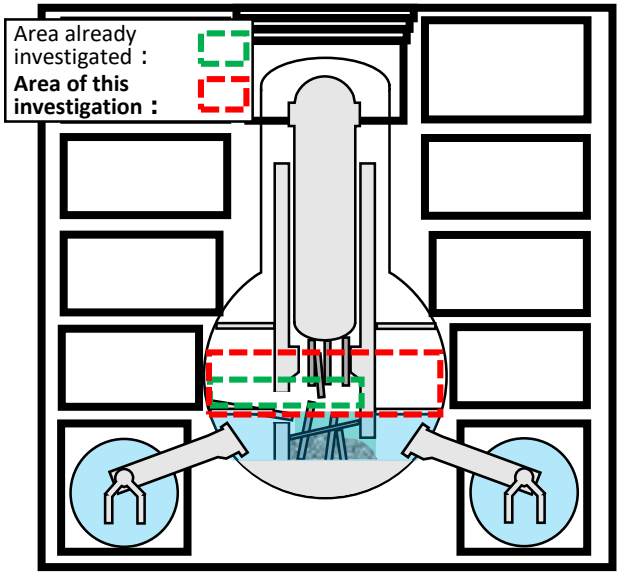
TEPCO

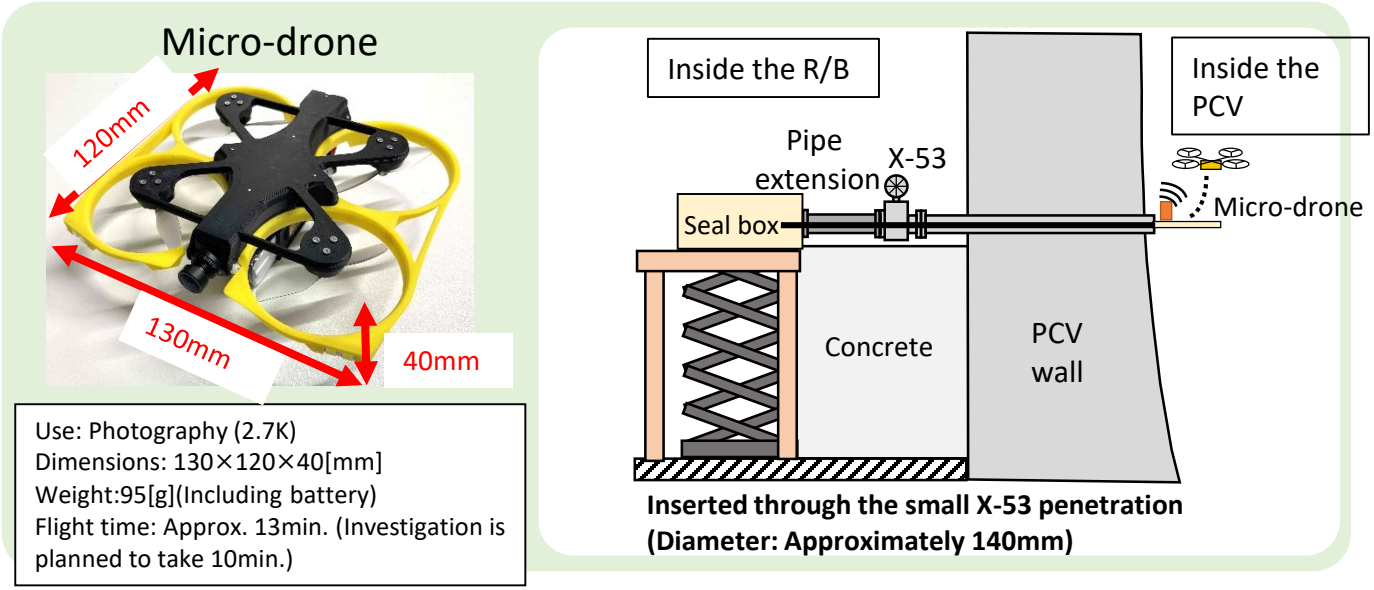
Tokyo Electric Power Company Holdings, Inc.

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.



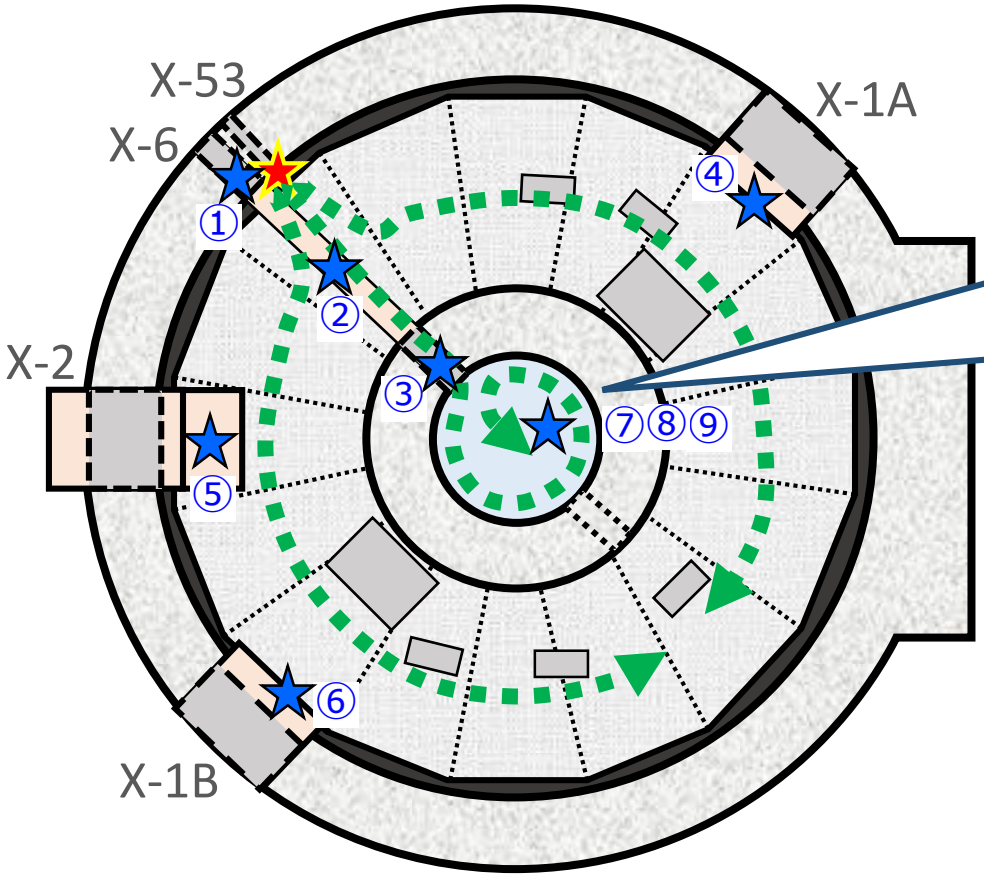
Cross-sectional diagram of the Unit 3 PCV internal investigation area



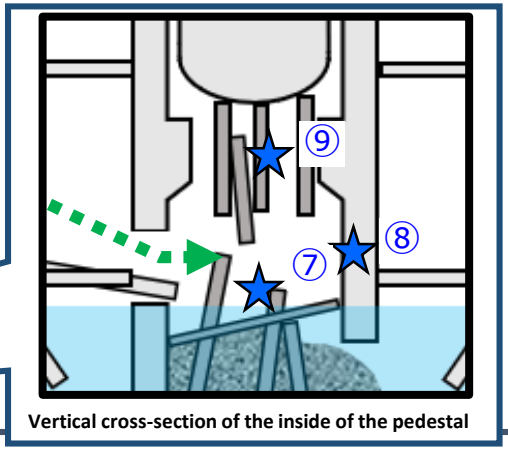
Concept diagram of Unit 3 micro-drone investigation

2. Investigation details

- During this investigation the micro-drawn will be flown on **the first floor of the D/W and inside the pedestal to take footage.**
- The **primary objective of the investigation is to gather information about the inside of the pedestal and the area around the X-6 penetration,** which are important for the side-retrieval of fuel debris and future deposit investigations.
- As with the drone investigation of Unit 1, **the footage will be used to compile point cloud data and the radiation noise will be used to estimate dose rates.**
- Since operating the micro-drone is difficult, the scope of the investigation may be altered depending upon field conditions, however mockup/training is underway in order to acquire as much information as possible.



Plainview diagram of proposed flight route on the first floor of the Unit 3 D/W



Vertical cross-section of the inside of the pedestal

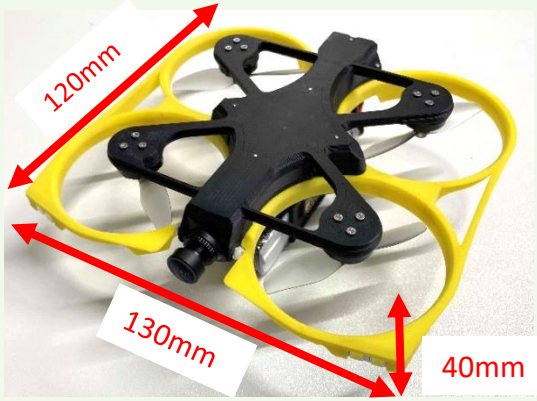
■Key
★: Radio and micro-drone takeoff/landing position
▶: Flight route
★: Areas of interest (red letters: high priority)
① : X-6 Penetration
② : CRD rails ※
③ : CRD Replacement opening ※
④ : X-1A Penetration
⑤ : X-2 penetration
⑥ : X-1B penetration
⑦ : Status of deposits/fallen objects + Water level ※
⑧ : Pedestal wall surface ※
⑨ : CRD housing, etc. ※

※ : Already partially investigated

3. 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 inserted 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-drone 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

Seal box

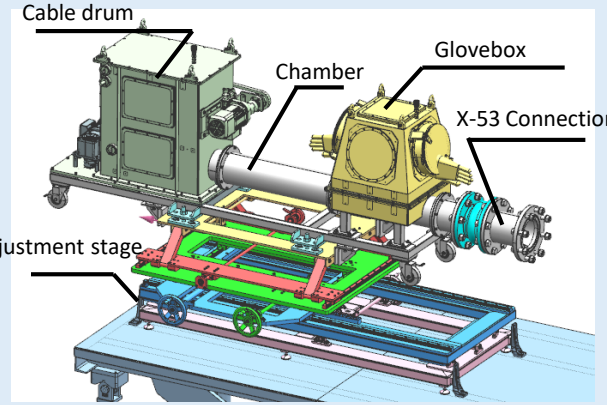


Diagram of Seal box

The drones to be inserted are housed in the chamber through which they are inserted 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

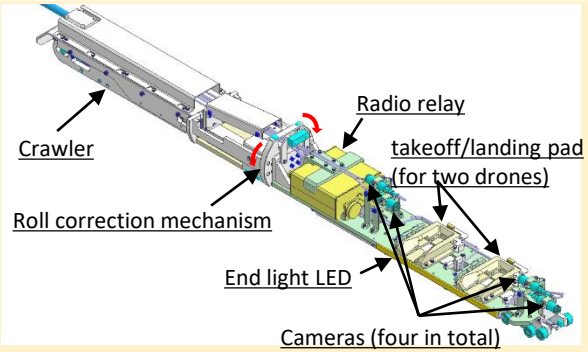


Diagram of insertion equipment

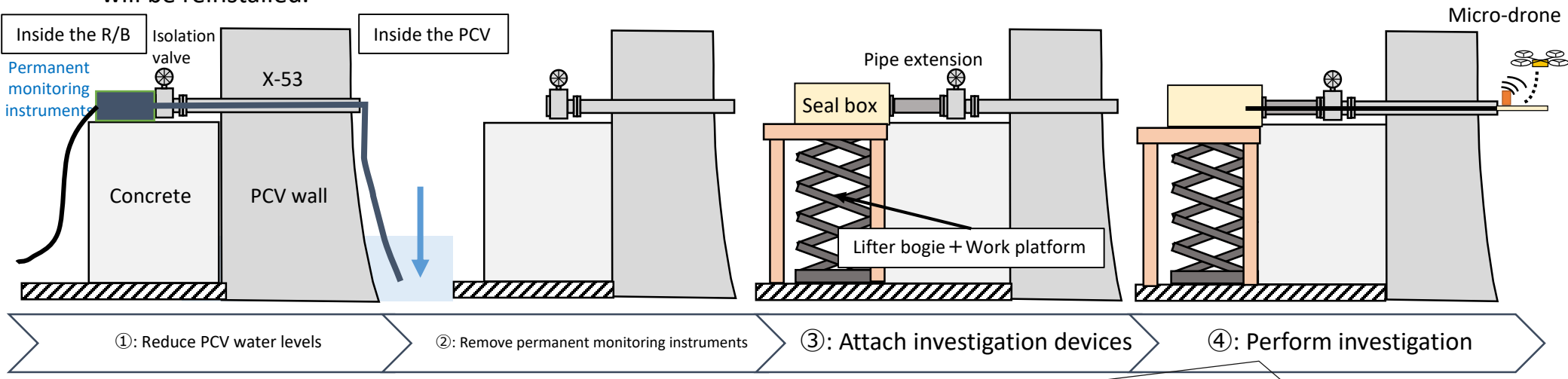
The crawler enables self-insertion thereby reducing worker exposure

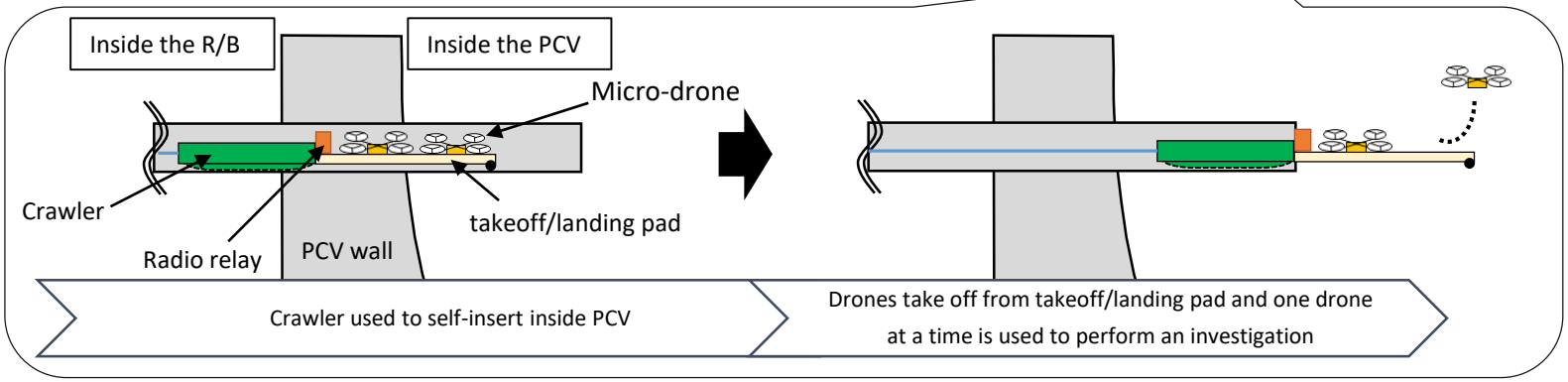
Two drones can be inserted simultaneously

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

4. Work flow

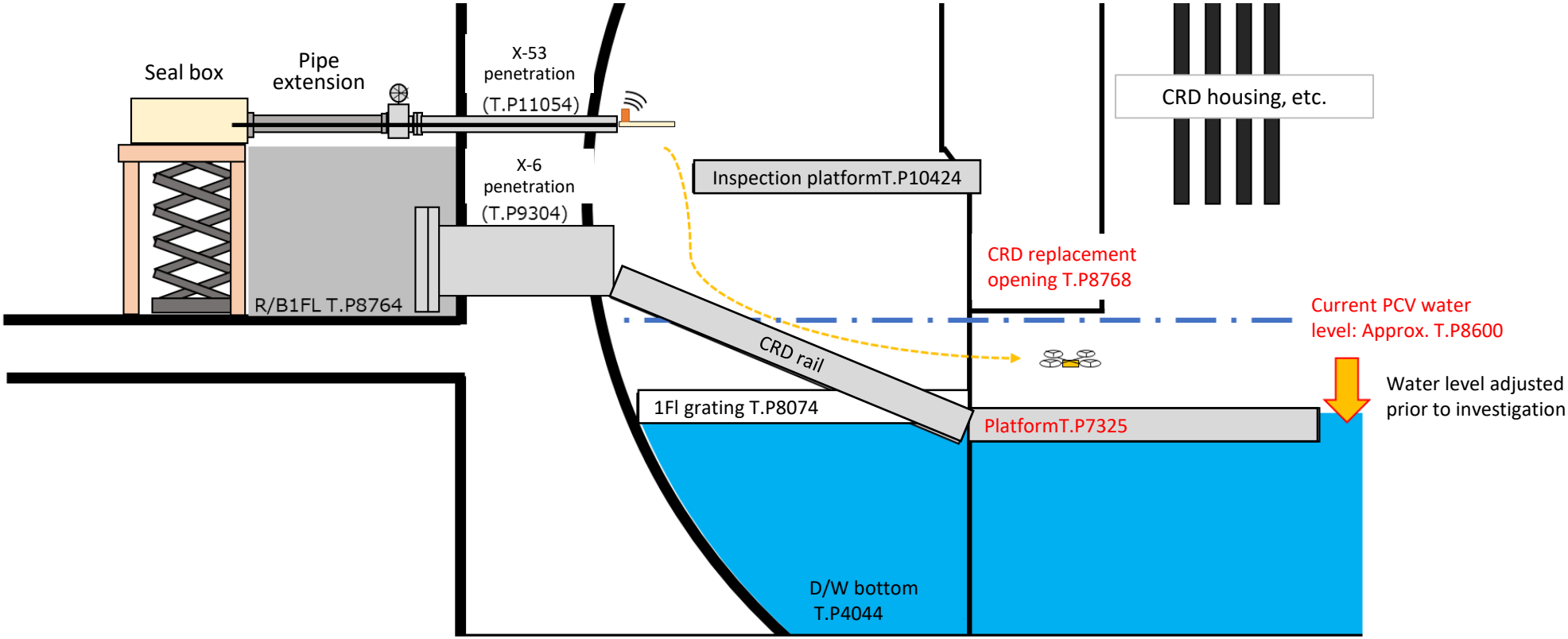
- Permanent monitoring instruments (water level/temperature gauge) newly installed after the accident are currently inserted through the X-53 penetration.
- And, in order to fly the micro-drone inside the pedestal, the water level inside the PCV must be lowered to the bottom edge of the CRD replacement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





5. Reducing water levels in conjunction with the PCV internal investigation

- The water level in the Unit 3 PCV is being kept at T.P8264~9264 (Between permanent monitoring instruments L1~L2) and is currently at approx. T.P8600.
- At this current water level, the CRD replacement opening, which is the access route into the pedestal, is submerged so the water level will be reduced to approximately T.P.7300 (the height of the platform) in order to expose the opening.
- Based on past experience, we know that it is highly possible that the RPV/PCV temperature gauge readings will fluctuate in conjunction with water level reductions. Therefore, a hold point will be established at approximately T.P. 8000 water level. If a change is confirmed, a temperature gauge reliability assessment will be conducted in accordance with a predetermined procedure as necessary.
- We will start decreasing the water level gradually from September with expected completion around October.



Drone flightpath and water levels during the investigation of the inside the pedestal (Concept diagram)

6. Risks during the investigation

- Investigation risks will be examined using the mockup and training, and countermeasures to mitigate such risks as much as possible deliberated.
- However, **since a loss of signal or obstructions in unexplored areas**, which could result in narrowing of the scope of the investigation or crashing of the drone, can only be discovered by entering the actual environment, these issues need to be examined while the investigation is underway and countermeasures formulated as necessary.

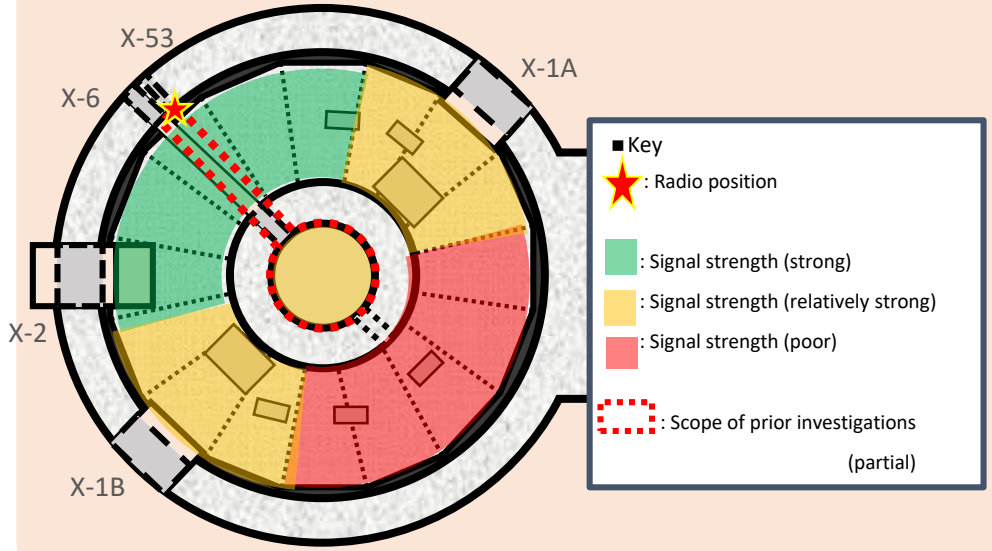
Risks that have already been examined/prepared for

- **The risk of a drone crash caused by miniaturization**
  - Micro-drones are relatively difficult to operate compared to normal drones and are more at risk of crashing.
  - In particular, since the diameter of the X-53 penetration is small, the takeoff/landing pad is also small and the risk of crash on takeoff/landing is high due to existing structures in the vicinity.
  - ✓ **Mastering operations through a mockup and training.**
  - ✓ **If a drone does crash and remains in the PCV, there will be no impact on conditions in the PCV.**
- **Risk of being unable to obtain footage due to the field environment, etc.**
  - Poor conditions such as radiation and dense fog, etc. may prevent clear footage from being acquired or cause drone malfunction.
  - ✓ **We have confirmed that footage can be taken if the drone encounters poor conditions, employed irradiation tests to confirm the resistance to the PCV internal environment, and performed waterproofness/dust prevention tests.**
  - The drone must return to the sealed box in order to acquire high-resolution video footage from the drone.
  - ✓ **The video footage sent back from the drone to the operator in real time can be saved even though the video quality is not as good.**
- **Dust dispersion risk during drone flight**
  - There is the risk that the drone may disperse dust due to the principles by which it flies.
  - ✓ **Since the drone has been miniaturized, there is little downwash and the risk of dust dispersion is low due to the damp environment inside the PCV (dust monitors will be watched during the investigation).**
- **The risk of a leak of PCV atmosphere or a decrease in PCV pressure**
  - It will be necessary to open the PCV boundary during the investigation so there is a risk that PCV atmosphere may leak or PCV pressure may decrease.
  - ✓ **Airtightness tests of the seal box will be performed at each step and the investigation will be conducted while confirming that there are no leaks.**

Risks that cannot be totally avoided

- **Risk of drone crash due to radio communication**
  - Although the radio communication performance of the drone has been confirmed during testing **the radio will be greatly impacted by the field environment and it is possible that the drone may not be able to fly as expected**.
- **Narrowing the scope of the investigation due to newly discovered obstructions**
  - Since this investigation will include areas that have yet to be investigated, such as the first floor of the D/W, unexpected obstructions may restrict the flightpath.

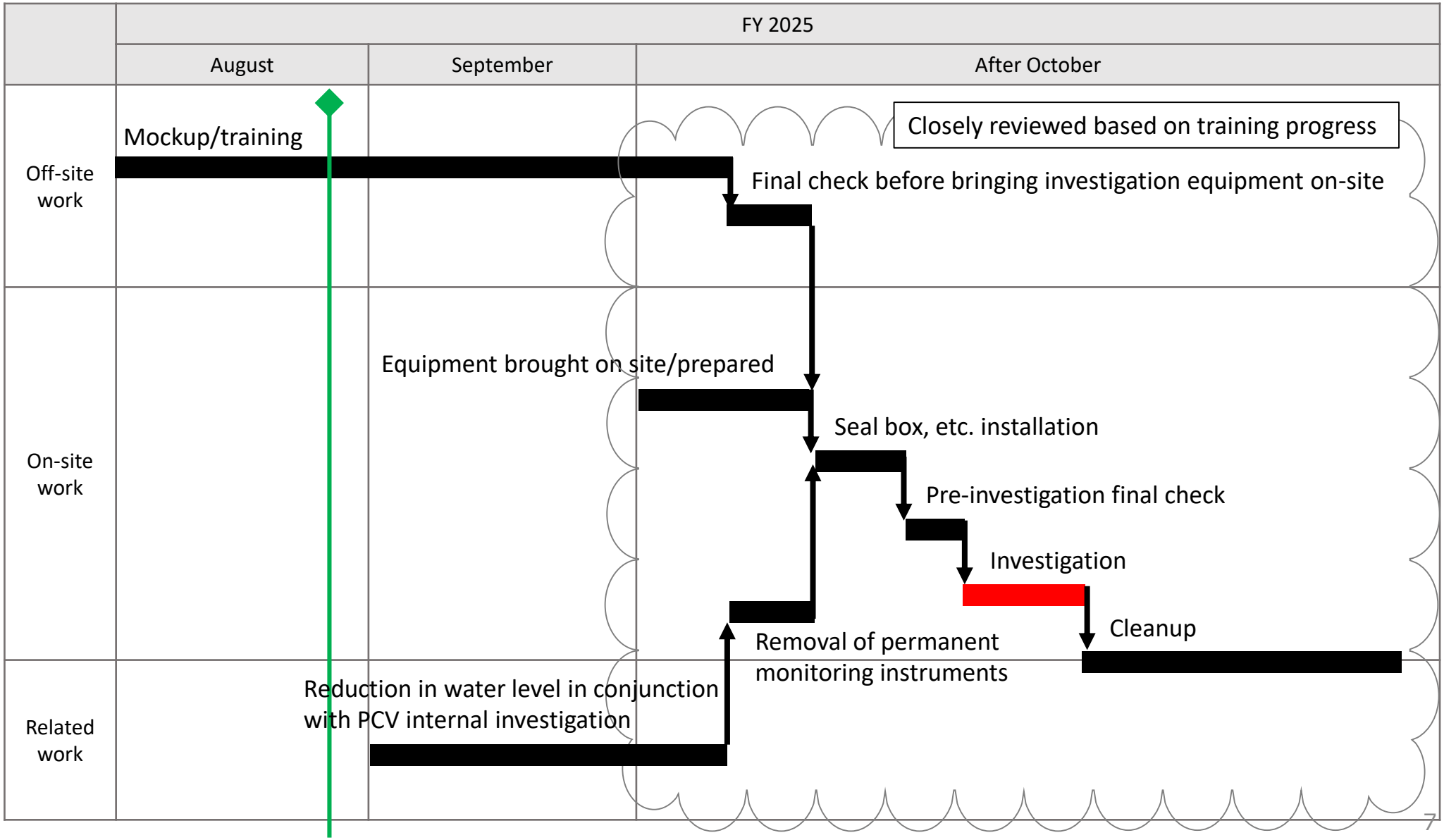
✓ **The strength of the radio signal will be checked during the actual investigation and the planned scope of the investigation will be reassessed in accordance with obstructions.**



Plainview of Unit 3 D/W 1Fl.

7. Investigation schedule

- Mockup/training is underway in preparation for investigation implementation after October



[Reference] Examples of how investigation results will be leveraged

- The results of the investigation will be used to "**deliberate fuel debris retrieval methods,**" "**deliberate future PCV/RPV internal investigations,**" and for "**accident progression analysis**".

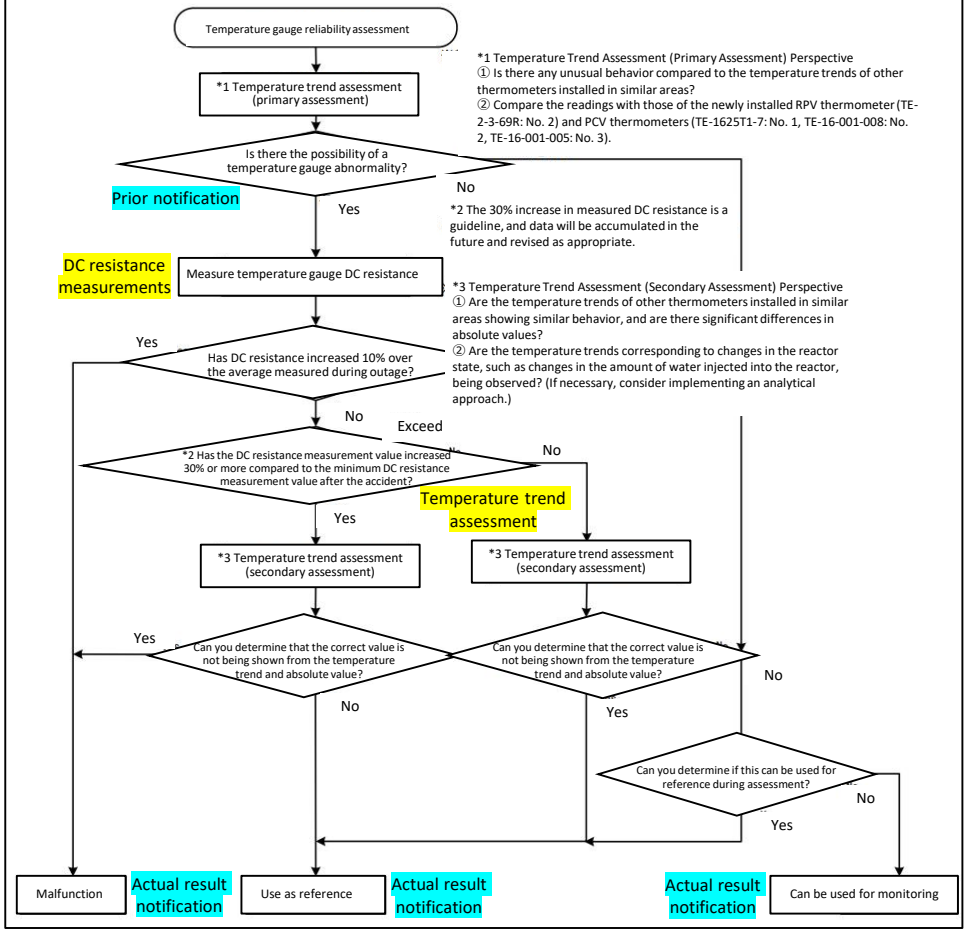
Item	Retrieval method deliberation	PCV/RPV internal investigations	Accident progression analysis
Condition of primary penetrations (X-6,1A/B)	Side-access method deliberation (Presence of obstructions)	PCV internal investigation access route deliberation	—
CRD rail condition	Side-access method deliberation (Presence of obstructions)	Deliberation of how to utilize the CRD rails during PCV internal investigations	—
Conditions around the CRD housing (damage status)	Side-access method deliberation (Presence of obstructions)	RPV access deliberation	Estimate locations of damage at the bottom of the RPV and how fuel debris migrated
CRD replacement opening condition	Side-access method deliberation (Presence of obstructions)	Pedestal access deliberation	—
Deposit distribution	Side-access method deliberation	Deposit sampling/analysis method deliberation	Fuel debris migration
Near the surface of the water inside the pedestal	—	—	Confirm water levels and estimate flow paths (if there is a current)
Condition of the inner walls of the pedestal	—	—	Fuel debris migration (if it has reached the walls)
Dose rate data (estimated)	Retrieval equipment radiation resistance performance deliberation	Investigation device radiation resistance performance deliberation	Fuel debris migration

[Reference] Responding to changes in the readings on existing temperature gauges

- A method for assessing the reliability of temperature gauges has been stipulated based on the instructions※ received from the Nuclear Regulatory Agency in 2012 after an abnormal increase in the temperature of Unit 2, and the results of these assessments are reported monthly to the Nuclear Regulatory Agency.
- Temperature gauge reliability assessments are conducted if the permanent temperature gauges noted in the implementation plan deviate approximately 10°C (internal operability value).
- Prior notification is given before taking DC resistance measurements and results are notified after the assessment is completed in the form of actual result notification.

※ Handling Procedure in the Wake of the Temperature Increase at the Bottom of the TEPCO Fukushima Daiichi Nuclear Power Station Unit 2 Reactor Pressure Vessel (Instructions)

Temperature Gauge Reliability Assessment Flow and Temperature Gauge Status Classifications

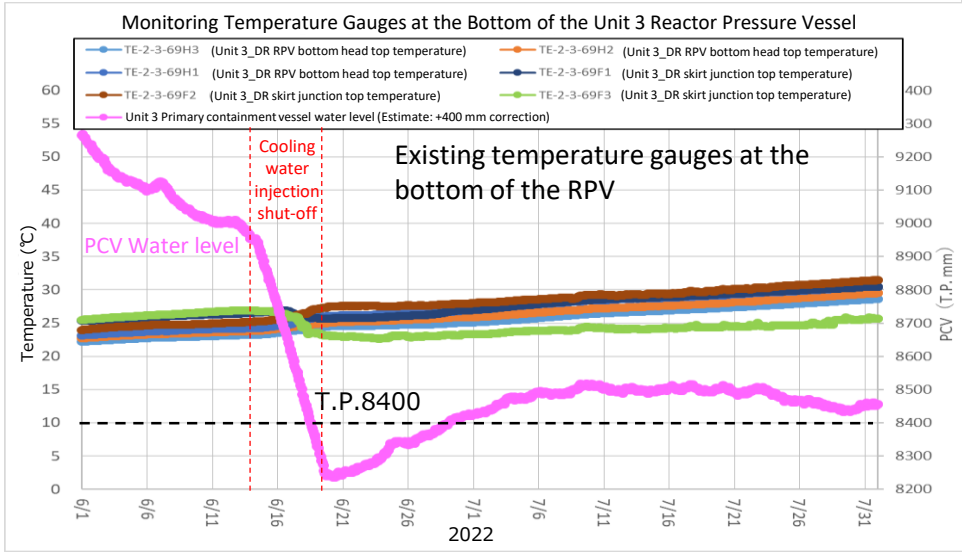


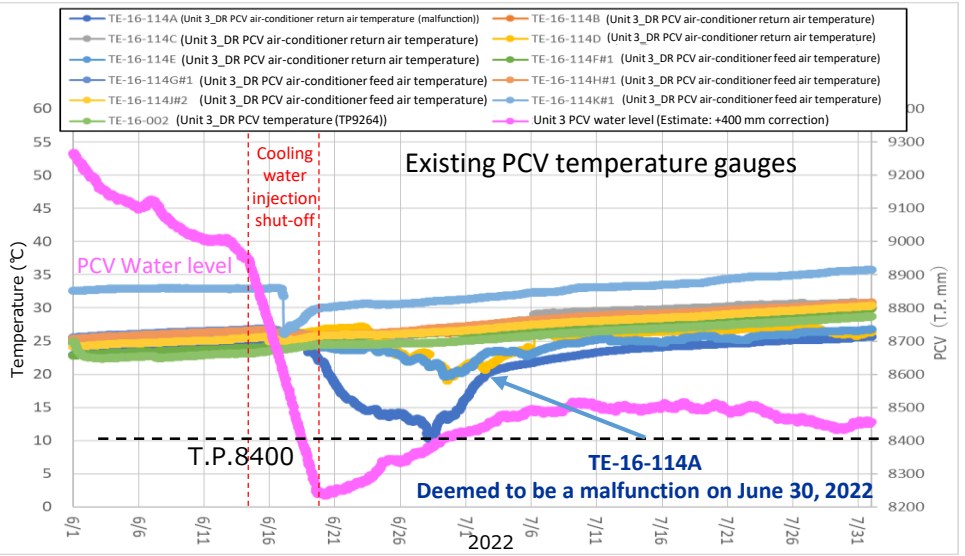
Status classification	Assessment method	Assessment method
Malfunction (When the outcome is (1) or (2))		(1) DC resistance has increased 10% over the average measured during outage
		(2) "DC resistance measurement value increased 30% or more compared to the minimum DC resistance measurement value after the accident(*)" and "It can be determined on an engineering-basis that the correct value is not being shown from temperature trends"
Use as reference (When the outcome is (1) or (2))		(1) "DC resistance measurement value increased 30% or more compared to the minimum DC resistance measurement value after the accident(*)" and "It can be determined on an engineering-basis that the correct value is not being shown from temperature trends"
		(2) "DC resistance measurement value increased less than 30% compared to the minimum DC resistance measurement value after the accident(*)" and "It can be determined on an engineering-basis that the correct value is not being shown from temperature trends"
Can be used for monitoring (Resistance decrease or normal)		Anything other than what's mentioned above

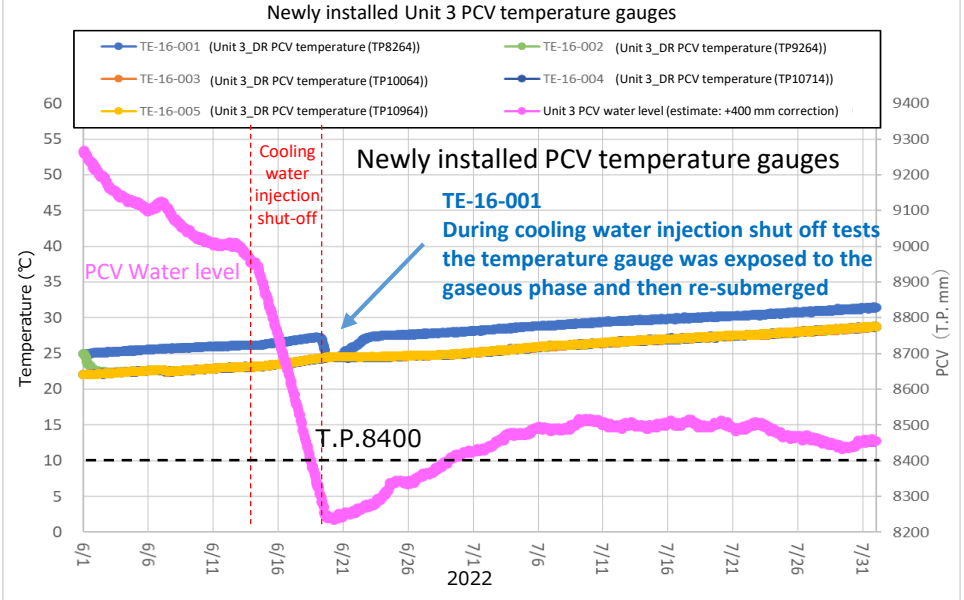
*30% (DC resistance measurement value/minimum DC resistance after the accident) is a benchmark that will be revised as necessary as data is accumulated

[Reference] Existing temperature gauge reading fluctuations (during 2022 Unit 3 reactor cooling water injection shut-off tests)

- In the past, fluctuations in the readings of some existing temperature gauges (including temperature gauges noted in the implementation plan) have been seen when the PCV water level fell below approximately T.P.8400. This might have been caused by partial gaseous phase exposure of the terminal board. (There were no reading fluctuations in newly installed PCV temperature [gauges]



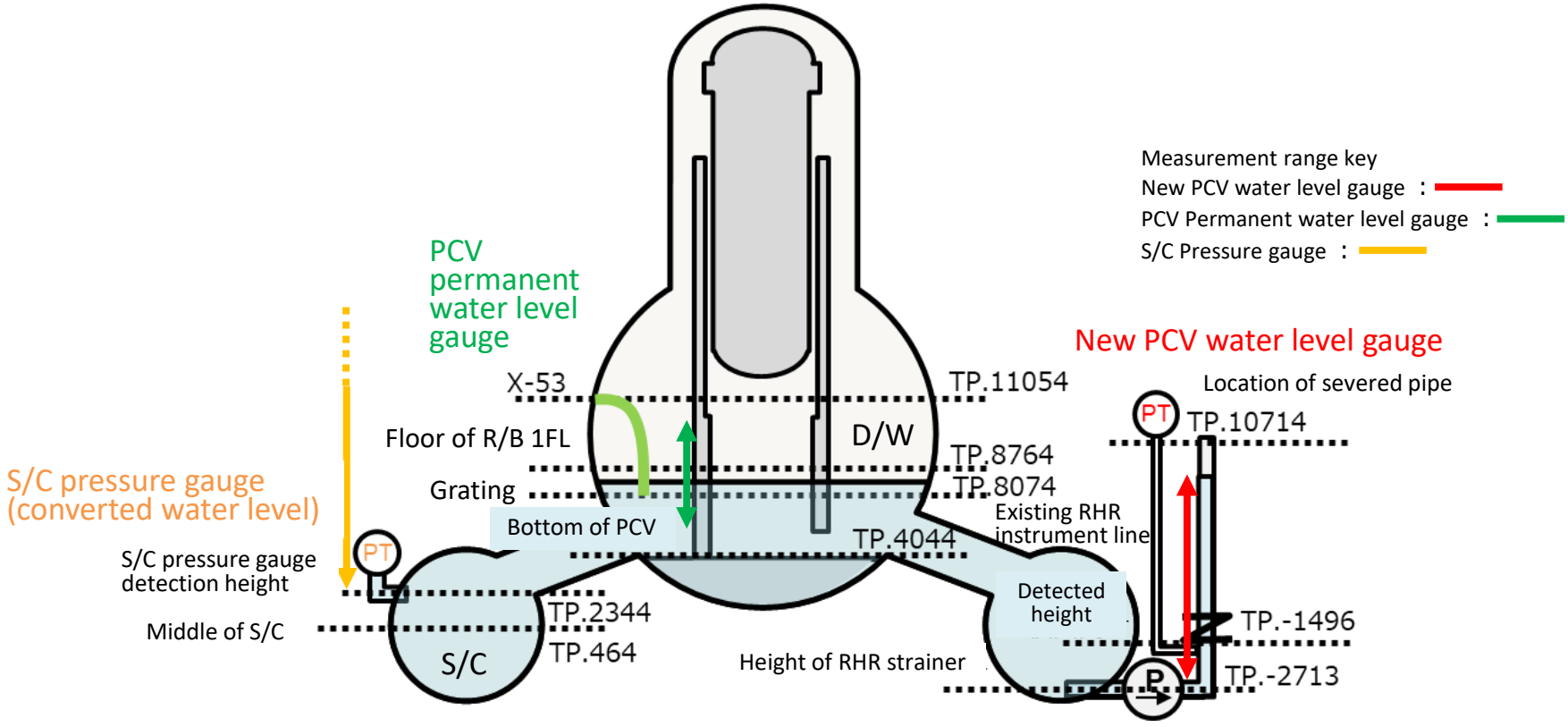




※Installation height of existing thermometer terminal board Approx. T.P8150 ~ 9150

[Reference] Overview of Unit 3 PCV water level monitoring instruments

- A bubbler-type water level meter has been installed on the Unit 3 RHR pump discharge pressure instrument line.
  - ✓ Overview: A bubbler-type water level gauge akin to a bubbler tube has been installed on the RHR pump pressure instrument line
  - ✓ Measurement range: From around the height of the X-53 penetration to the middle of the S/C (TP. 10,714~-1,496)



Height relationship of Unit 3 PCV water level instruments