

Fukushima Daiichi Nuclear Power Station Unit 2 Primary Containment Vessel Internal Investigation

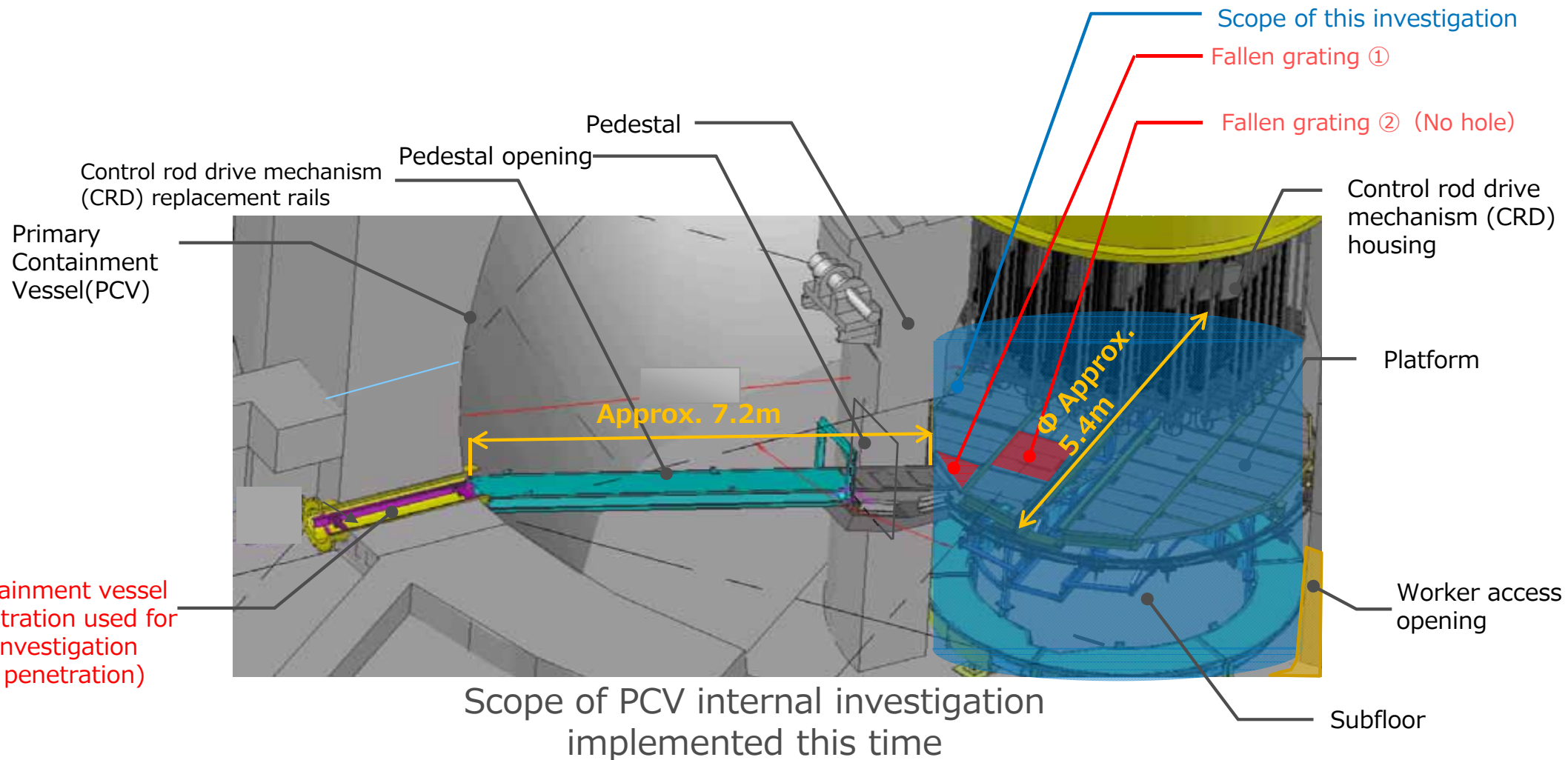
April 26, 2018



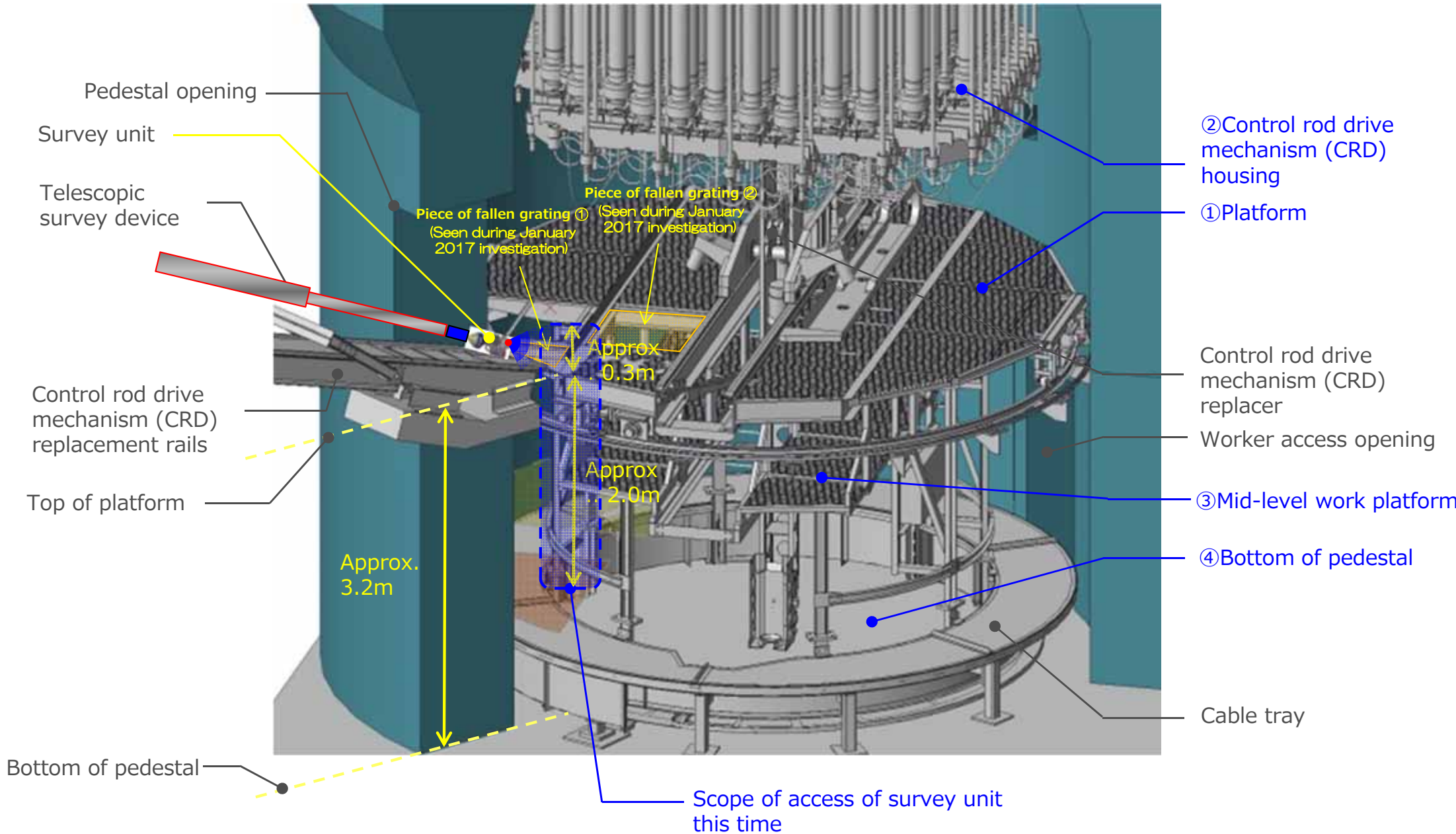
Tokyo Electric Power Company Holdings, Inc.

1. Primary containment vessel internal investigation overview

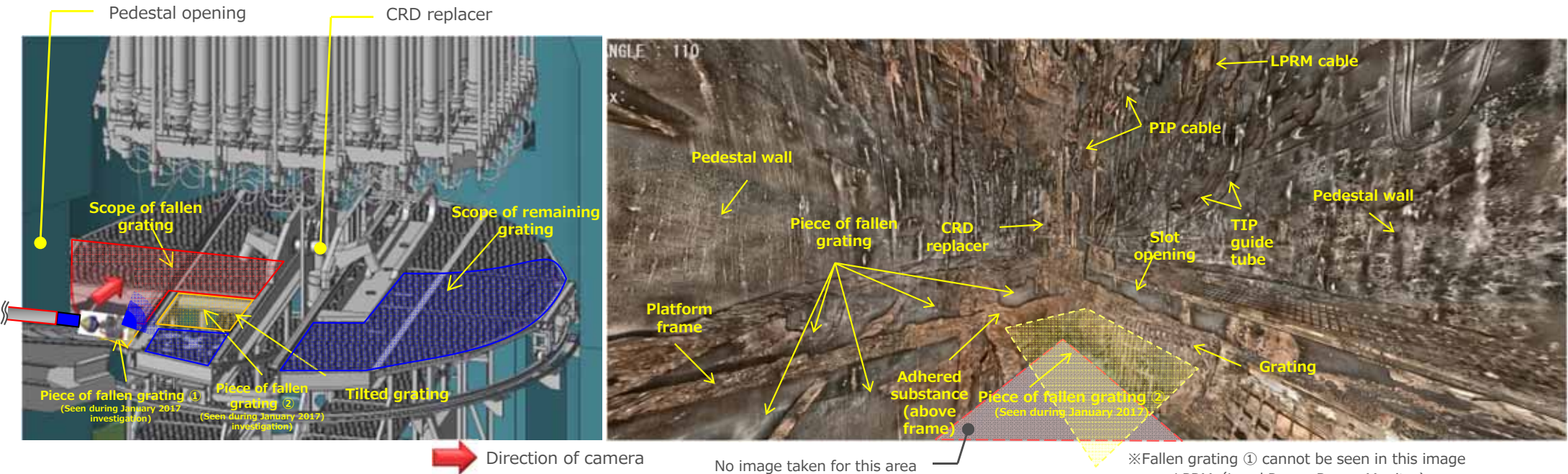
【Investigation Overview】 : The investigation focused on the area beneath the platform where fuel debris might be present. (January 2018)



2. Scope of access of survey unit



3. Investigation results ① Top of Platform



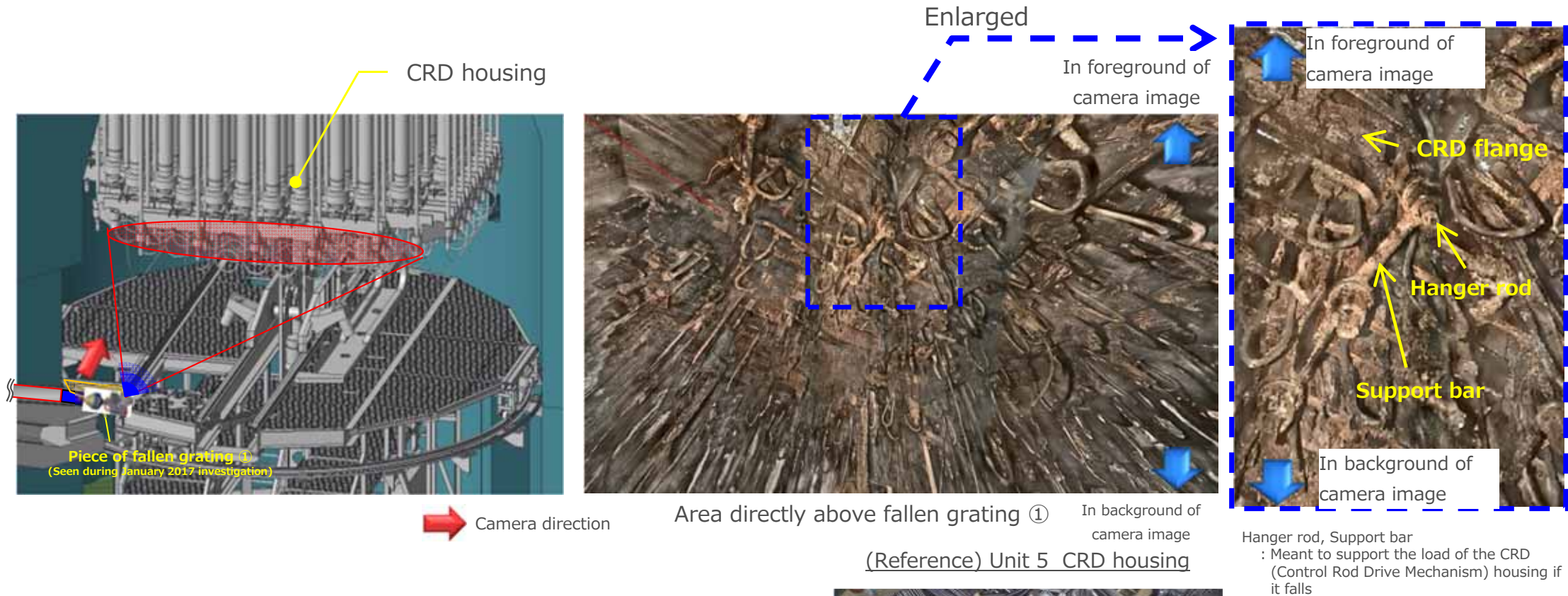
- No significant damage was seen to the CRD replacer or platform frame, etc., and the conditions of these objects remain unchanged from the last investigation (January 2017).
- Structures in the foreground of the camera image (TIP guide tube, PIP cable and grating, etc.) were found to be damaged and fallen, which may indicate the path of the fallen fuel debris in consideration of the relatively large amount of adhered substances on top of the platform frame.
- Blind spots in the background of the camera image prevent observation of structure deformation or damage, as well as the conditions of the fallen grating and adhered substances.
- As with the previous investigation (January 2017) no damage was seen to the inner walls of the pedestal within the scope of the observed area.

※Fallen grating ① cannot be seen in this image
 LPRM (Local Power Range Monitor)
 : Measures the level of neutron flux in the reactor
 TIP (Traversing In-core Probe)
 : Used to calibrate the LPRM
 PIP (control rod Position Indicator Probe)
 : Used to detect the position of the control rods



3. Investigation results

② Around CRD housing (1/2)



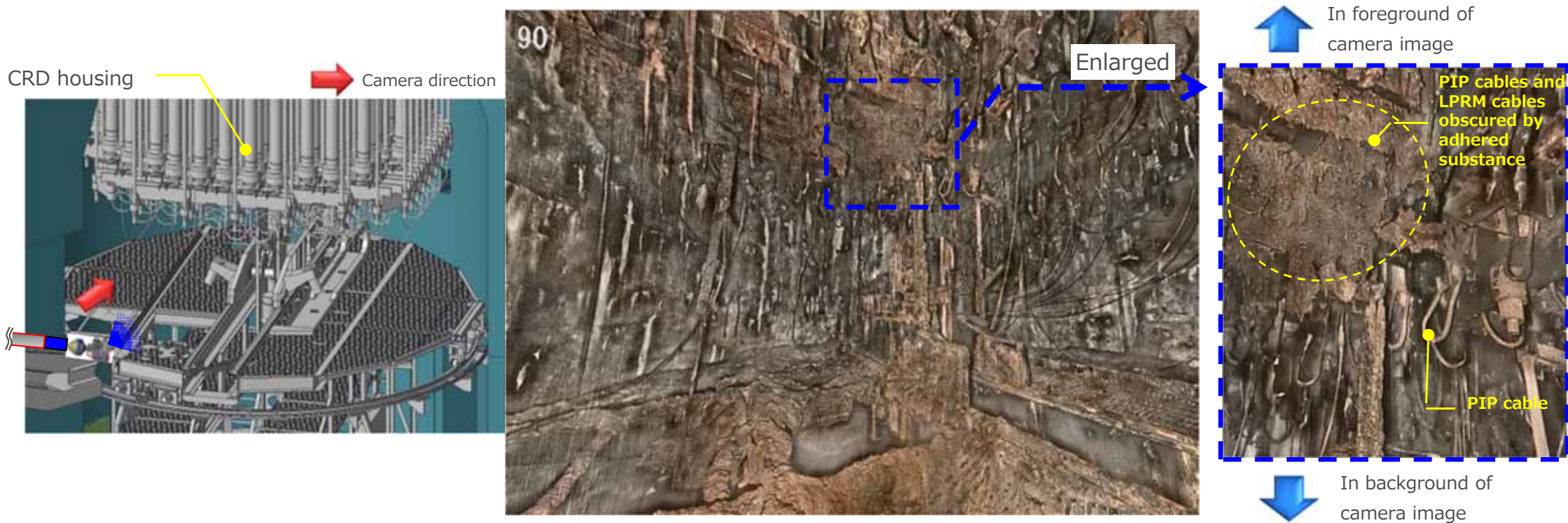
Hanger rod, Support bar
: Meant to support the load of the CRD (Control Rod Drive Mechanism) housing if it falls

- The CRD housing supports directly above the piece of fallen grating ① shows no significant deformation or damage and remains unchanged since the last investigation (January 2017)
- Within the scope that was investigated none of the CRD housing supports appear to have fallen.



3. Investigation results

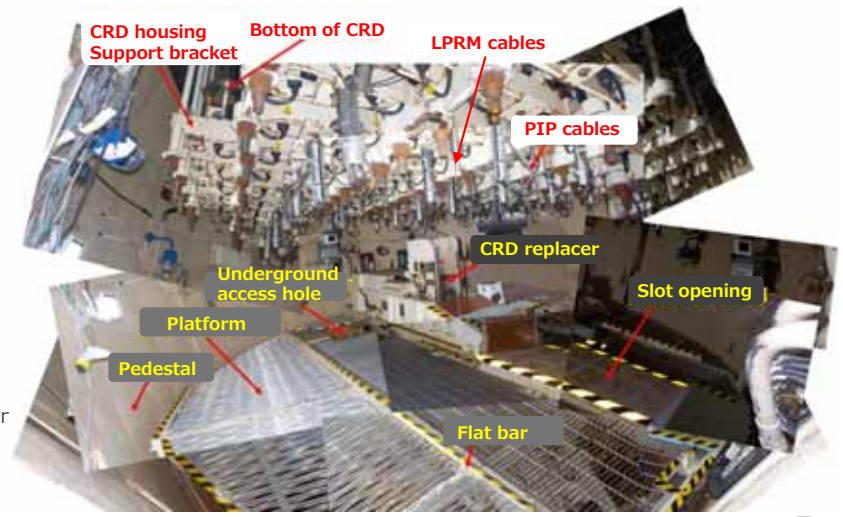
② Around CRD housing (2/2)



(Reference) Inside Unit 5 pedestal

- Parts of the TIP guide tube, PIP cables and LPRM cables could not be observed due to adhered substances.
- The grating directly below the areas where parts of the TIP guide tube, PIP cables and LPRM cables could not be observed was found to have fallen.

LPRM (Local Power Range Monitor)
: Measures the level of neutron flux in the reactor



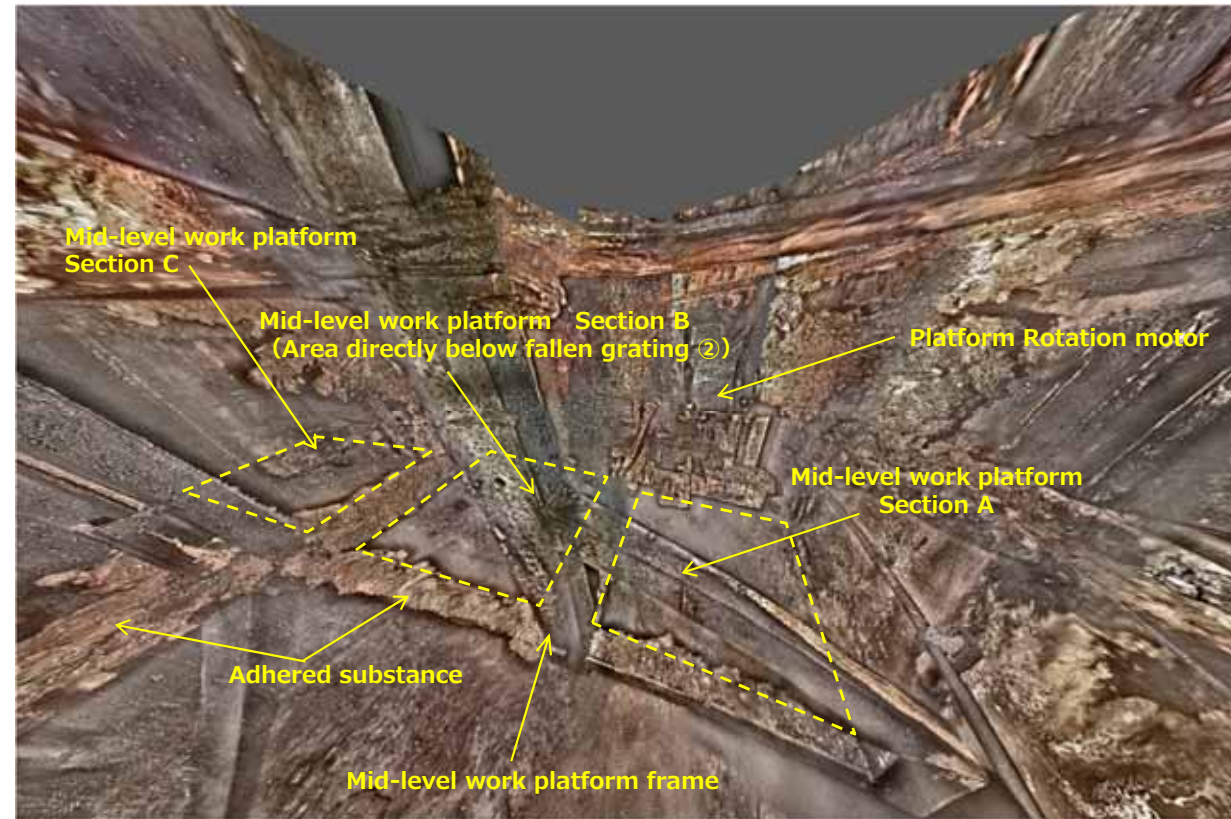
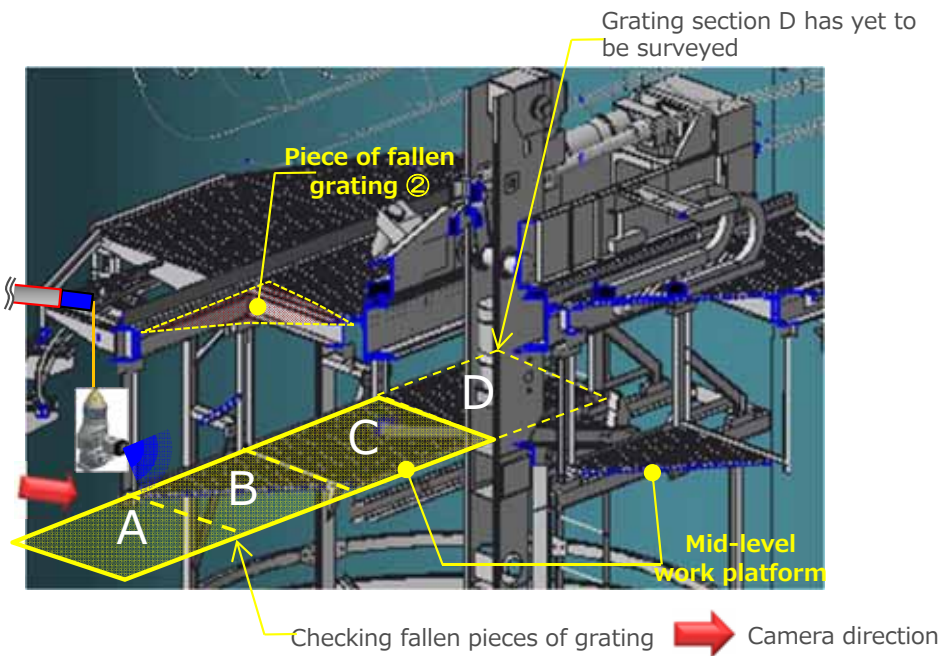


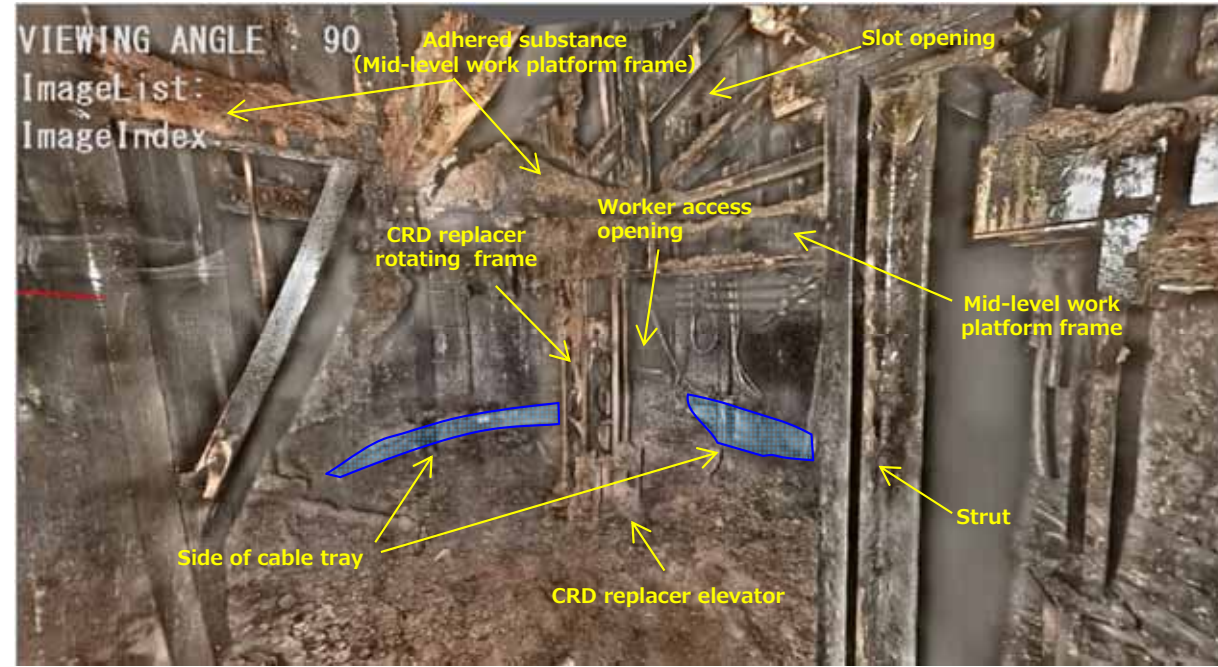
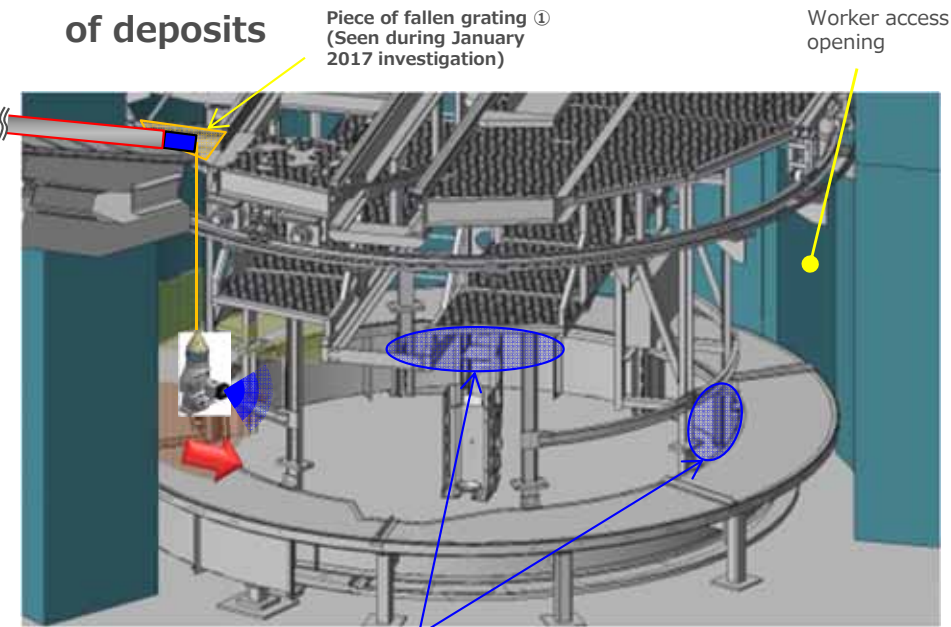
Image source and rendering: International Research Institute for Nuclear Decommissioning (IRID)

- It was confirmed that the grating (Sections A~C) in the foreground of the location where the camera was lowered has fallen. Locations where Section B and C grating has fallen show the same conditions as the platform.
- No significant deformation or damage was seen to the mid-level work platform frame

3. Investigation results

④ Bottom of pedestal (1/4)

○ Condition of structures and distribution of deposits



- No significant deformation or damage was seen to structures such as the CRD replacer rotating frame, mid-level work platform frame, struts, or cable trays, etc.
- Pebble and clay-like deposits cover the entire bottom of the pedestal.
- Although the deposits appear to be solidified molten material, it is possible that the temperature of the deposits when this substance started to accumulate on top of the cable tray was not hot enough to cause deformation of the cable trays in consideration of the fact that no deformation of the cable trays (4mm thick stainless steel) could be observed.

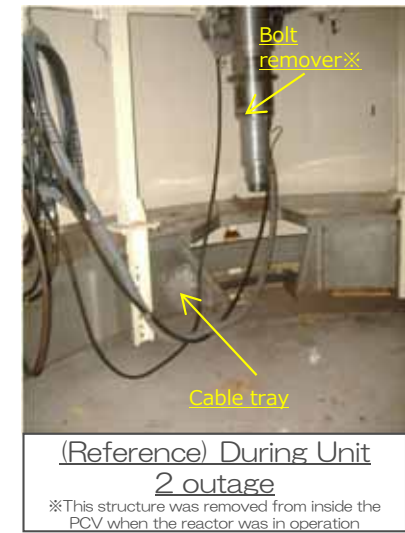
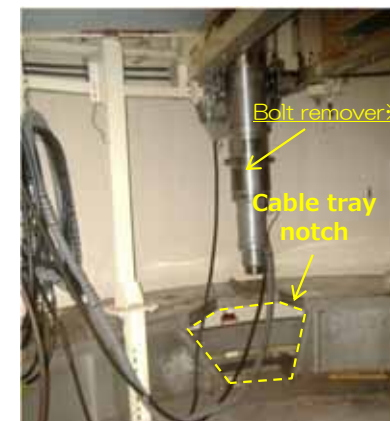
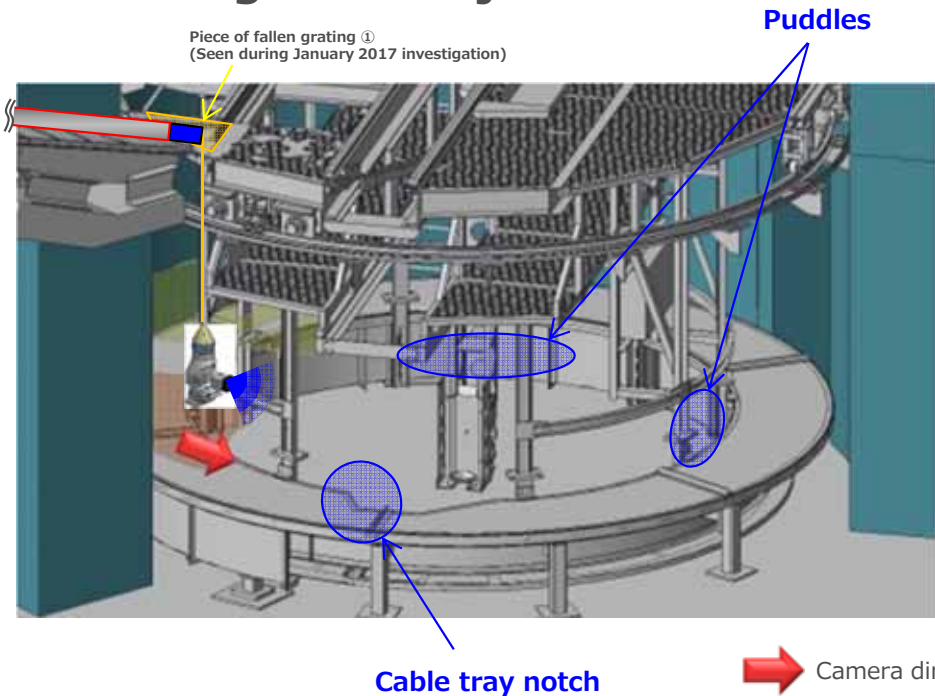


Image source and rendering: International Research Institute for Nuclear Decommissioning (IRID)

○ Cooling water injection status



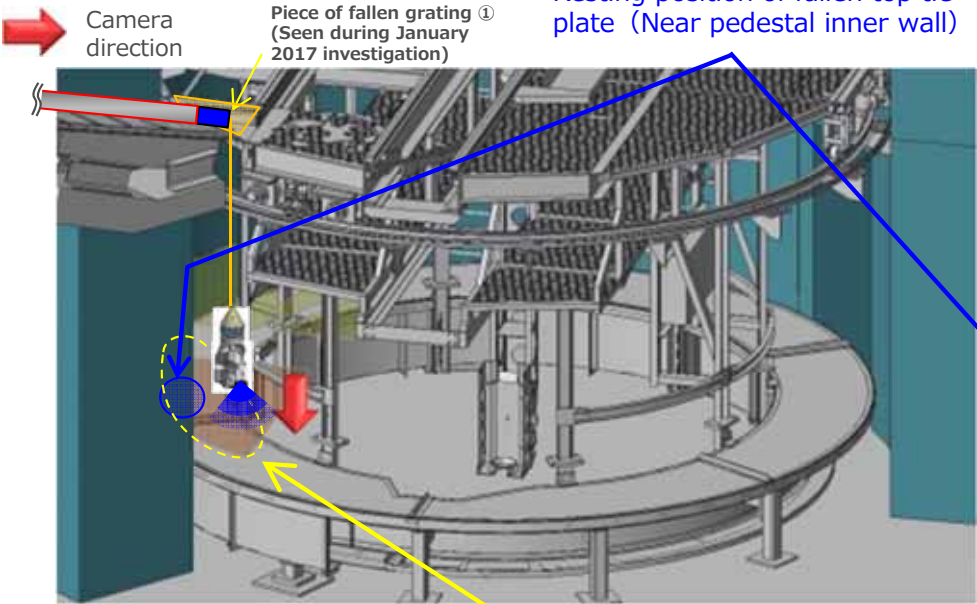
- Considering that cooling water is pouring in and that the temperature around the bottom of the pedestal is approximately 21°C it is assumed that the deposits are being kept cool and stable by the cooling water that's being injected.
- Puddles were found on the side of the worker access opening and in cable trays through the cable tray notches.

(Reference) During Unit 2 outage
 ※This structure was removed from inside the PCV when the reactor was in operation

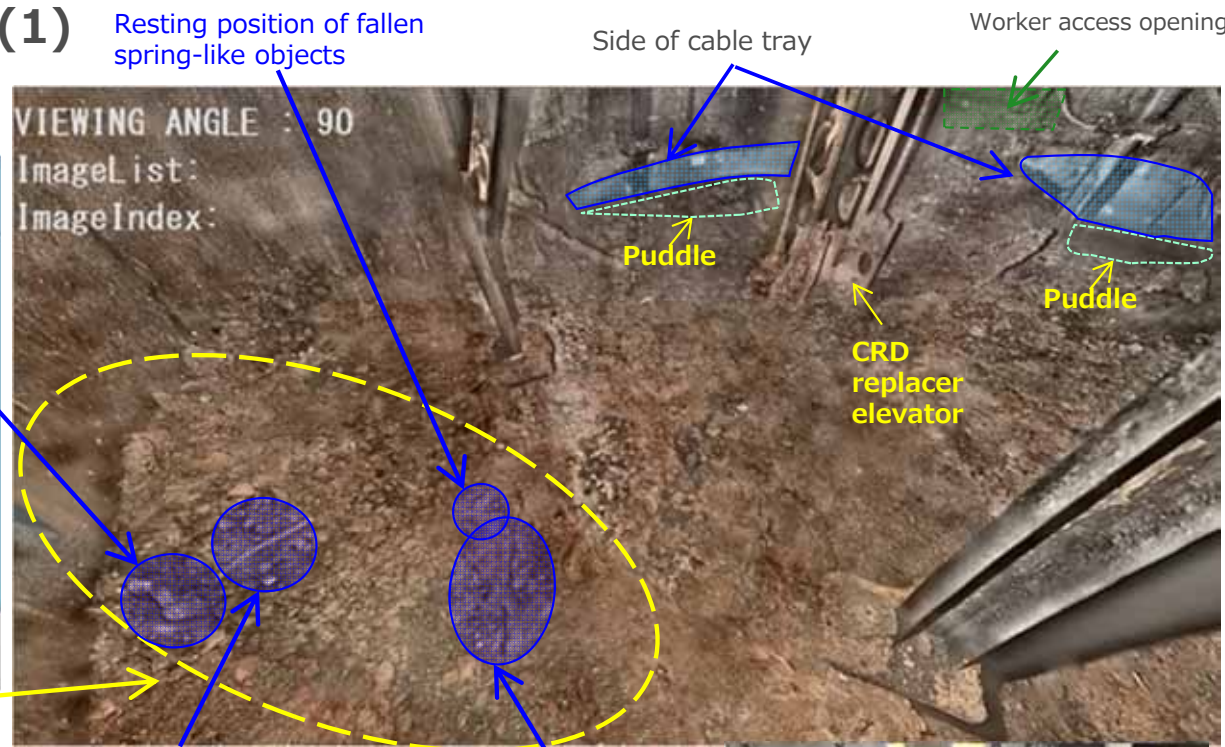
3. Investigation results

④ Bottom of pedestal (3/4)

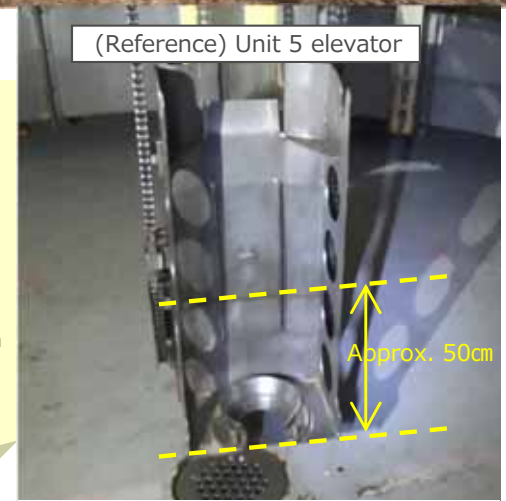
○ Detailed look at deposit distribution (1)



Area where deposits are relatively high (Directly below fallen platform grating ①)



- When looking at the center of the pedestal from the location of the lowered camera the step in elevation that should be present around the cable tray on the left side (approximately 70cm in height) was not clearly defined thereby suggesting that the height of deposits in this area may exceed 70cm at some points. The height of deposits around the CRD replacer elevator appears to be between 40cm to 50cm considering the extent to which the elevator is buried. Furthermore, when looking from the position where the camera was lowered, it was confirmed that the height of the deposits in the area behind the elevator are lower than the cable tray.
- When viewing the left side of the center of the pedestal from the location where the camera was lowered parts of a fuel assembly (top tie plate) could be seen and fallen objects shaped like rods, pipes, and springs, could be seen in the vicinity. Furthermore, since the height of deposits in this area is higher than that in the surrounding areas, it is possible that the area directly above this location marks one of the paths by which fuel debris fell.

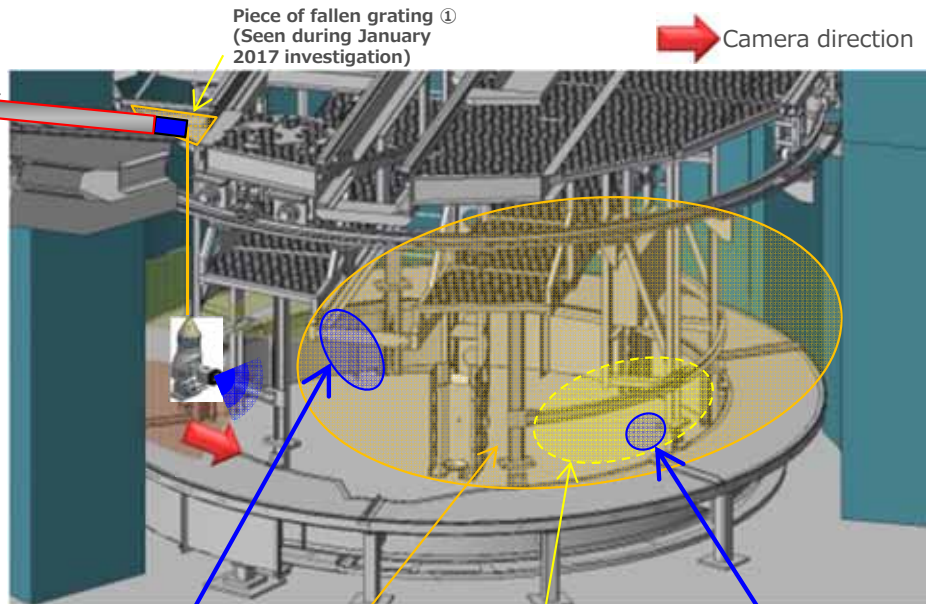


Height of deposits in which the CRD replacer elevator is buried

3. Investigation results

④ Bottom of pedestal (4/4)

○ Detailed look at deposit distribution (2)

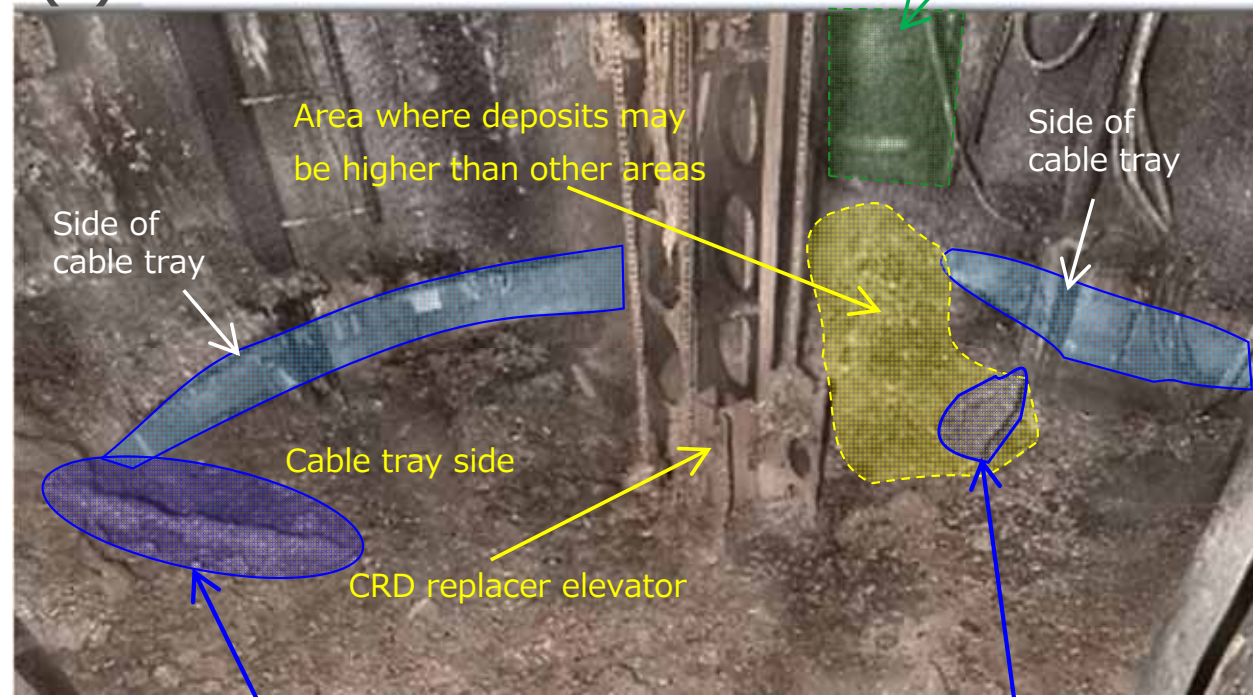


Resting place of fallen rod-like object

Area shown in photo on the right

Area where deposits may be higher than other areas

Resting place of fallen grating-like object



Resting place of fallen rod-like object

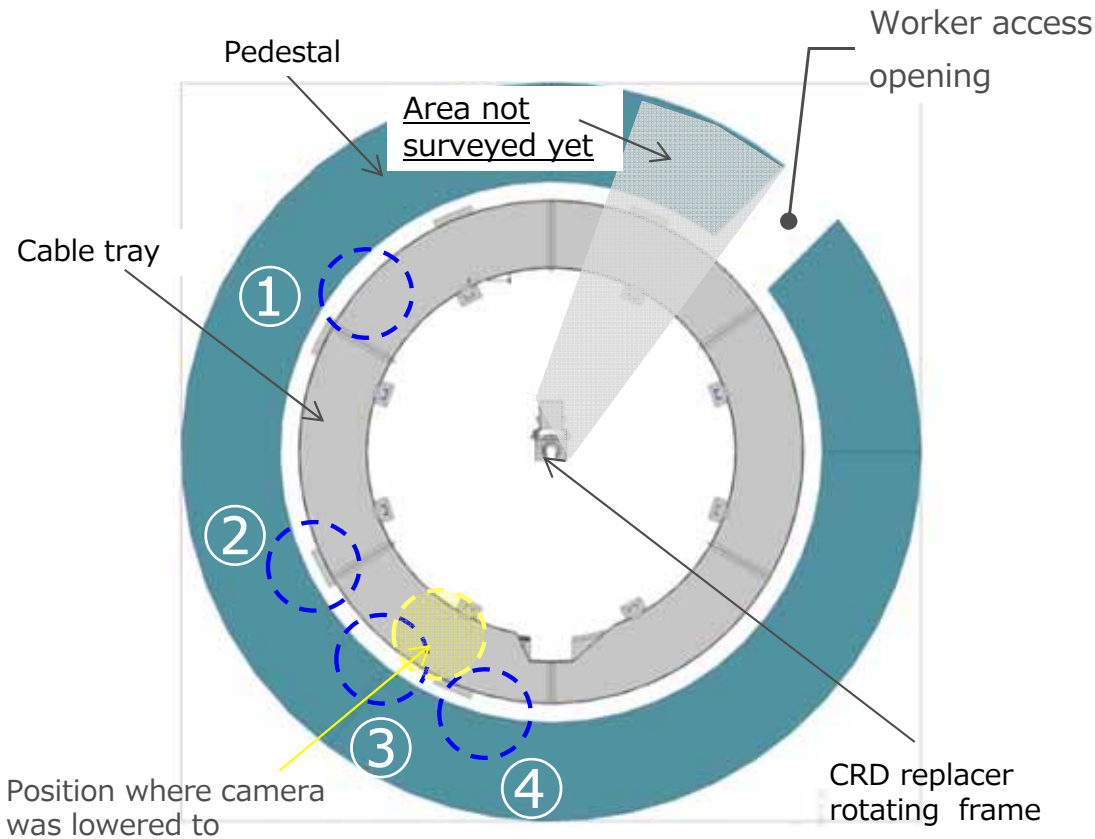
Resting place of fallen grating-like object

Image source and rendering: International Research Institute for Nuclear Decommissioning (IRID)

- Spots where the height of deposits may be higher than those in the surrounding area were found near the worker access opening. Considering the distribution of these deposits it is possible that there may be multiple locations at which fuel debris fell in addition to the location to the left of the center of the pedestal when looking from the position of the lowered camera.
- Grate-like fallen objects were found in the vicinity of the location where the height of deposits may be higher than the surrounding area.
- Rod-shaped falling objects were found near the cable tray.
- In regards to the conditions outside the worker access opening, it cannot be confirmed whether or not deposits leaked outside of the pedestal because this area cannot be seen in the images obtained during this investigation.

3. Investigation results

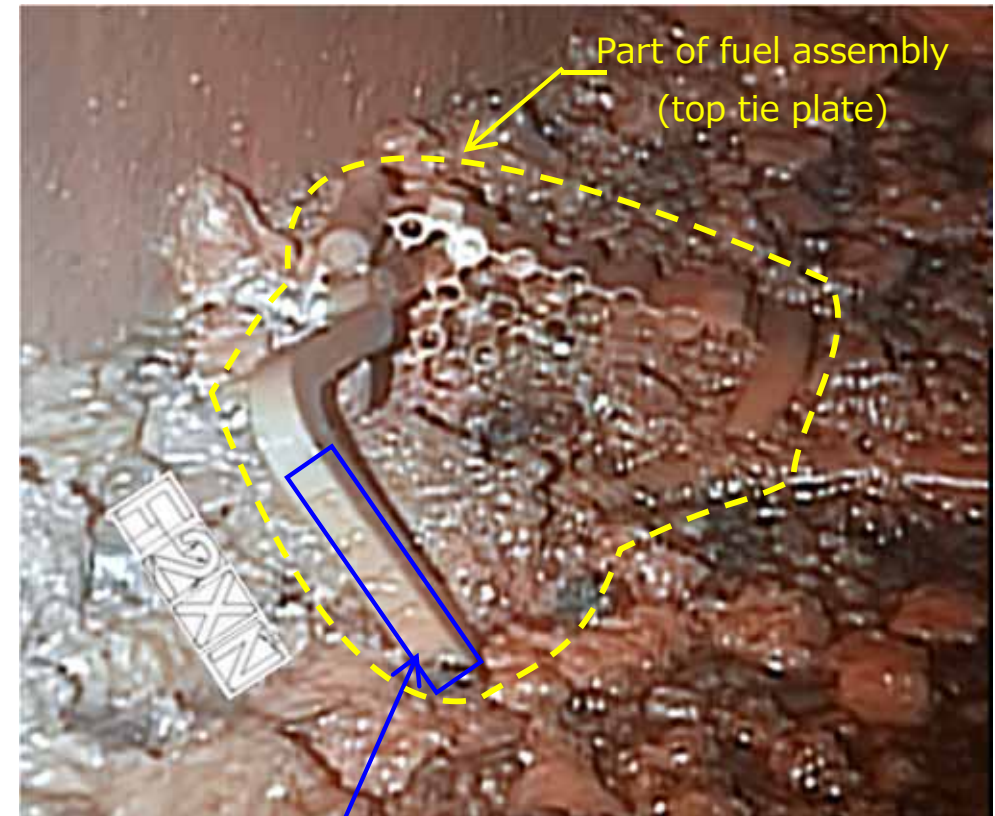
⑤ Bottom of pedestal (pedestal wall)



- Although the epoxy paint is flaking off and the surface is rough, no significant deformation or damage was found to the inner walls of the pedestal.

Image source: International Research Institute for Nuclear Decommissioning (IRID)

4. Inscription on top tie plate



- The inscription on the top type plate found at the bottom of the pedestal was examined in order to find out the charging location of the fuel assembly from which it came.
- Starting from the left the following four letters/numbers could be read: F2XN

However, since the serial number, which starts with the fifth letter in this series could not be seen we were unable to identify the charging location of the fuel assembly from which this top tie plate originated.

Location of inscription

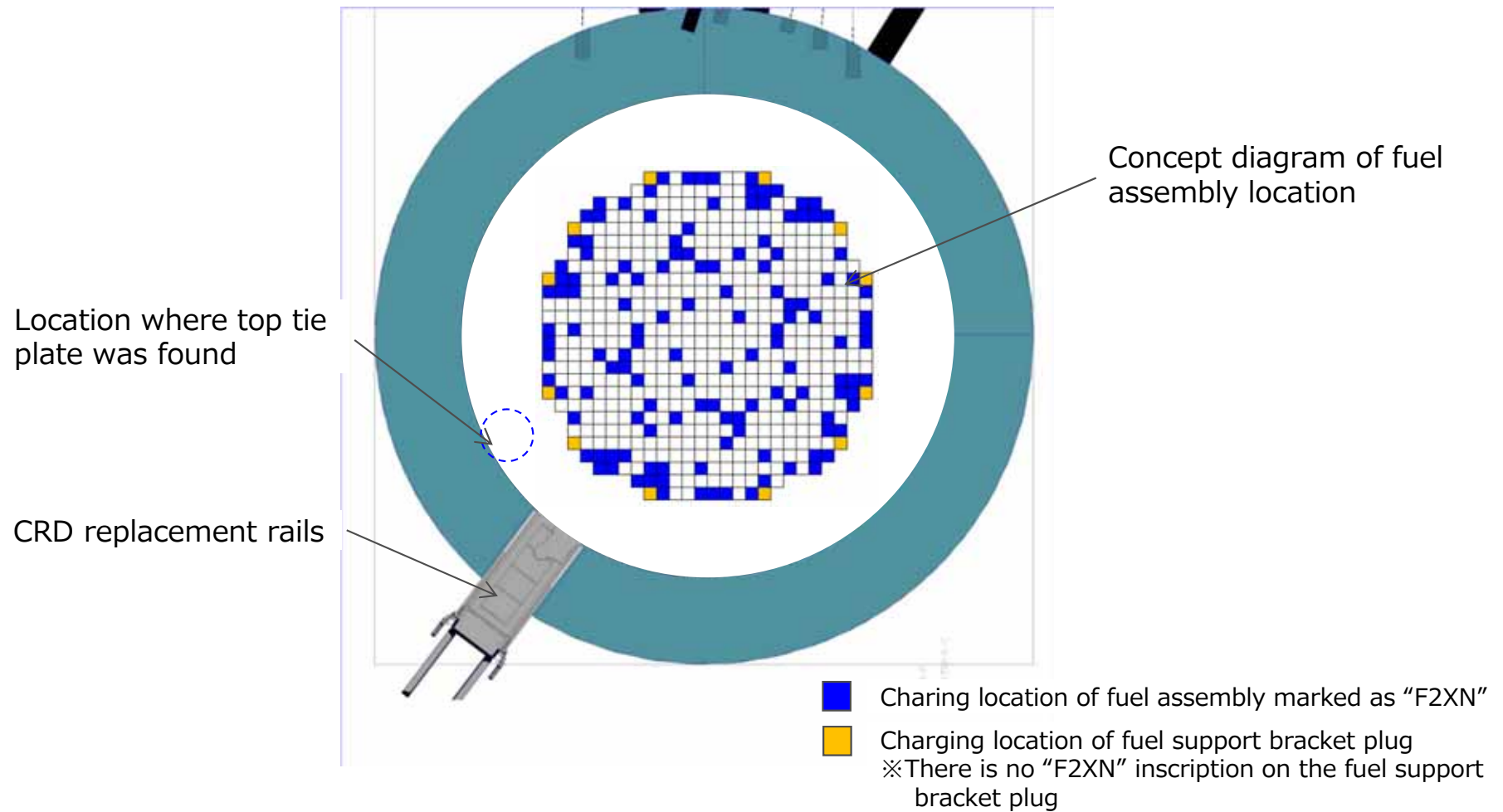
○Inscription

- The inscriptions on fuel assemblies charged into Unit 2 are between five to eight digits long
- (Plant name (F2)) + (Purchase period (V~AB)) + (Abbreviation for seller (N)) + (serial number (1~))

Image source: International Research Institute for Nuclear Decommissioning (IRID)
Image rendering: Tokyo Electric Power Company Holdings, Inc.

Supplement 1 Fuel assembly charging position

- 132 out of the total 548 fuel assemblies that were in the reactor begin with the inscription F2XN and are followed by a serial number. The locations of these fuel assemblies are shown in the diagram below.



5. Conclusion (1/2)

<Results of this investigation>

- Above the platform the structures in the foreground of the image taken with the lowered camera (TIP guide tube, PIP cable, and grating, etc.) have been significantly damaged and/or have fallen, and a relatively large amount of adhered substances were found on top of the frame.
- On the mid-level work platform grating in the foreground of the images taken with the lowered camera were found to have fallen, much like the conditions above the platform.
- At the bottom of pedestal no significant deformation was seen to the CRD replacer rotating frame, mid-level work platform frame, struts, or cable tray, etc. Furthermore, considering that cooling water is pouring in and that the temperature around the bottom of the pedestal is approximately 21°C it is assumed that the deposits are being kept cool and stable by the cooling water that's being injected.
- Since the height of the deposits at the bottom of the pedestal is higher on the left side of the center of the pedestal when viewed from the position of the lowered camera, it is possible that the area directly above this location may be one of the paths by which fuel debris fell.
- At the same time, since deposits on the side of the worker access opening are higher than in the surrounding area it is possible that there are multiple paths by which fuel debris fell.
- In regards to the conditions outside the worker access opening, it cannot be confirmed whether or not deposits leaked outside of the pedestal because this area cannot be seen in the images obtained during this investigation.

5. Conclusion (2/2)

< Results of this investigation (cont.) >

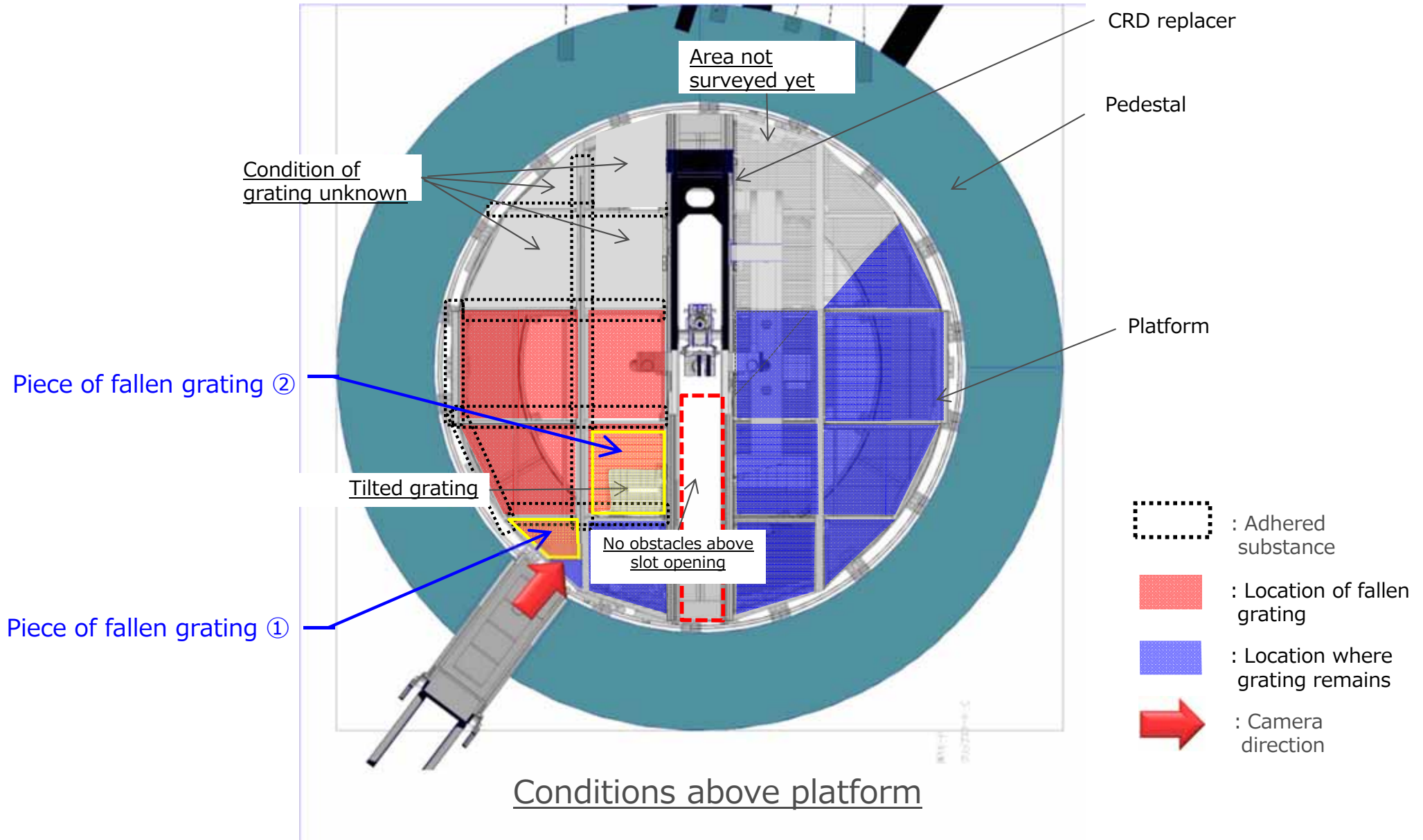
- Although the epoxy paint is flaking off and the surface is rough, no significant deformation or damage was found to the inner walls of the pedestal.
- The inscription on the top tie plate that was found to have fallen to the bottom of the pedestal could not be read completely thereby preventing the charging location of the fuel assembly from which it originated from being identified.

< Measures going forward >

- Since this investigation yielded information about the conditions at the bottom of the pedestal and the structures that exist between the platform and the bottom of the pedestal, we are deliberating the implementation of another investigation using an arm-shaped access/survey device that can be reinserted through the X-6 penetration to perform a multipurpose survey in order to ascertain dose rate distributions and a detailed distribution of structures inside the PCV which are necessary in order to deliberate methods for removing the debris.

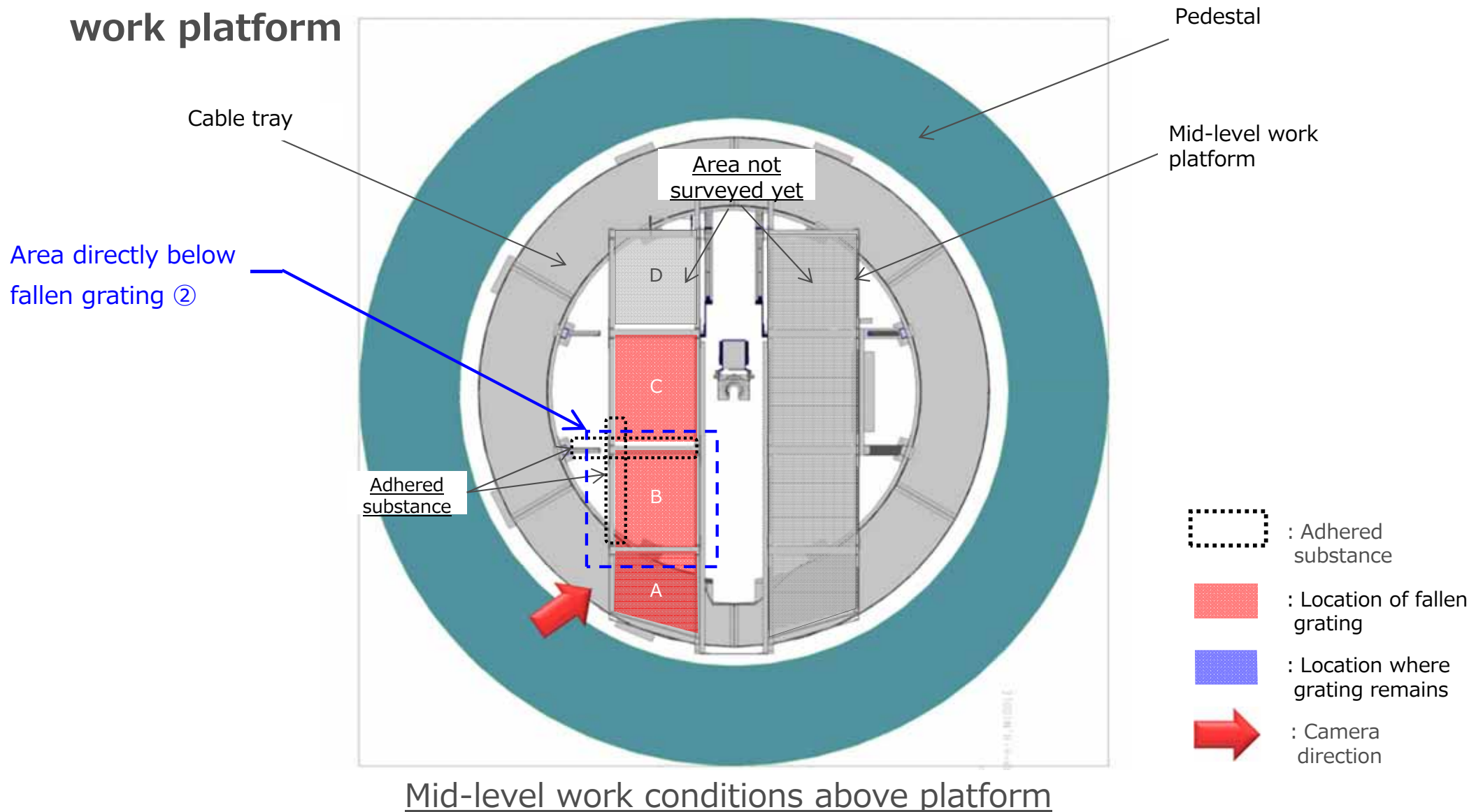
Supplement 2 Condition of structures and adhered substances found inside the pedestal (1/3)

Above Platform

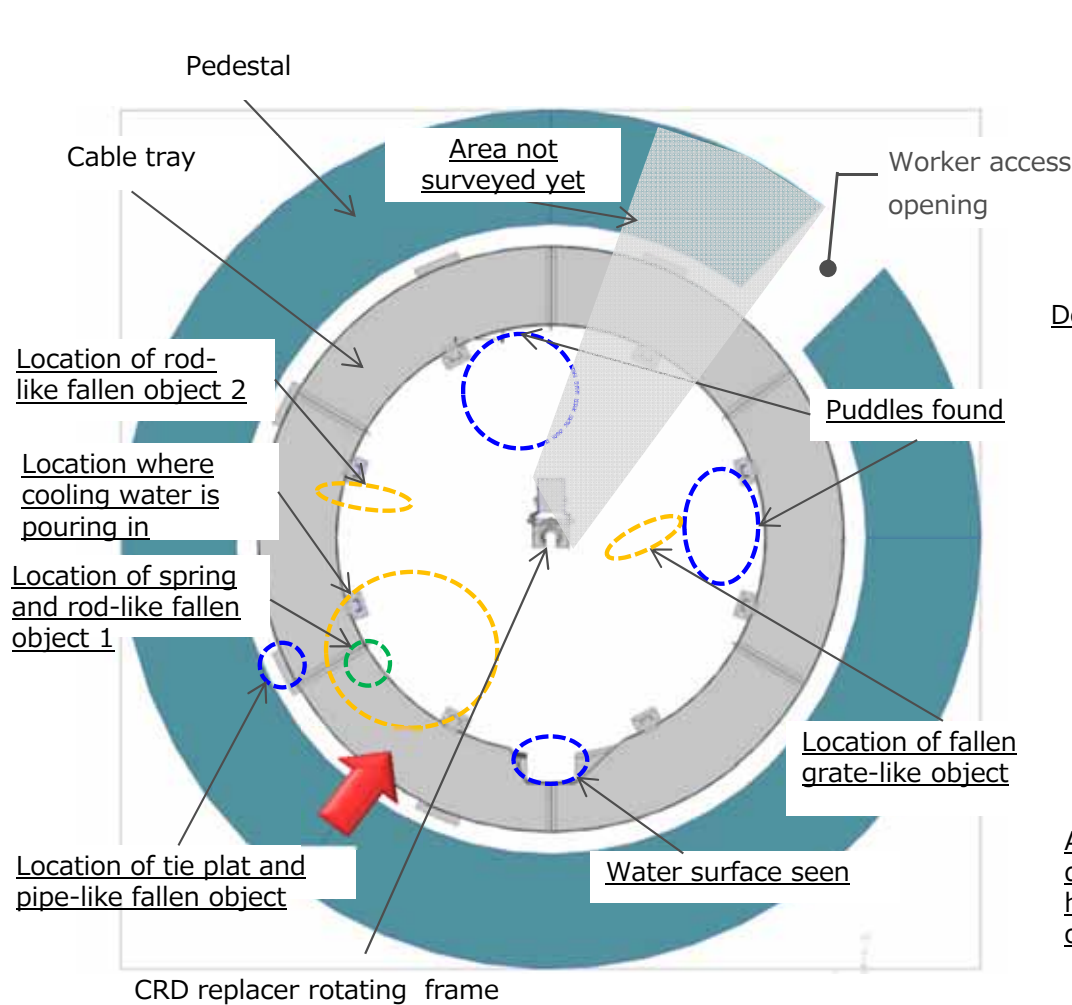


Supplement 2 Condition of structures and adhered substances found inside the pedestal (2/3)

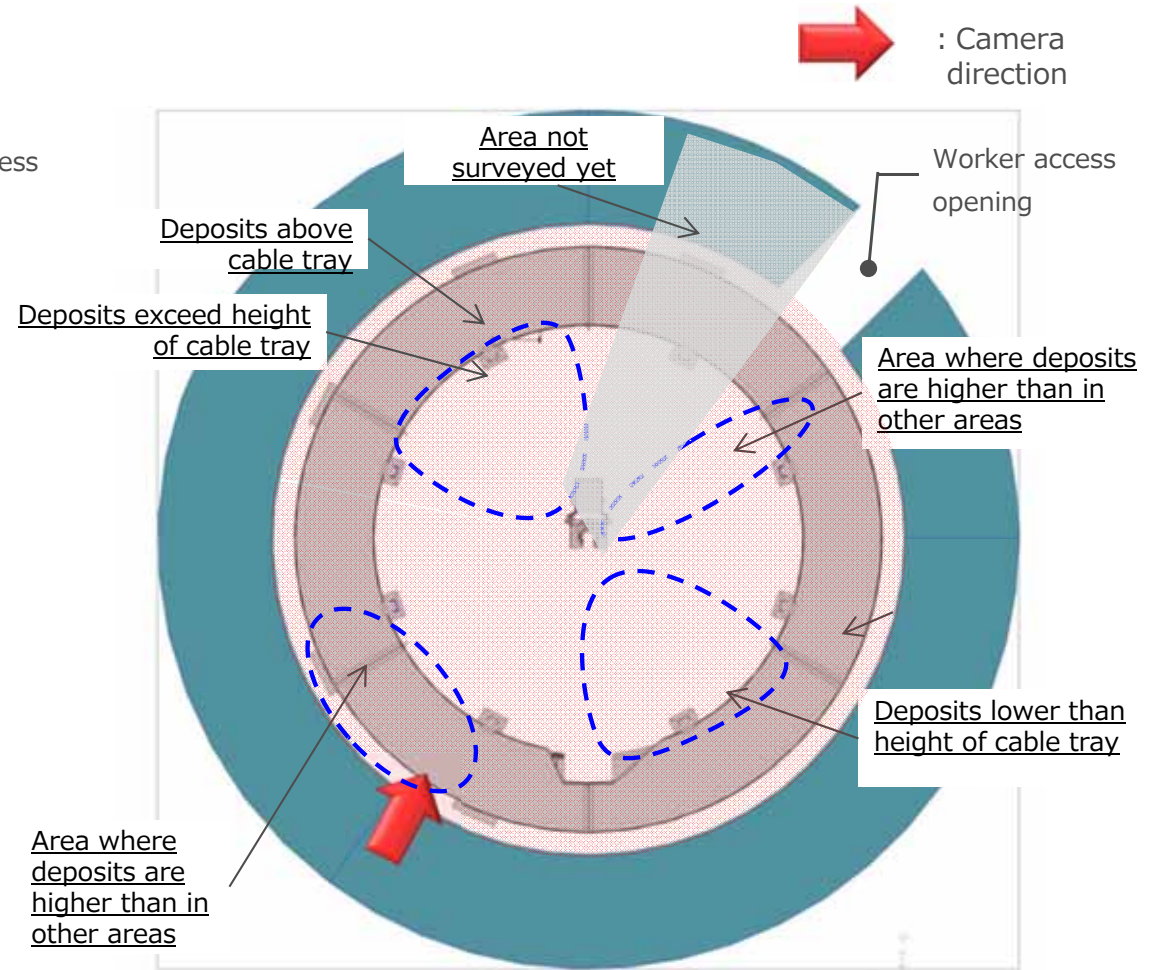
■ Around the mid-level work platform



Bottom of pedestal



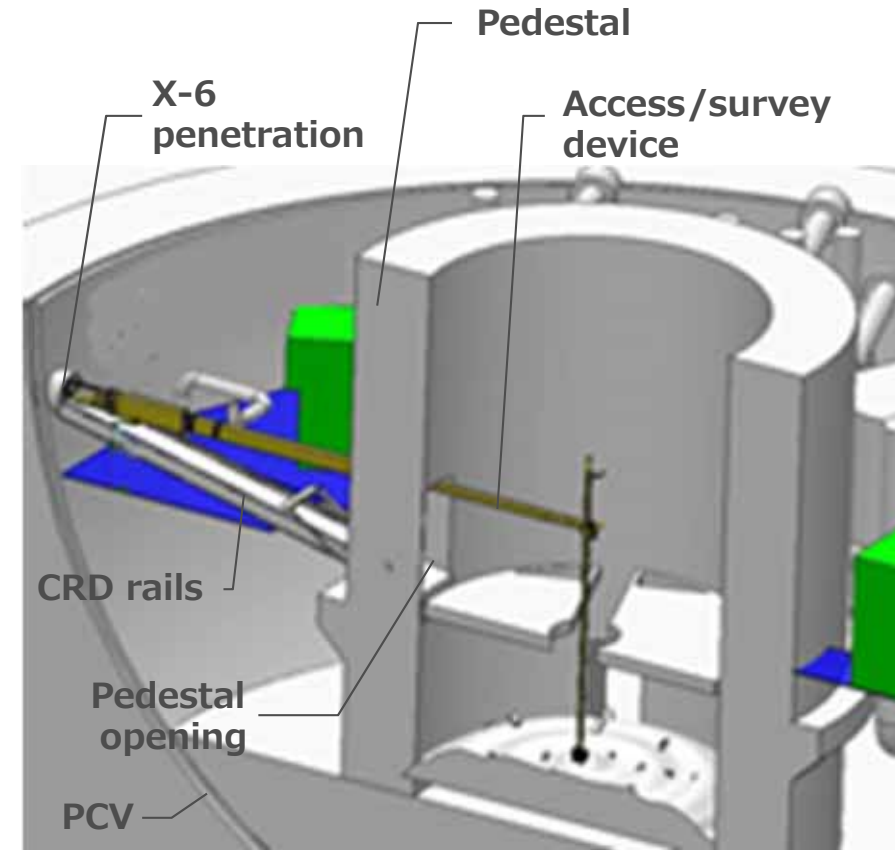
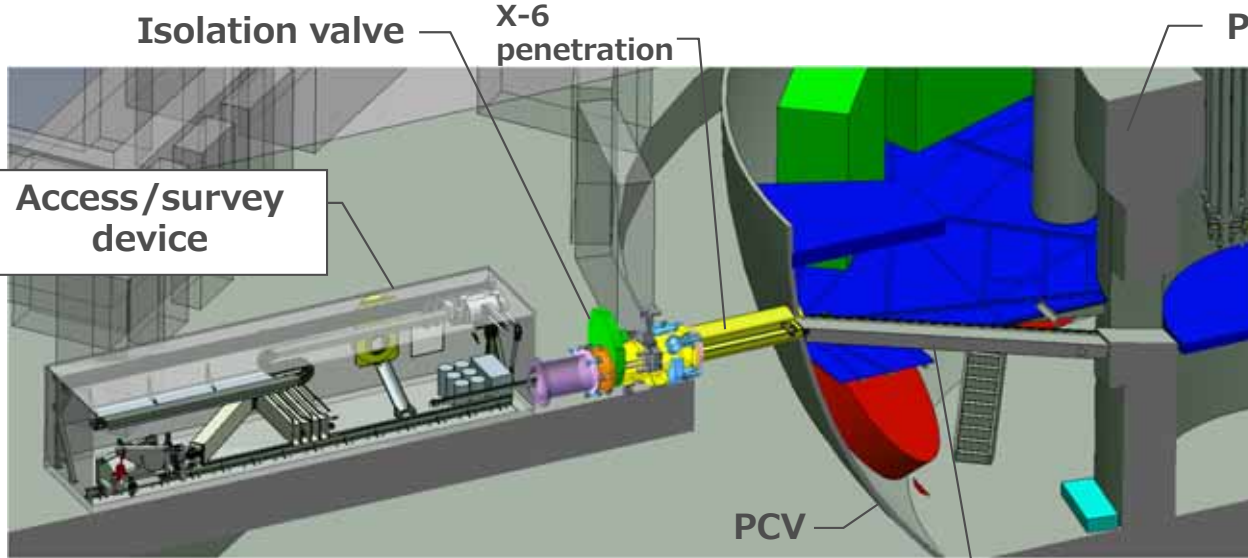
Puddles and fallen objects found at the bottom of the pedestal



Deposits found at the bottom of the pedestal

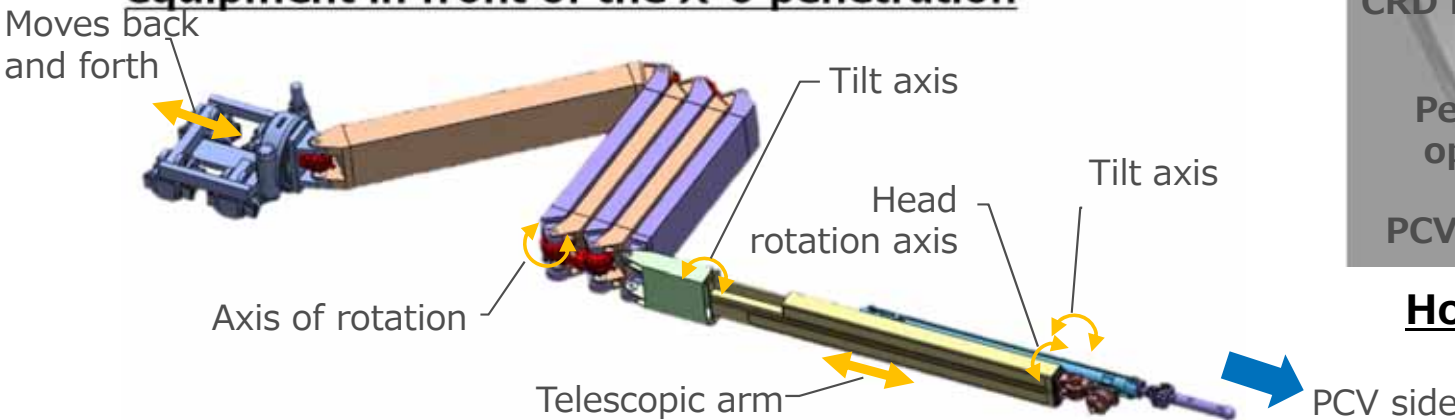
Supplement 3 Equipment for accessing and surveying the PCV through the X-6 penetration

- We are deliberating the implementation of another investigation using an arm-shaped access/survey device that can be reinserted through the X-6 penetration to perform a multipurpose survey in order to ascertain dose rate distributions and a detailed distribution of structures inside the PCV



Proposal for setting up access/survey equipment in front of the X-6 penetration

How access/survey equipment shall be used inside the PCV



Arm-shaped access/survey device

Reference 1- 1 : Other observed structures

Fallen object above rotation rails

<Visible external characteristics>

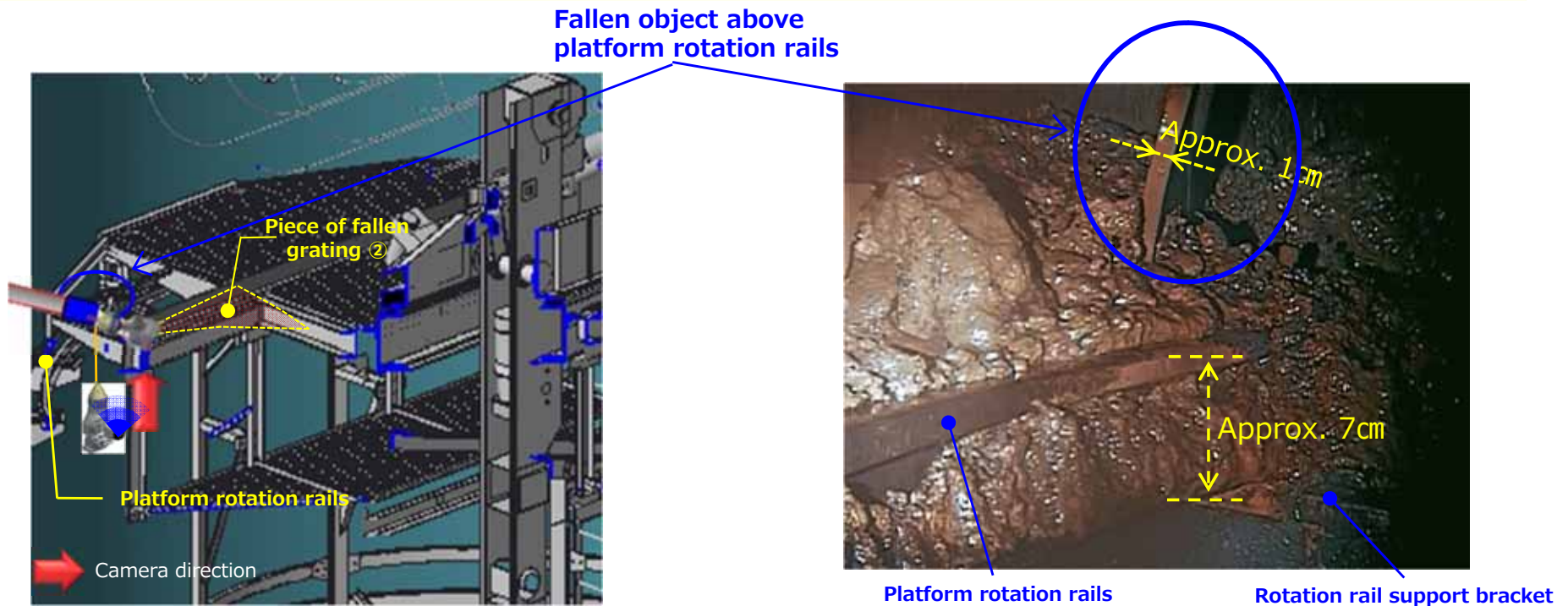
- An object resembling the handle of the top tie plate was found to have fallen on top of the platform rotation rails

<Estimated dimensions>

- Using the height of the rotation rails (approximately 7 cm) as reference, the thickness of the object thought to be the handle was estimated to be approximately 1cm which matches the design dimensions of the handle.

<Confirmed facts>

- No identifying characteristics of the handle could be seen



Fallen object above platform rotation rails

Reference 1- 2 : Other observed structures

Pipe-like fallen objects

<Visible external characteristics>

- A pipe-shaped fallen object was found near the location where the top tie plate has fallen at the bottom of the pedestal.
- A diameter difference can be seen at the end of this object

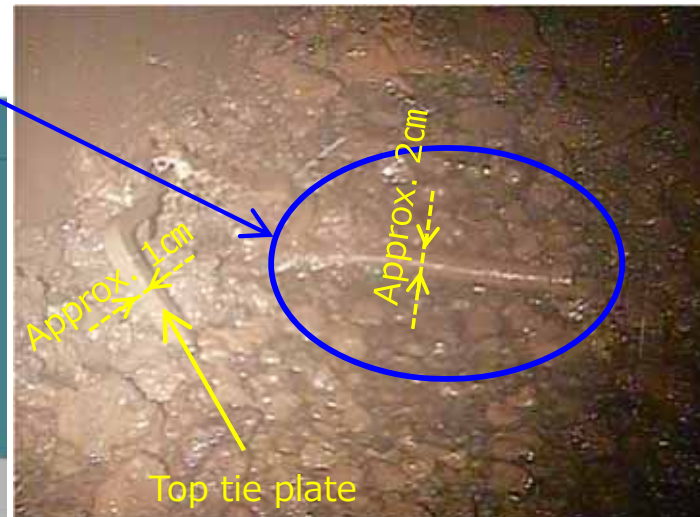
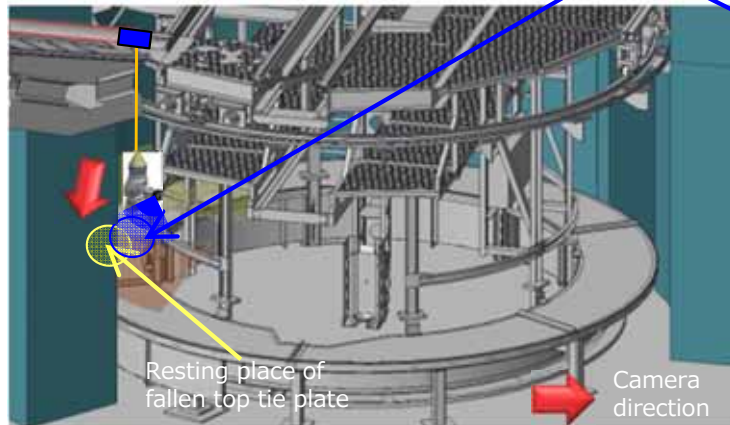
<Estimated dimensions>

- Using the top tie plate width (approximately 1cm) as reference the width of this pipe was estimated at approximately 2cm.

<Confirmed facts>

- The object could not be identified based upon the visible external characteristics and estimated dimensions

Pipe-like fallen objects



Reference 1-3 : Other observed structures

Spring-like fallen objects

<Visible external characteristics>

- A spring-shaped fallen object was found near the location where the top tie plate has fallen at the bottom of the pedestal.

<Estimated dimensions>

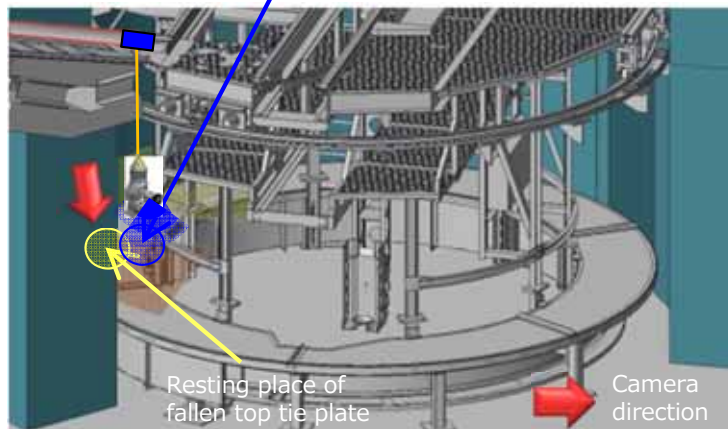
- There were no structures that could be used as reference for estimating the dimensions of this object so the dimensions were not estimated. This spring has a relatively small diameter and more than 15 coils.

<Confirmed facts>

- SRNM detectors, LPRM detector and fuel assemblies all use small diameter springs with more than 15 coils, but it could not be determined from what structure this object originated.

Location of spring-like fallen objects

SRNM (Startup Range Neutron Monitor): Measures the level of neutron flux in the reactor during startup



Reference 1-4 : Other observed structures

Rod-like fallen object (around springs)

<Visible external characteristics>

- A rod-like fallen object was found near the spring-like fallen object at the bottom of the pedestal.

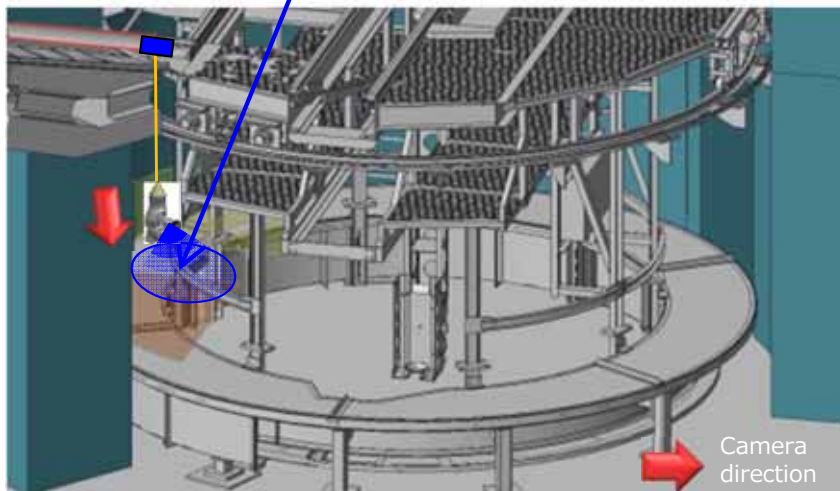
<Estimated dimensions>

- There were no structures that could be used as reference for estimating the dimensions of this object so the dimensions were not estimated.

<Confirmed facts>

- The object does not have sufficient dimensions or structural characteristics to aid in identification.

**Location of rod-like fallen object
(around location of fallen spring)**



Springs



**Rod-like
fallen object**

Reference 1- 5 : Other observed structures

Rod-like fallen object

<Visible external characteristics>

- A Rod-shaped fallen object was found at the bottom of the pedestal. The rod portion of the fallen object appears to have different diameters.

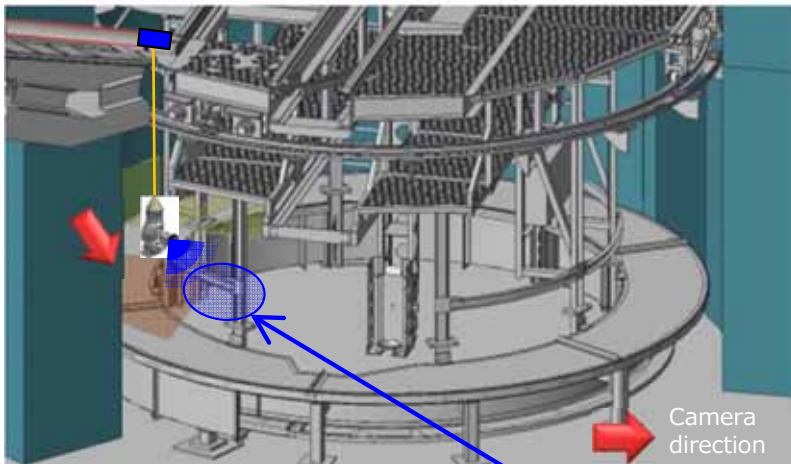
<Estimated dimensions>

- There were no structures that could be used as reference for estimating the dimensions of this object so the dimensions were not estimated.

<Confirmed facts>

- The object does not have sufficient dimensions or structural characteristics to aid in identification.

Rod-like fallen object



Location of rod-like fallen object



Reference 1- 6 : Other observed structures

Grate-like fallen object

<Visible external characteristics>

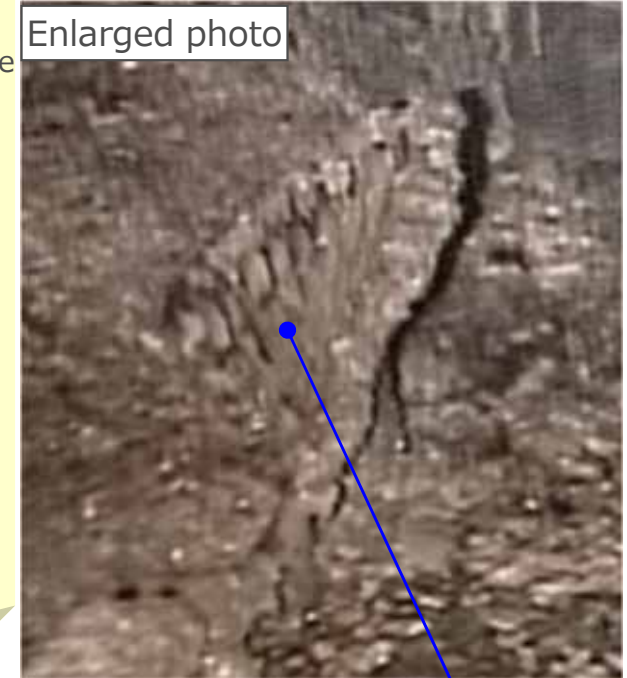
- Plate-like fallen objects were found near the CRD replacer elevator at the bottom of the pedestal. These fallen objects appear to have grating and are buried in deposits. The objects also appear to be deformed.

<Estimated dimensions>

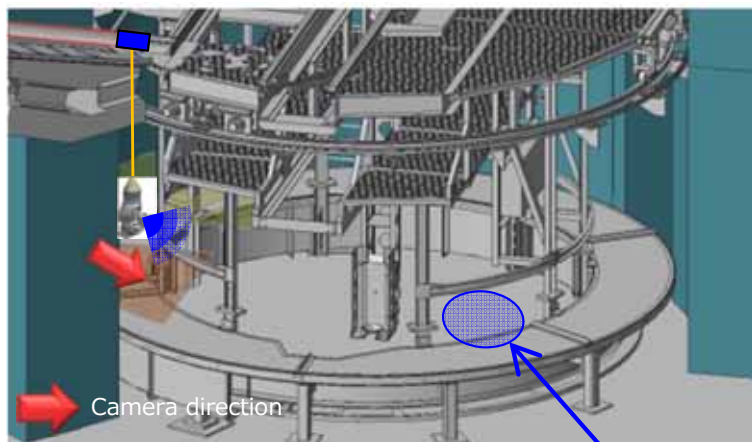
- There were no structures that could be used as reference for estimating the dimensions of this object so the dimensions were not estimated.

<Assessment results>

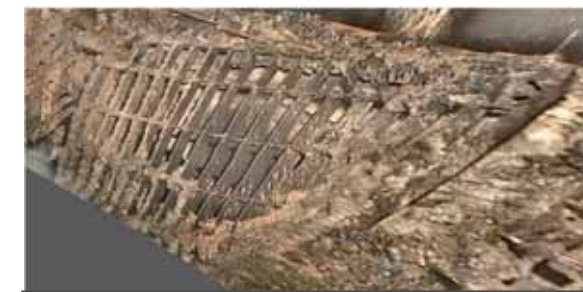
- This object is assumed to be grating based on the visible external characteristics. If it is assumed that this grating fell from directly above then it must be from the mid-level work platform because the grating on the platform still remains. However, the mid-level work platform has only been partially examined so it was impossible to identify the location from which this grating originated.



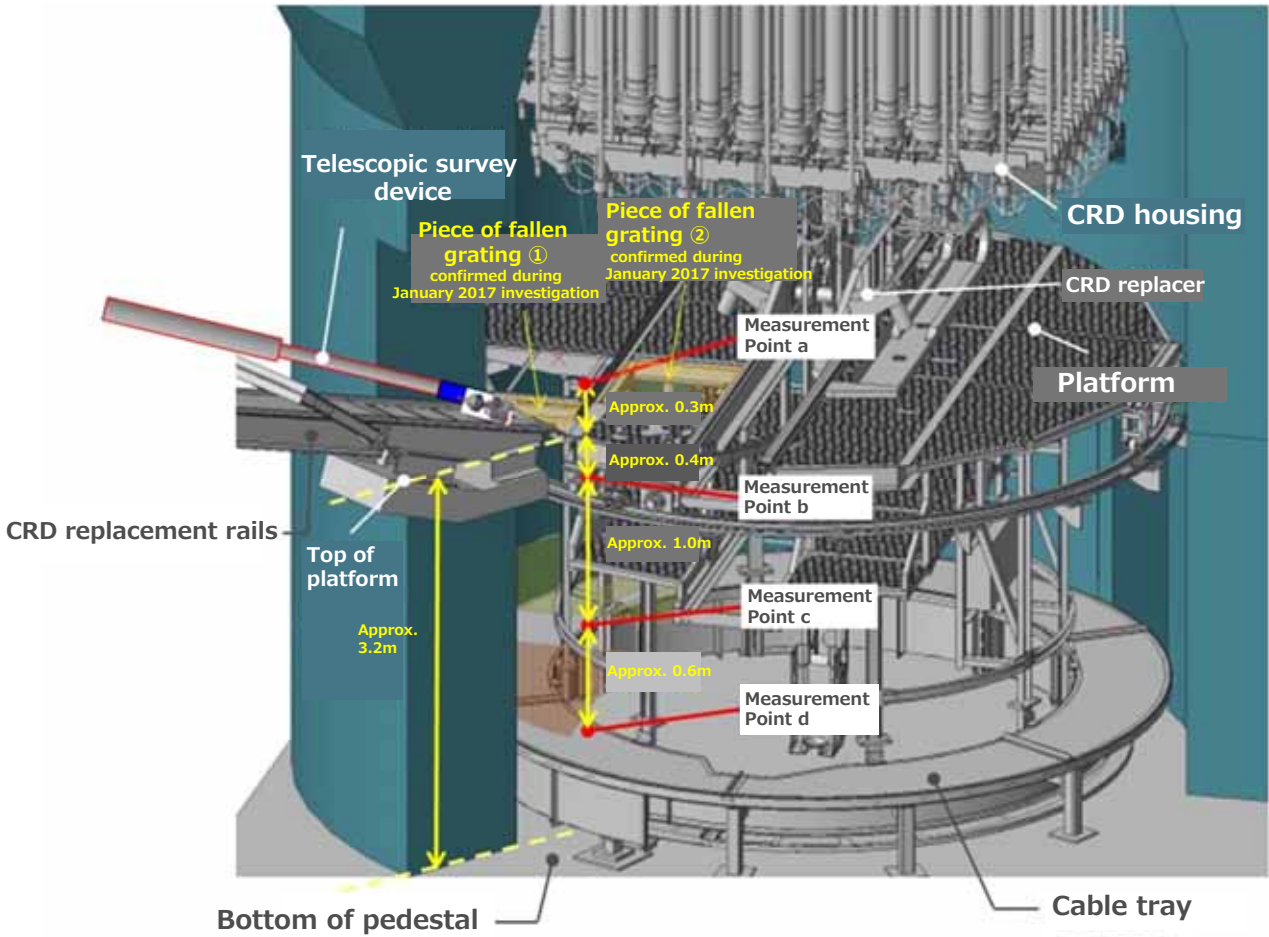
Grating-like pattern observable



Resting place of fallen grate-like object



Reference 2 : Dose rate and temperature measurements from inside the pedestal



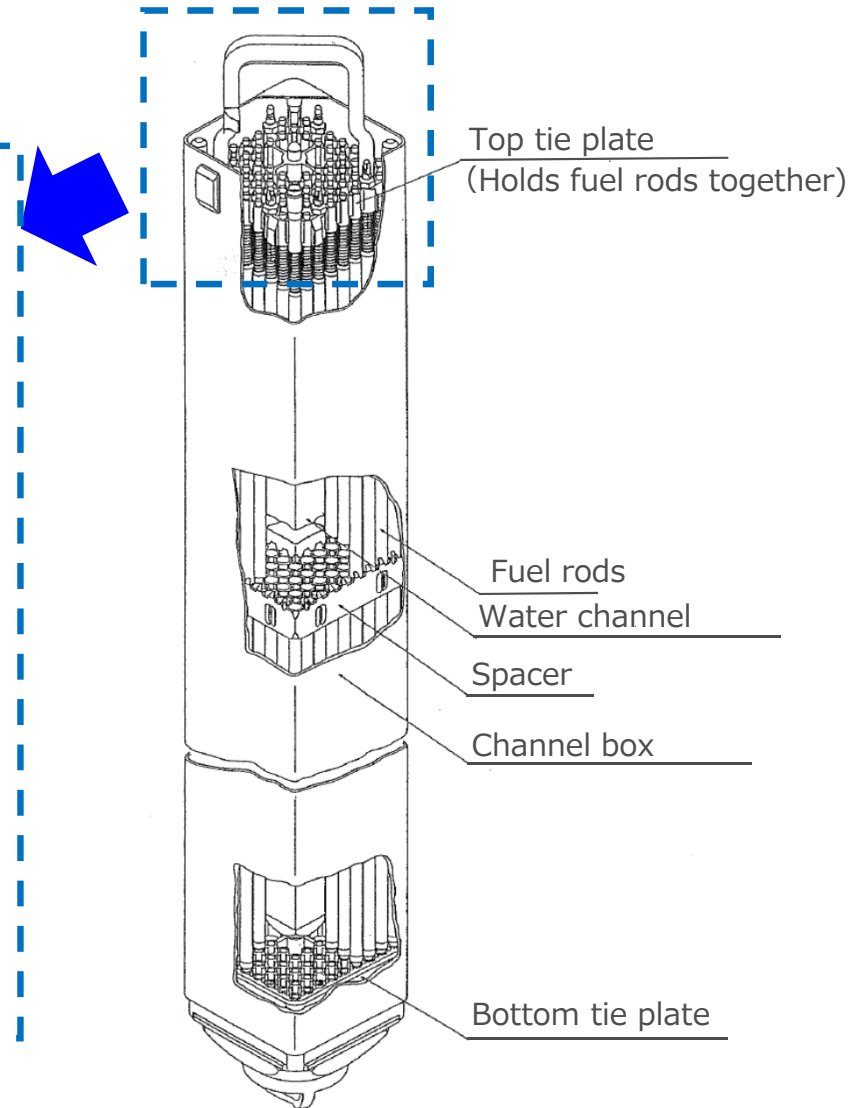
Measurement point	Dose rate ^{※1, 2} [Gy/h]	Temp. ^{※2} [°C]
a	7	21.0
b	8	21.0
c	8	21.0
d	8	21.0

※1 : Calibrated using Cs-137 radiation source
 ※2 : Degree of error:
 Dosimeter: ±7%
 Temp. gauge: ±0.5°C

Reference 3 : Overview of fuel assembly parts (top tie plate)



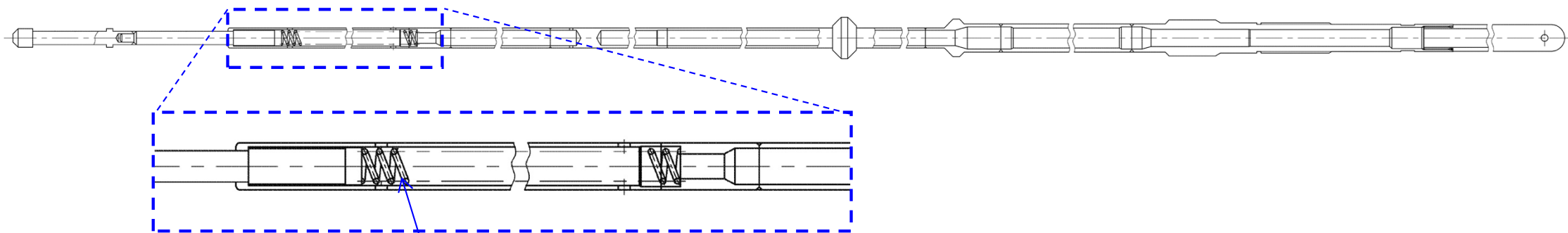
Overview of fuel assembly parts (top tie plate)



Fuel assembly diagram

Reference 4 : Example of equipment that uses springs (SRNM detector)

Up ←

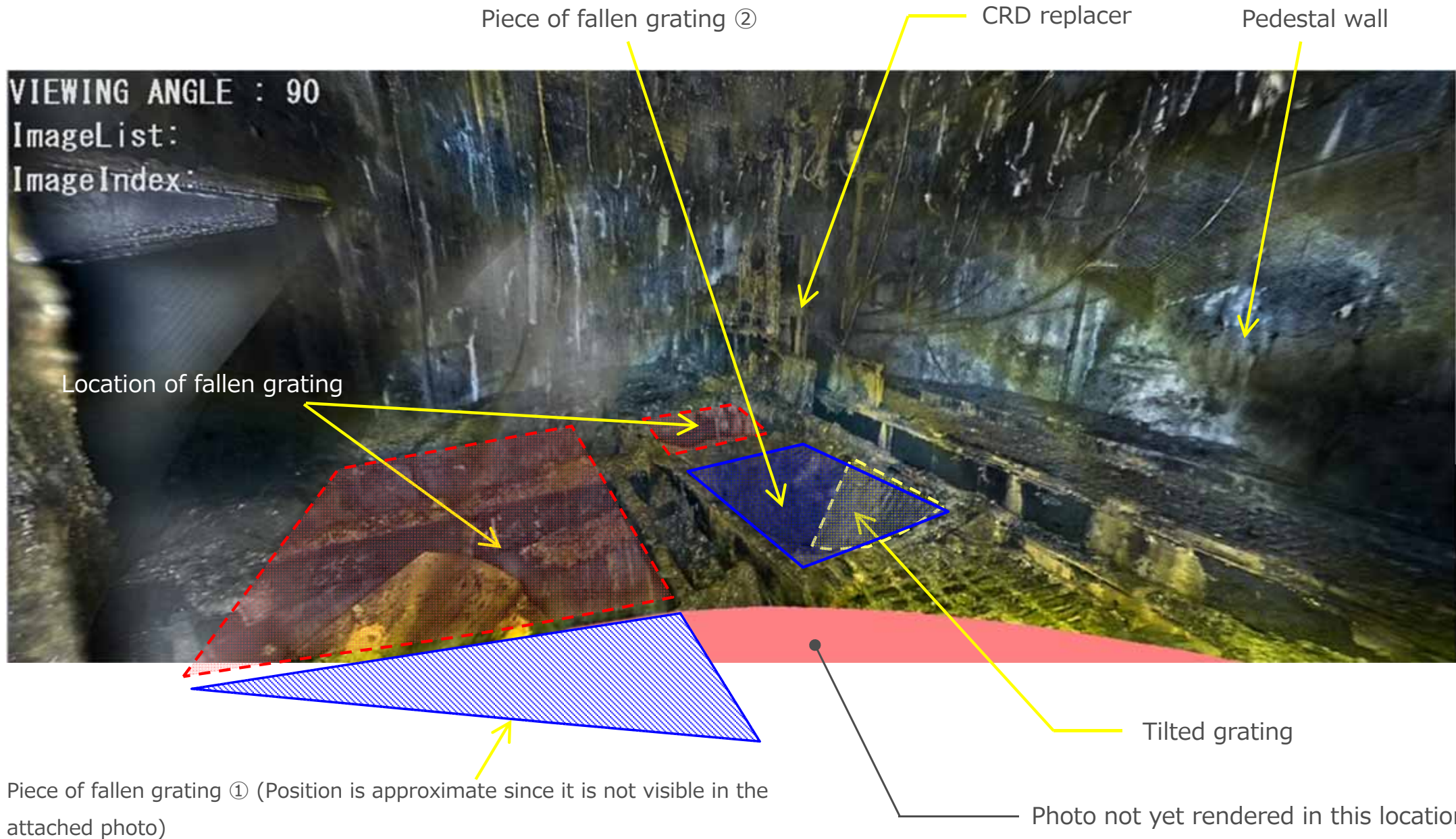


Spring (diameter: Approx. 2cm)

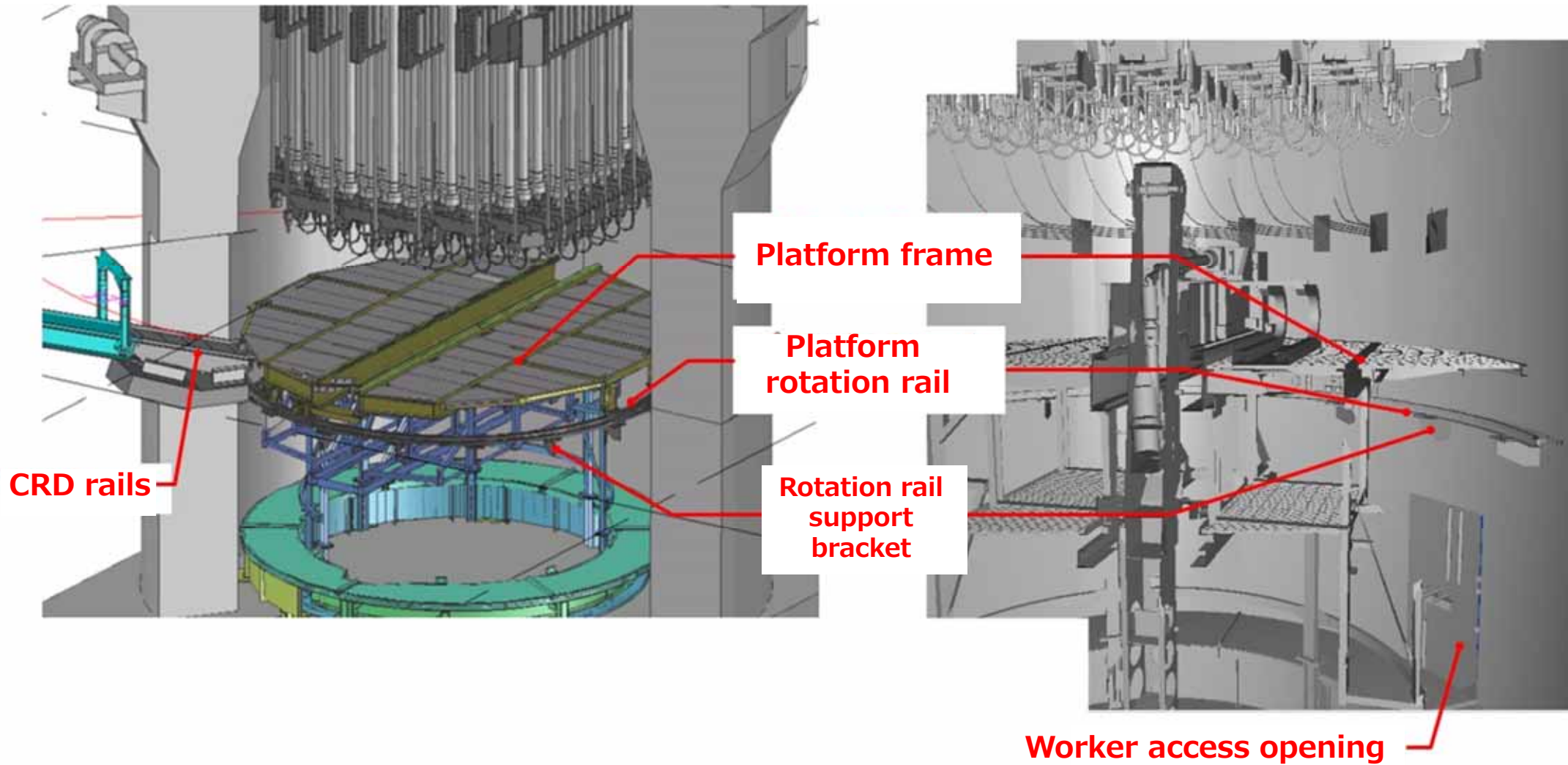
- Used to attach tip of SRNM detector to location of attachment (device attached using elastic force of spring)

External view of SRNM detector

Reference 5: Images obtained during January 2017 investigation



Reference 6 : Structures inside the pedestal



Reference 7 : Core internals

Reactor Pressure Vessel (RPV)

