Unit 3 Primary Containment Vessel Internal Investigation

November 30, 2017

Tokyo Electric Power Company Holdings, Inc.

1. Overview of the PCV internal investigation

The investigation inside the pedestal (VT) was conducted using a submersible remotely operated vehicle (submersible ROV) in July, 2017.

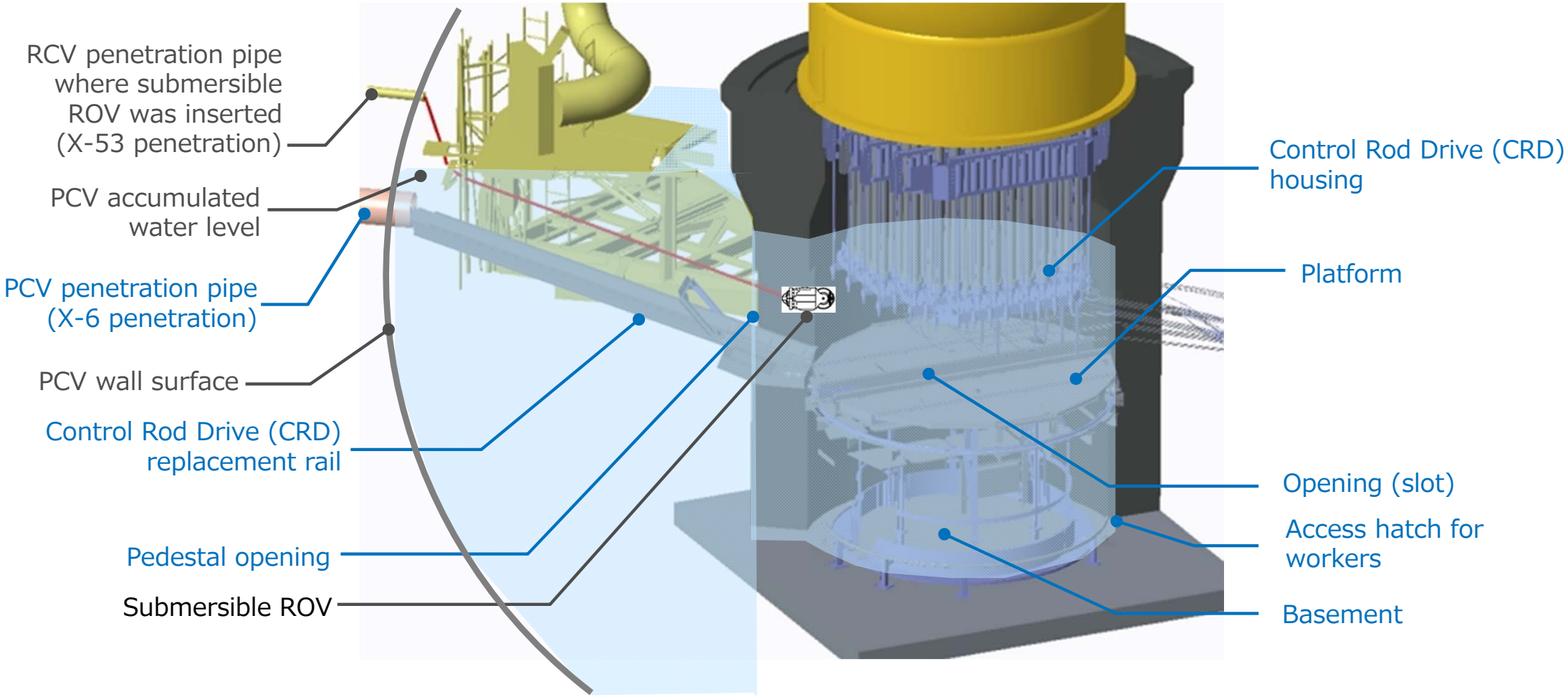
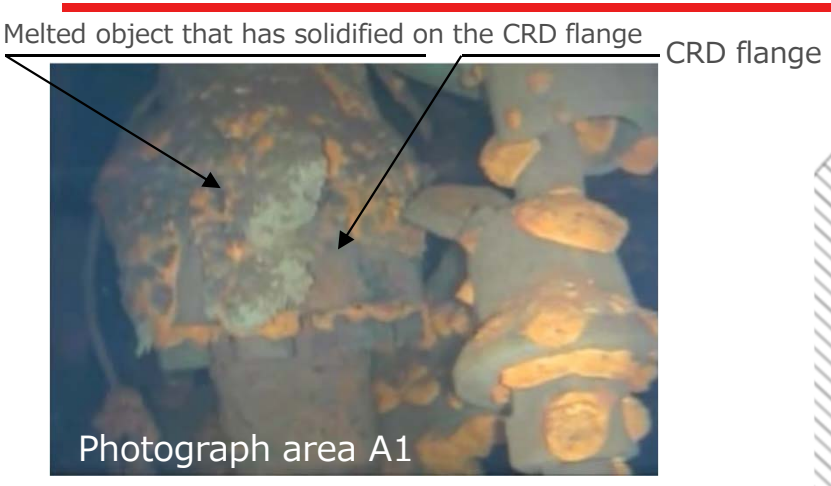
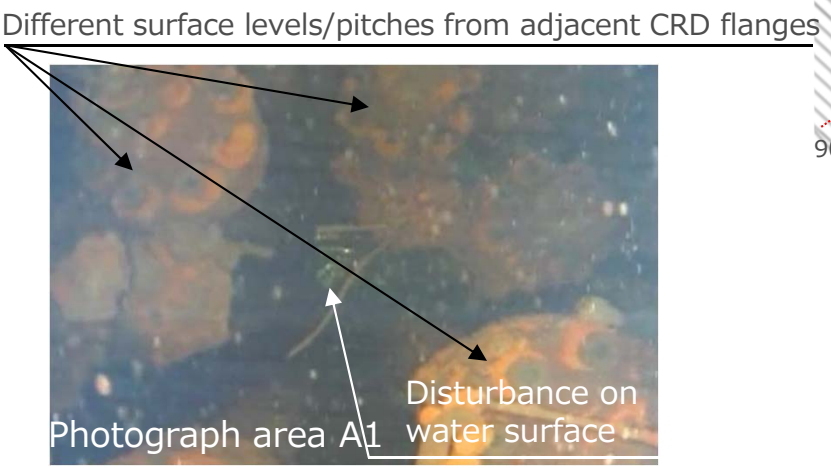
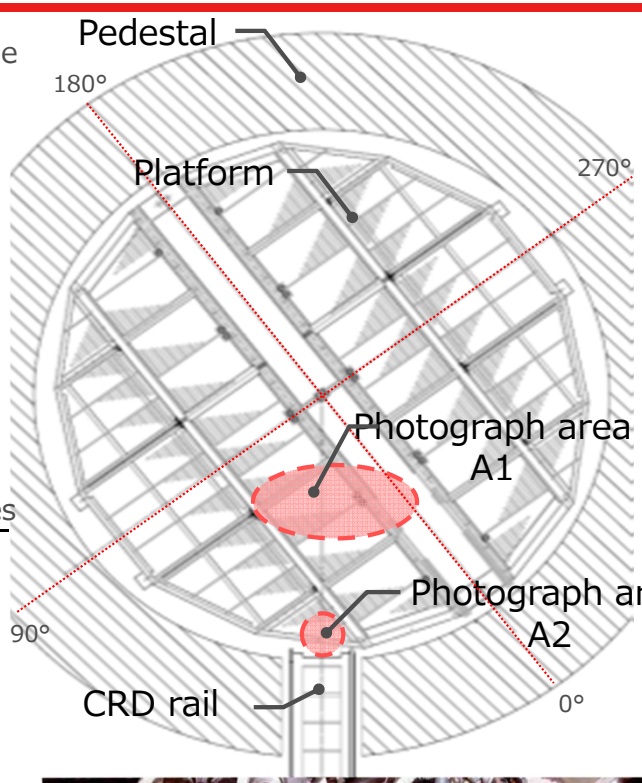


Diagram of the investigation

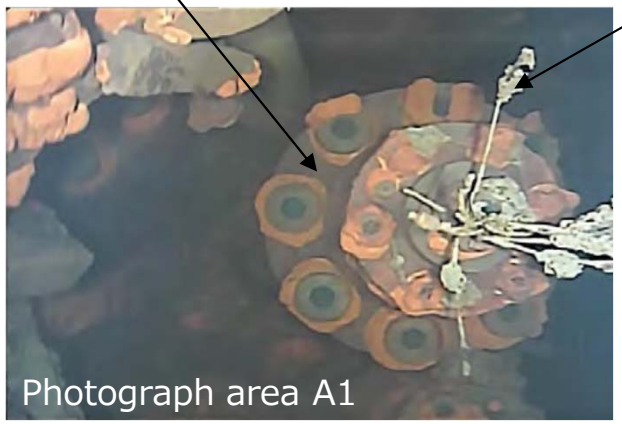
2. Investigation results
2.1. Near the CRD housing (1/2)

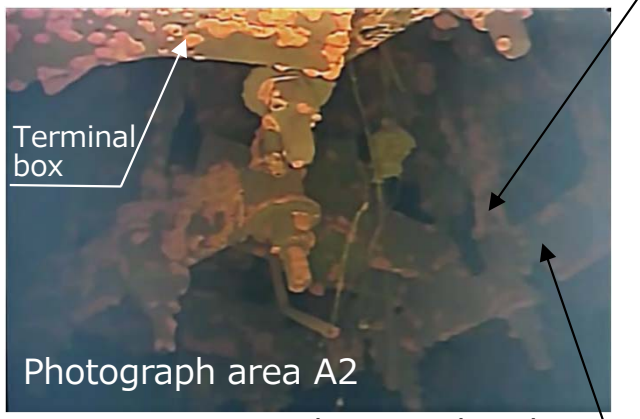






CRD housing brackets before the accident (Unit 3)

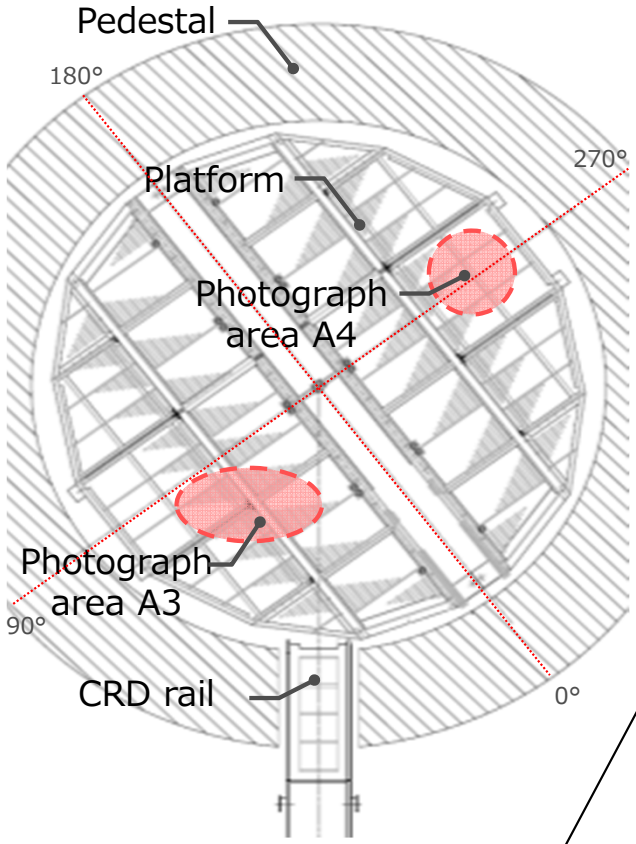




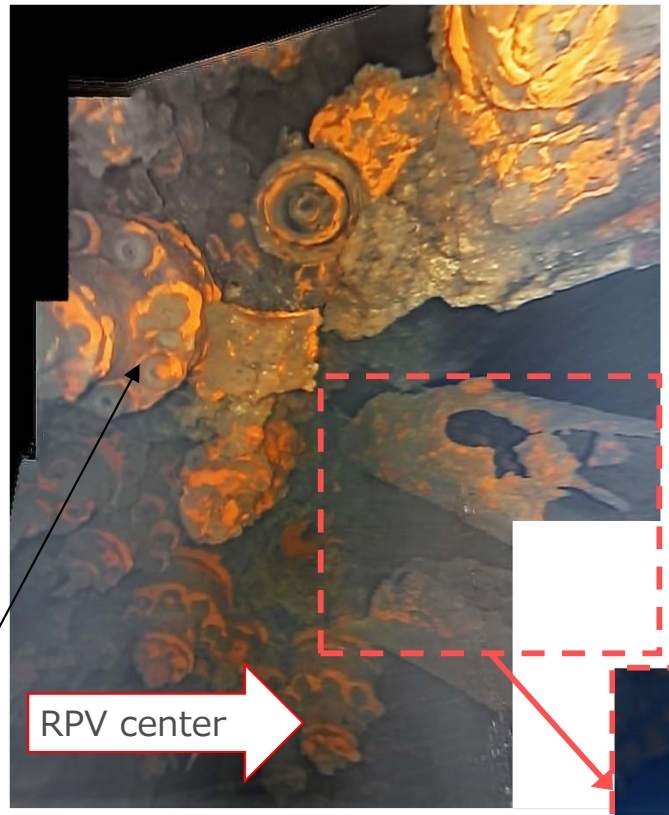
<Camera angle : All Upward>

- The CRD housing brackets were damaged or have fallen off at multiple points.
- CRD flange surfaces have different level and pitch from adjacent ones.
- A disturbance on the water surface was seen from a gap in the CRD housing (suggesting that water may be dripping from above) (Refer to Supplement 1 for the other places where disturbances on the water surface were observed).

2. Investigation results
2.1. Near the CRD housing (2/2)

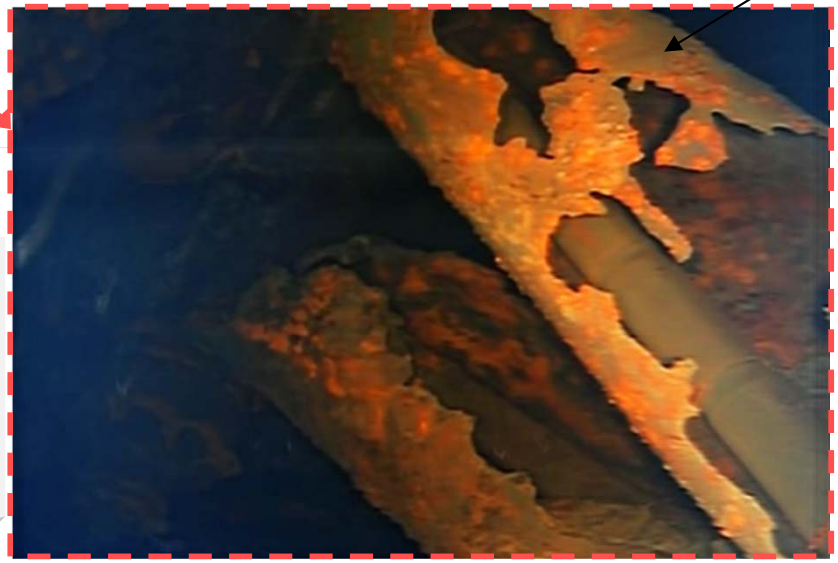


Photograph area A3 <Camera angle : Upward>



Photograph area A4 <Camera angle : Horizontal>

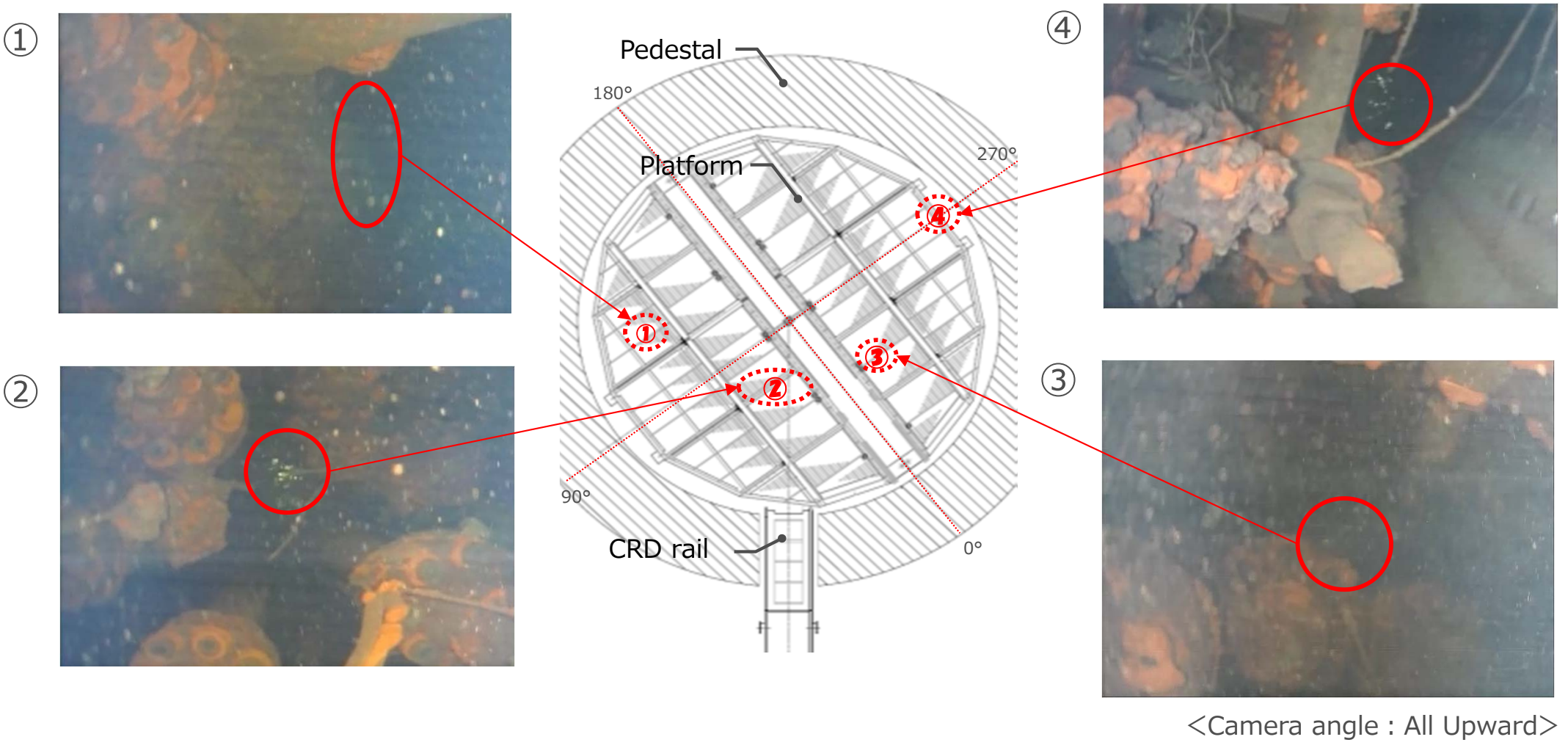
Cylindrical structure (assumed to be CR guide tube)



- A structure that is assumed to be the CR guide tube was found near the CRD housing. (Refer to supplement 2 for the basis for this assumption.)
- Melted objects solidified and are attached to the CRD housing brackets.

Image provided by International Research Institute for Nuclear Decommissioning (IRID)
Image processed by Tokyo Electric Power Company Holdings, Inc.

Supplement 1. Assumed damage at the bottom of the RPV



<Camera angle : All Upward>

- Disturbances on the water surface at ①～④ suggest the possibility that there is damage on the periphery of the RPV as well as at the center of the bottom of the RPV.

Image provided by International Research Institute for Nuclear Decommissioning（IRID）

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Supplement 2. Basis for assuming that the structure is the CR guide tube (1/2)

- Characteristics of appearance
  - There is the rod-shaped structure inside the cylindrical structure.
  - There are notches at uniform intervals in the rod-shaped structure.

  ⇒ The CR was fully inserted and the CR index tube was stored in CRD guide tube at the time of the accident, so it is assumed that the cylindrical structure is CR guide tube and the rod-shaped structure is CRD index tube.
- Dimension estimate 1
  - **The outer diameter of the cylindrical structure** is estimated to be **approx. 28cm** based on the photos since the interval between the notches on CRD index tube is approx. 15cm. **This estimate is almost the same as the design dimensions for the outer diameter of the CR guide tube (also approx. 28cm).**

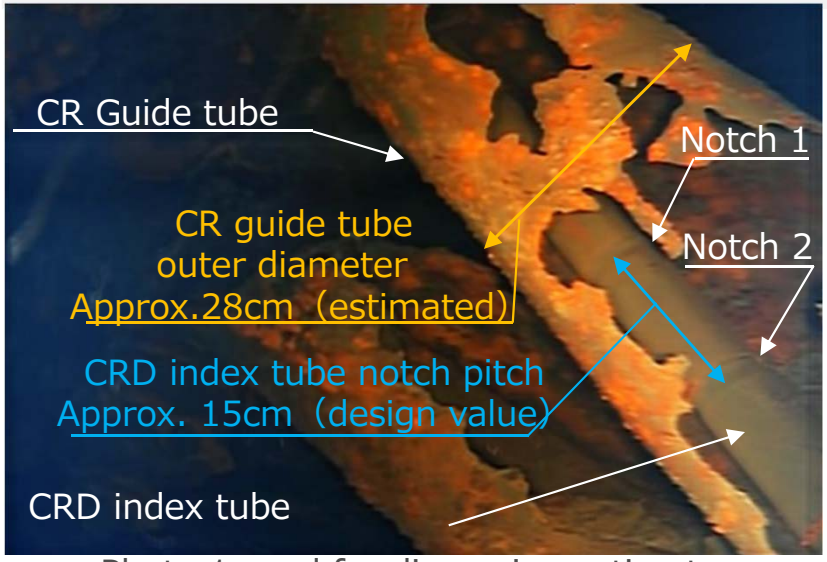


Photo 1 used for dimension estimate

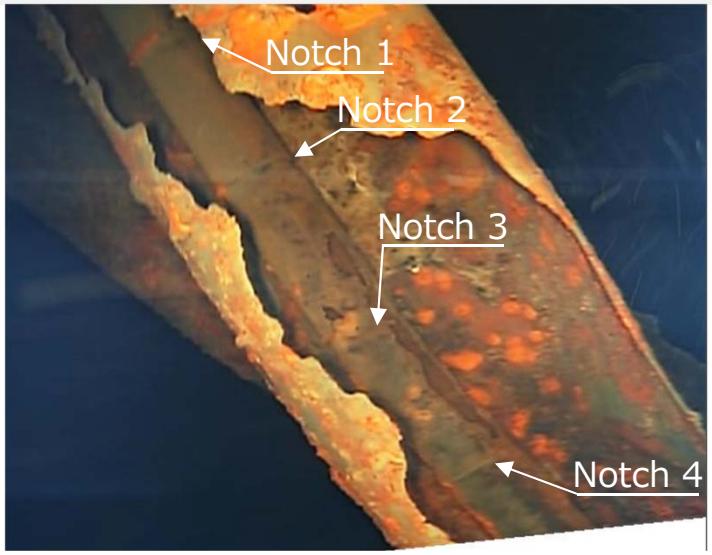
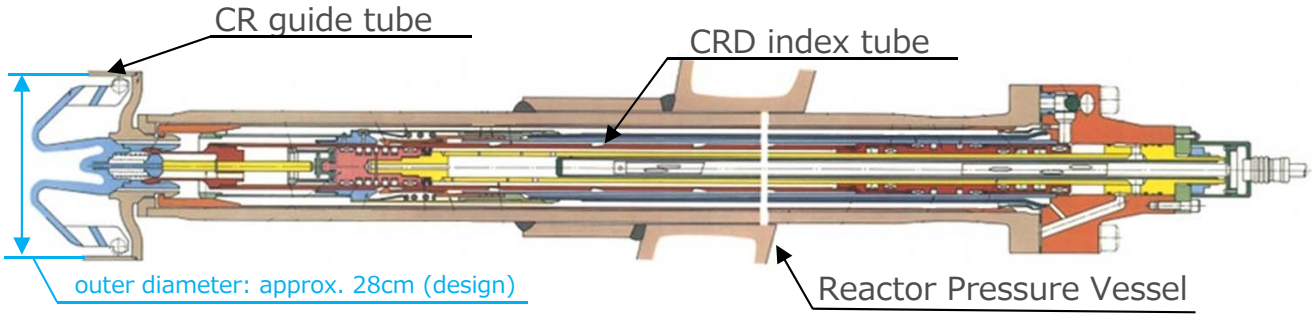


Photo 2 used for dimension estimate

Equip-ment	Material	Melting point
CR guide tube	Stainless Steel (SUS304)	Approx. 1450℃
CRD index tube	Stainless Steel (XM-19) (nitridization)	Approx. 1450℃

<Camera angle : All Horizontal>



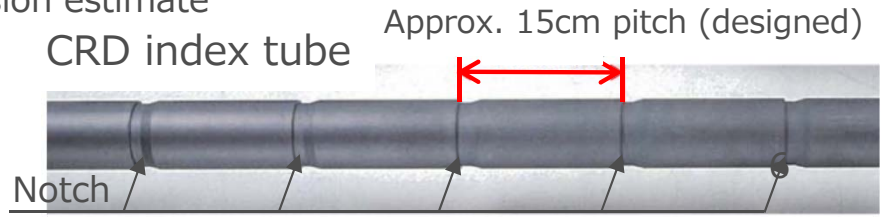


Image provided by IRID
Image processed by TEPCO

Supplement 2. Basis for assuming that the structure is the CR guide tube (2/2)

- Dimension estimate 2
  - **Each interval between the notches** was estimated at approx. 15cm from photos 1 and 2 by referencing the design values for the outer diameter of the CRD index tube, which is approx. 7cm. **All estimated values are almost the same as the design dimensions (approx. 15cm).** Therefore, this structure is assumed to be the CRD index tube.

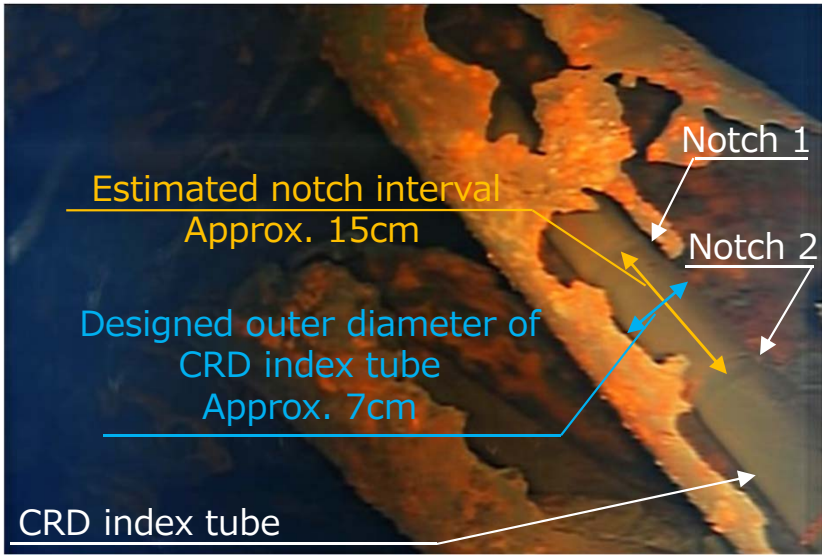


Photo 1 used for dimension estimate

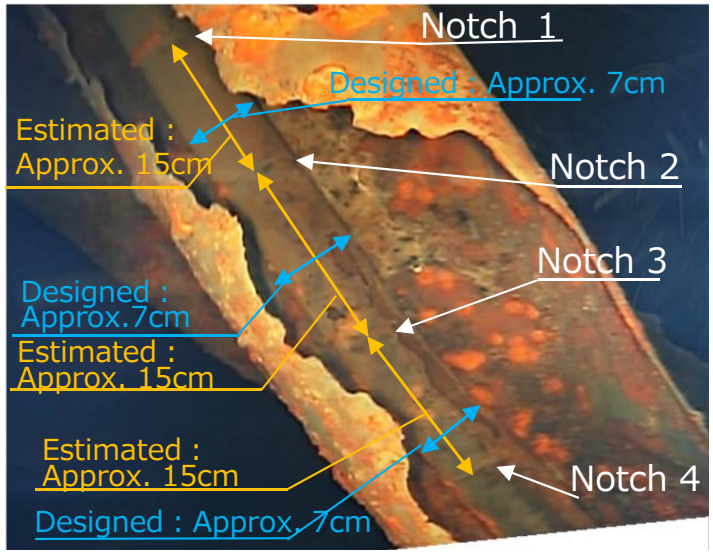
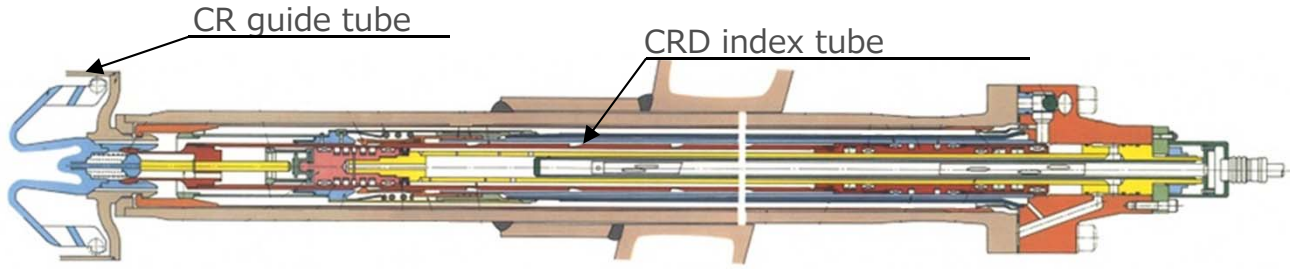
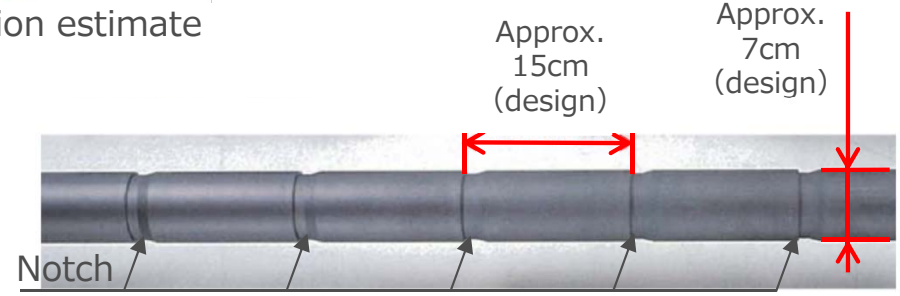


Photo 2 used for dimension estimate

Image	Notch	Estimated interval between notches
1	1～2	Approx. 15cm
2	1～2	Approx. 15cm
	2～3	Approx. 15cm
	3～4	Approx. 15cm

<Camera angle : All Horizontal>



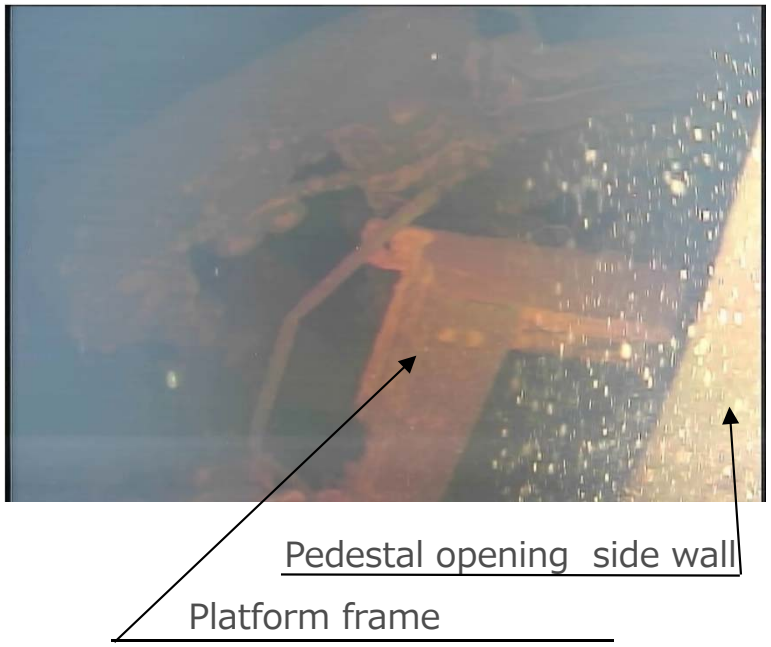


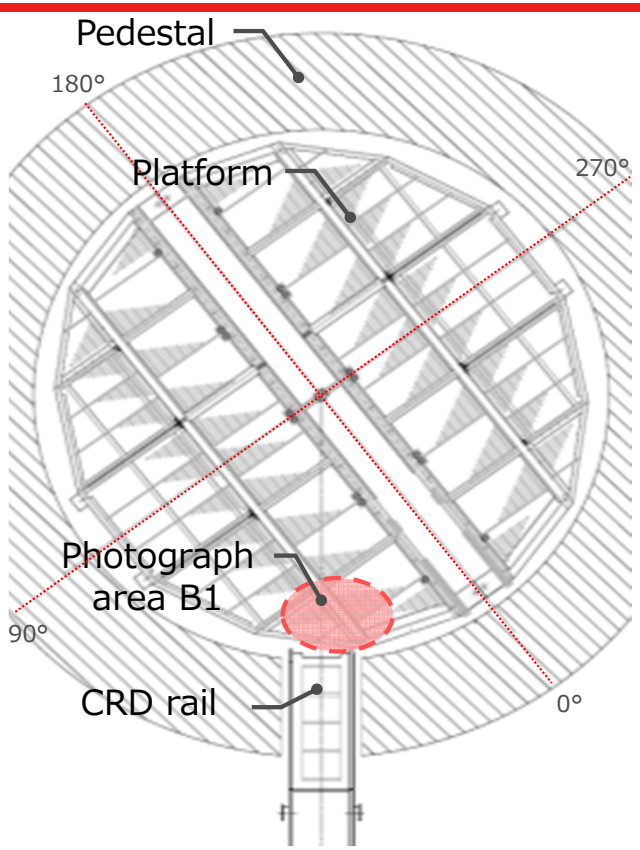
CRD index tube

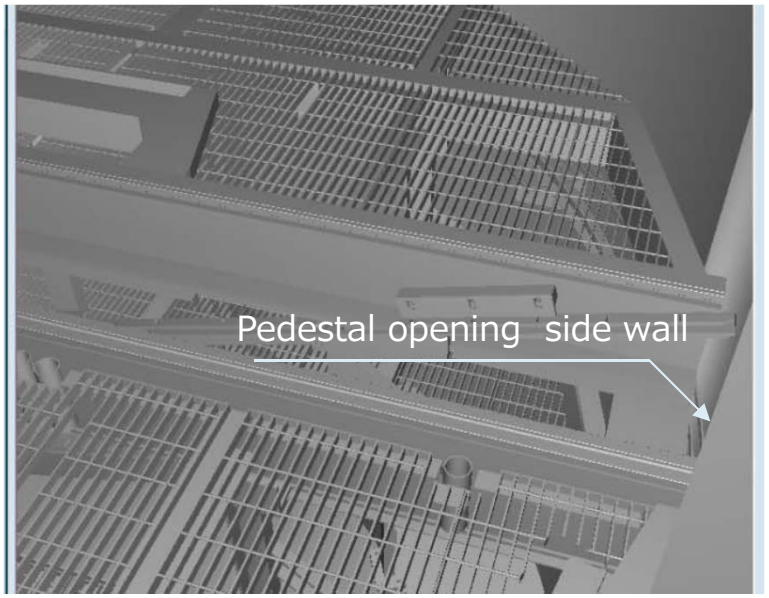
Image provided by International Research Institute for Nuclear Decommissioning（IRID）
Image processed by Tokyo Electric Power Company Holdings, Inc.

2. Investigation results
2.2. Near platform (1/3)

Photograph area B1 <Camera angle : Downward>







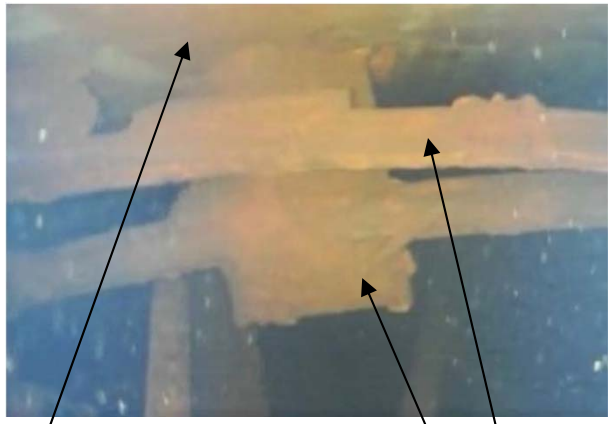
CAD image at the same angle as the photo on the left

- Grating for the platform was not found.
- Pieces of the platform were found (the platform has fallen).

Image provided by International Research Institute for Nuclear Decommissioning（IRID）

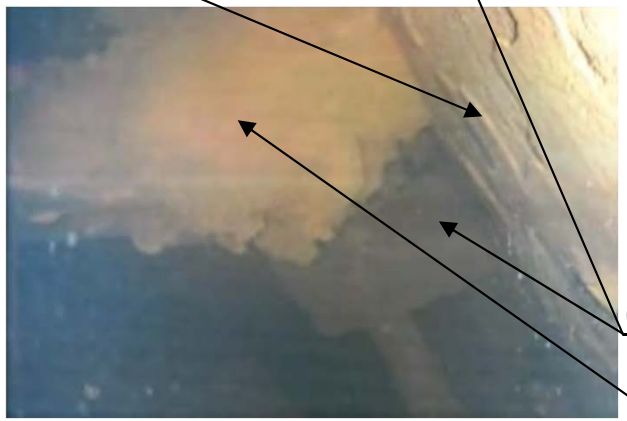
2. Investigation results
2.2. Near the platform (2/3)

Photograph area B2 <Camera angle : Downward>



Pedestal internal wall

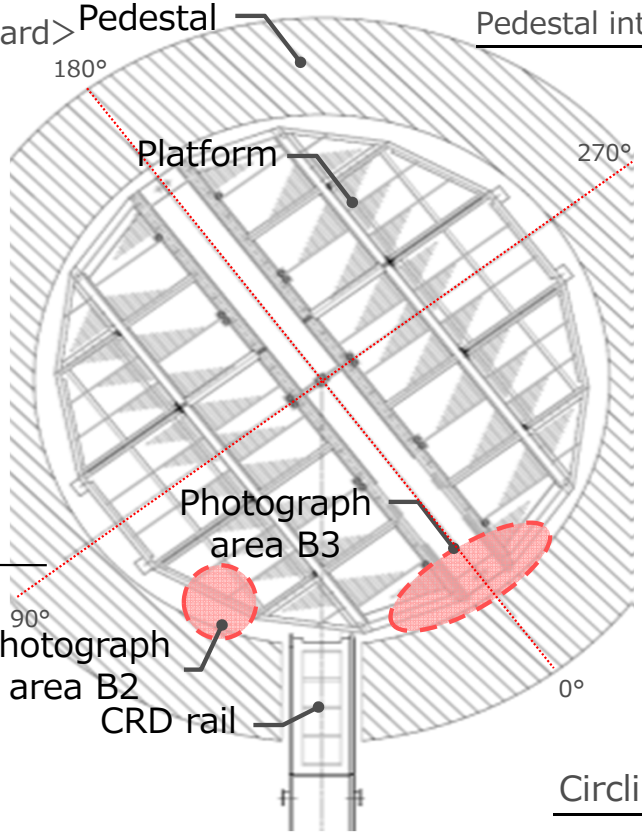
Platform circling rail



Circling rail bracket

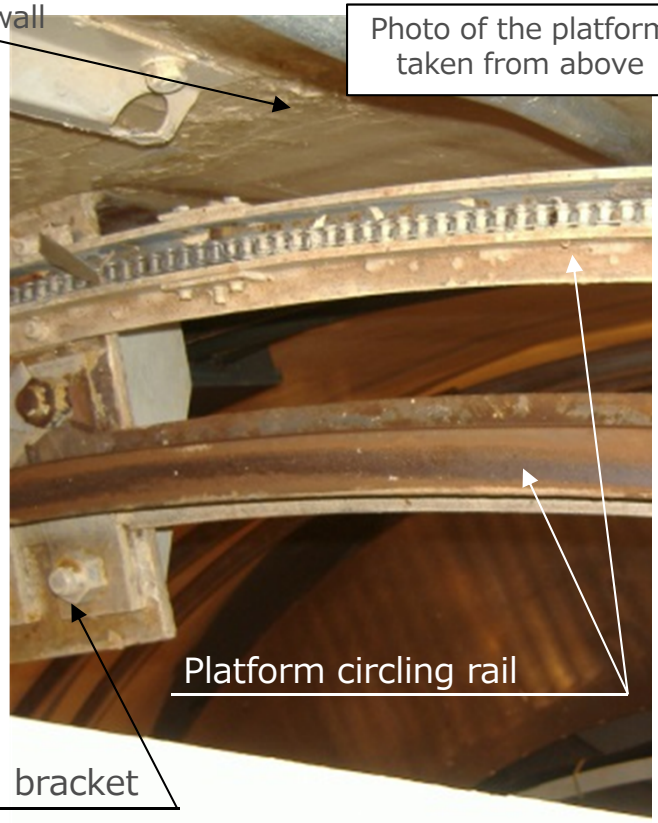
Deposit

Photograph area B3 <Camera angle : Downward>



Pedestal internal wall

Photo of the platform taken from above



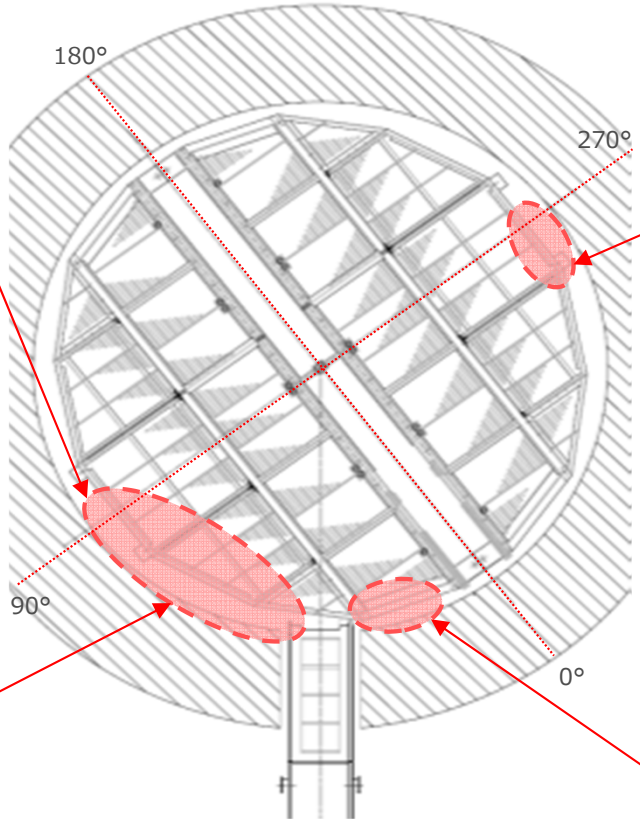
Platform circling rail before the accident (Unit 3)

- Platform circling rail and circling rail bracket remain.
- Deposit found on the circling rail bracket.

Image provided by International Research Institute for Nuclear Decommissioning（IRID）

2. Investigation results
2.2. Near the platform (3/3)〈Pedestal internal wall〉

<Camera angle : Downward>



<Camera angle : Horizontal>

<Camera angle : Upward>

<Camera angle : Downward>

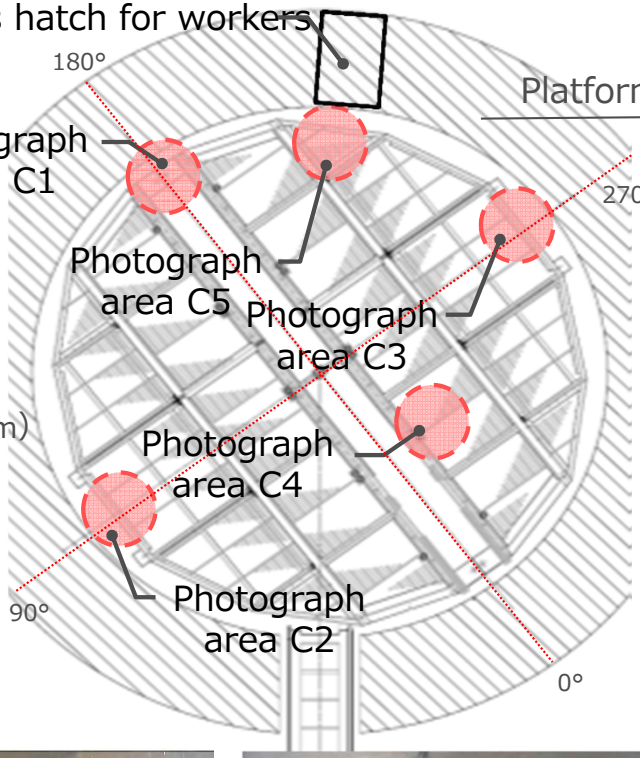
- While peeling of the epoxy paint and rough surfaces were seen on the pedestal internal wall, no major damage or deformation was found.

Image provided by International Research Institute for Nuclear Decommissioning（IRID）

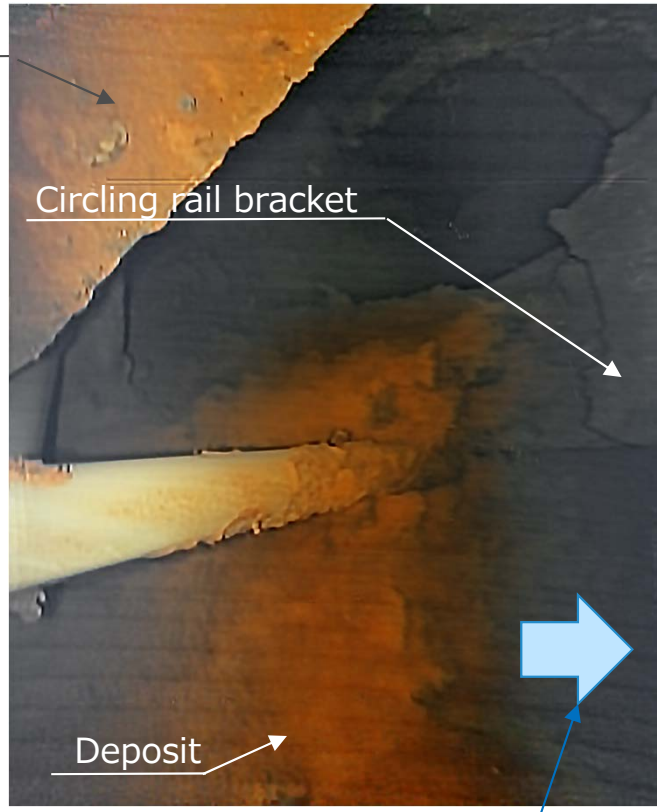
2. Investigation results
2.3. Lower part inside pedestal

Photograph area C1
<Camera angle : Downward>

Deposit (pebble form)

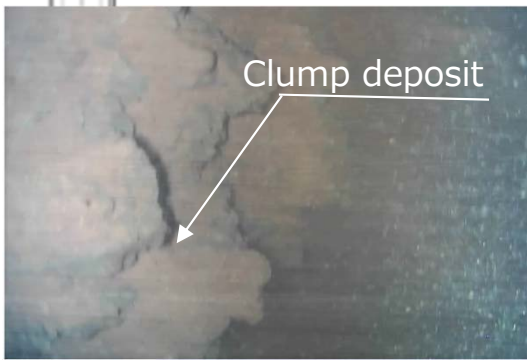


Photograph area C5 <Camera angle : Downward>



Photograph area C2
<Camera angle : Horizontal>

Photograph area C3
<Camera angle : Upward>



Photograph area C4
<Camera angle : Downward>

- Deposits resembling sand, pebbles and clumps were found.
- Access hatch was not visible. (Deposits were found nearby.)

Image provided by IRID
Image processed by TEPCO

3. Conclusion

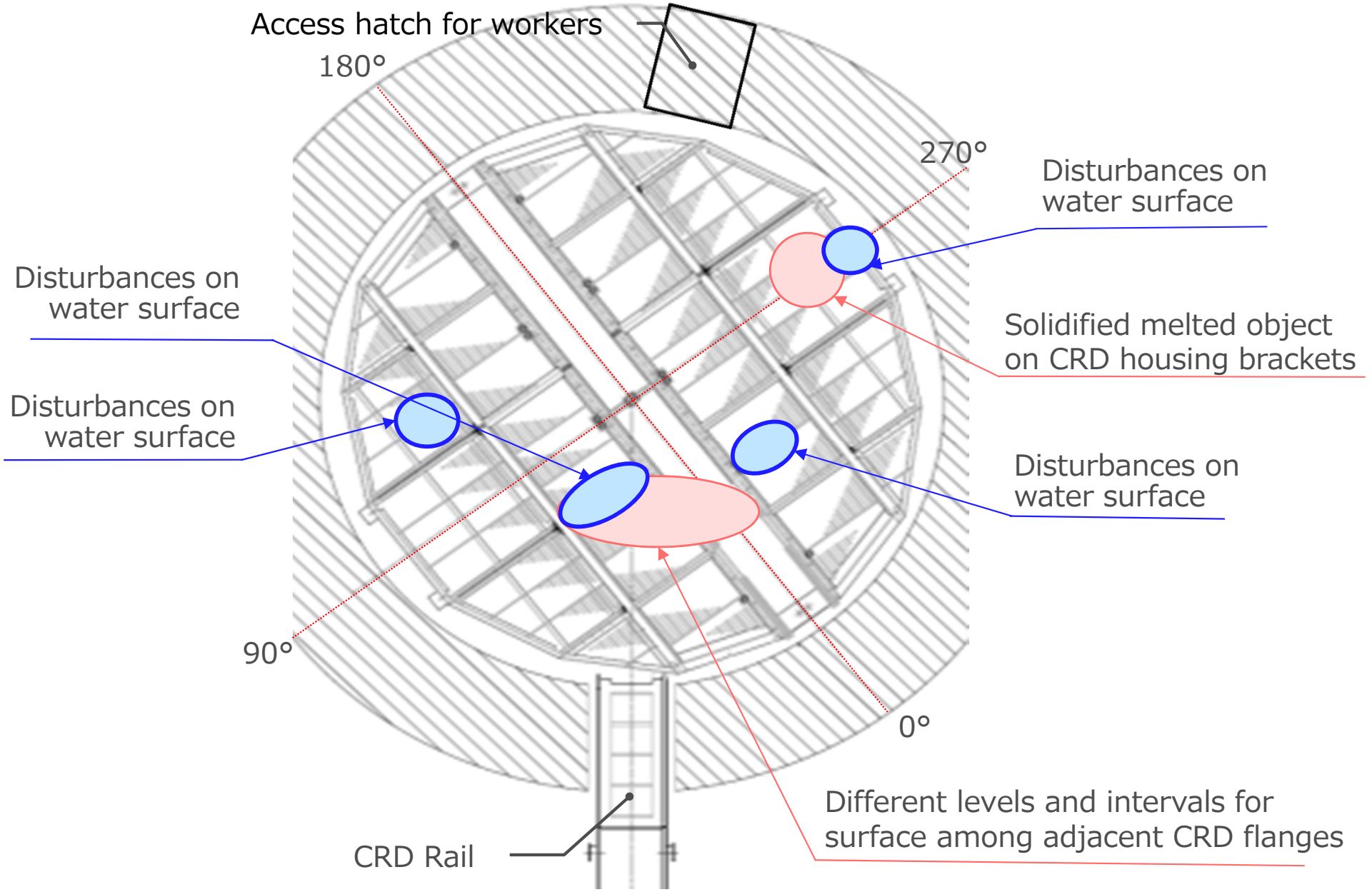
<Conditions inside the pedestal observed during this investigation (refer to supplement 3)>

- Multiple damaged structures and solidified melted objects were found attached to the CRD flange etc. and deposits resembling sand, pebbles and clumps were found at multiple locations inside the pedestal.
- Structures assumed to be reactor internals (CR guide tube and CRD index tube) were found. Other structures were seen but could not be identified. (Refer to References 1-1 to 1-4)
- Disturbances on the water surface were seen on the periphery as well as at the center of the RPV suggesting the possibility that there might be holes at both the center and surrounding areas of the RPV.
- Access hatches for workers on the lower floors of the pedestal basement were not visible but deposits were found nearby. (The possibility that fuel debris leaked outside of the pedestal cannot be denied.)

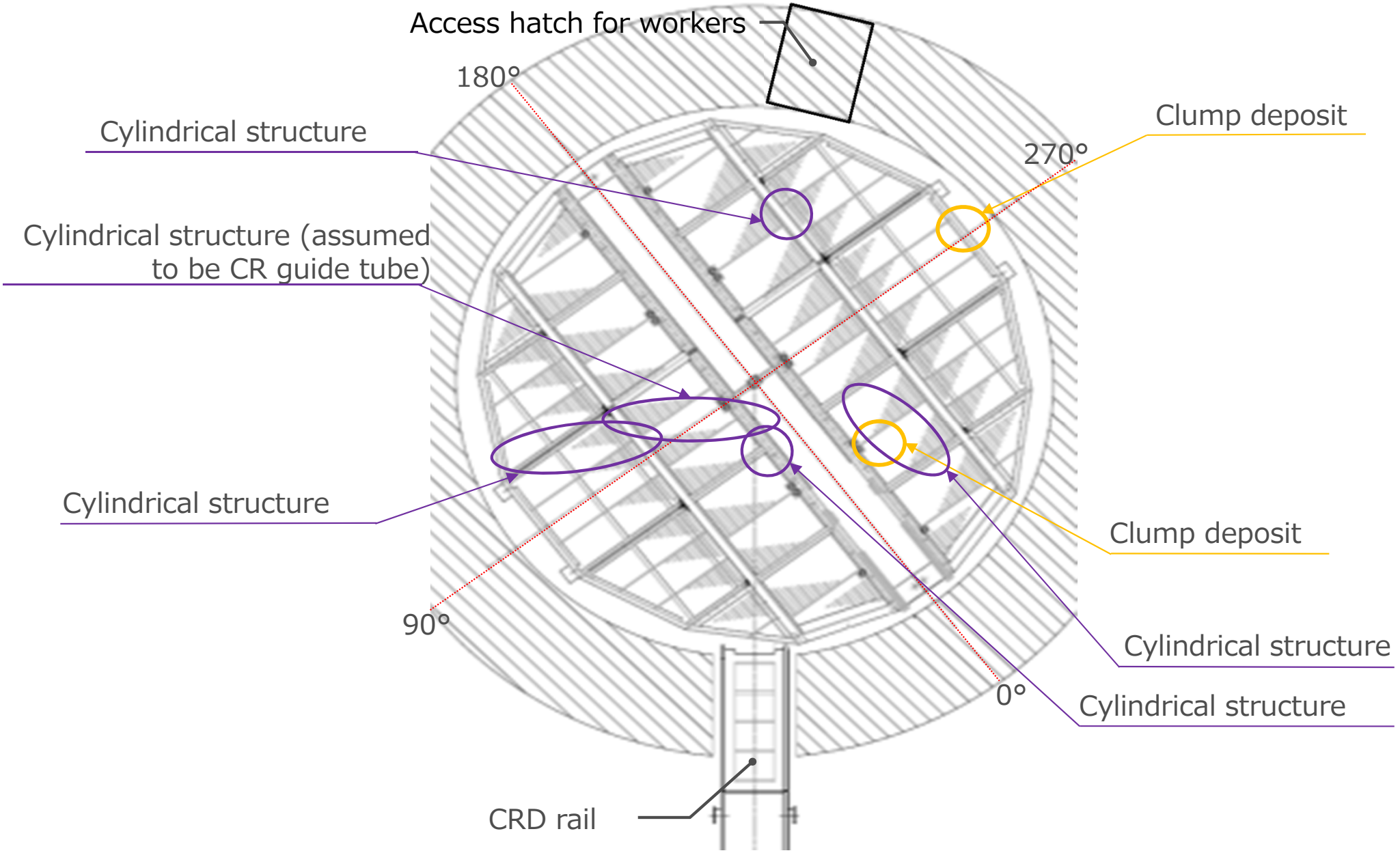
<Actions to be taken>

- We will deliberate the design of equipment for removing fuel debris and end jigs, as well as methods for removal based on the “condition and location of interfering structures” and “characteristics and locations of fuel debris” as we make preparations to remove fuel debris.
- We will continue to deliberate how to remove fuel debris based upon the information obtained through this PCV internal investigation upon identifying what information is necessary as above.

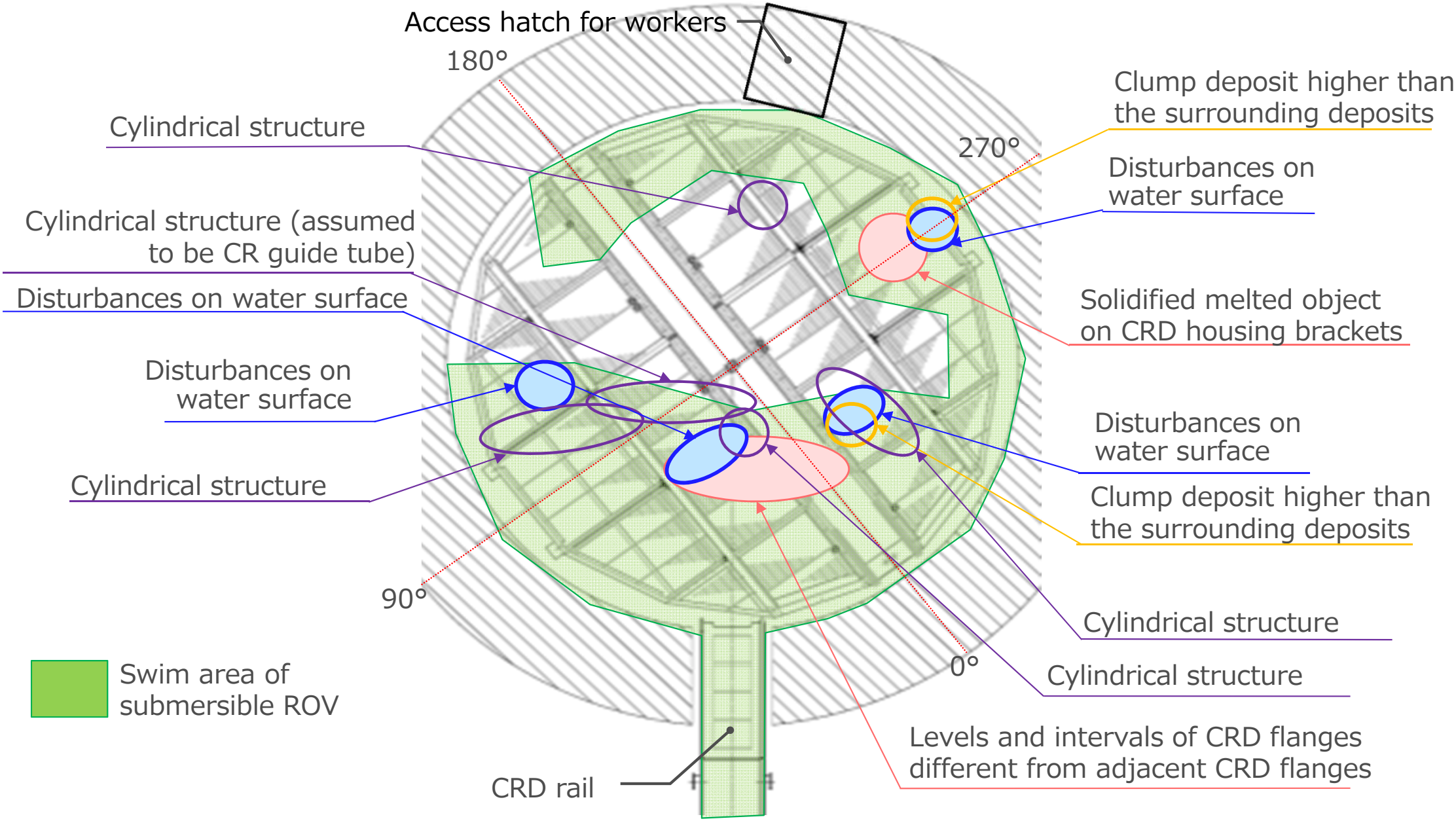
Supplement 3. Estimated position of disturbances on the water surface and structures



Supplement 3. Estimated position of structures found at the bottom of the pedestal

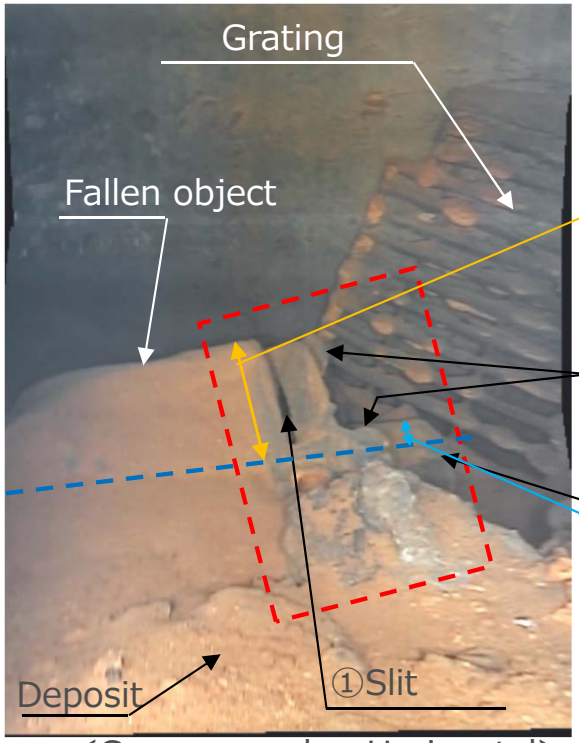


Supplement 3. Estimated position of observed structures and disturbances on the water surface



Reference 1-1 Other observed structures

- Characteristics of appearance
  - At the right edge of the fallen object (within the red box) ①a slit and ②two roller-shapes could be seen suggesting that this might be the CR falling speed limiter. However, the unique umbrella-shaped part of the CR falling speed limiter could not be seen because it is buried underneath deposits.
- Dimension estimate
  - The radius of the structure assumed to be the falling speed limiter was estimated as approx. 13cm based upon the design values for the socket radius (approx. 3cm). That is almost the same as the design dimensions (approx. 12cm).
- Results
  - This object could not be identified for certain since the unique umbrella-shaped part of the structure could not be found.



<Camera angle : Horizontal>

Equipment	Material	Melting point
Control Rod	Stainless Steel	Approx. 1450℃

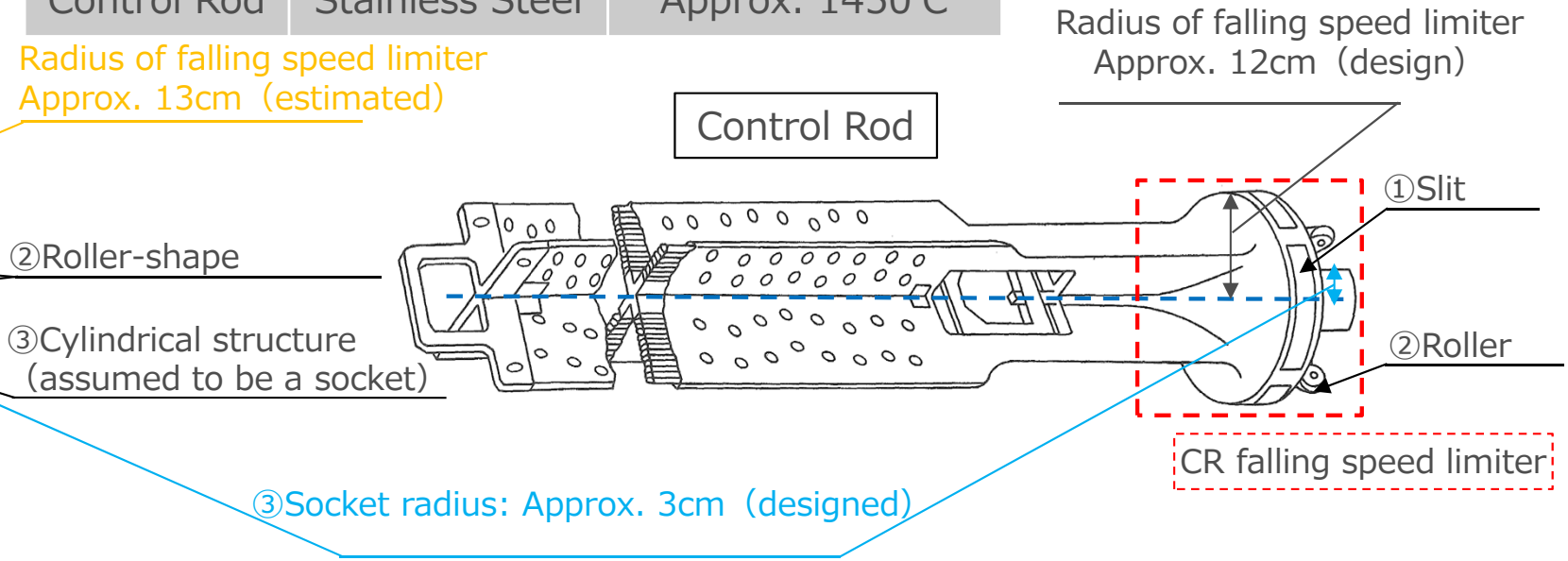


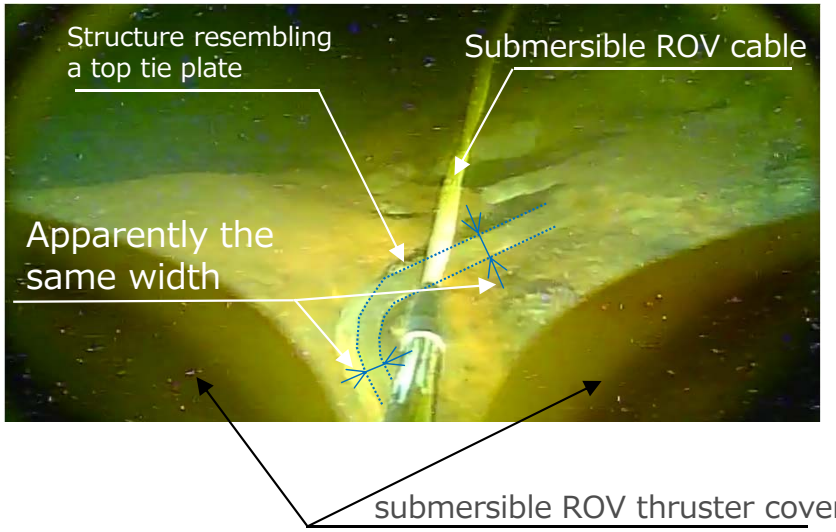
Image provided by International Research Institute for Nuclear Decommissioning (IRID)
Image processed by Tokyo Electric Power Company Holdings, Inc.

Reference 1-2 Other structures found

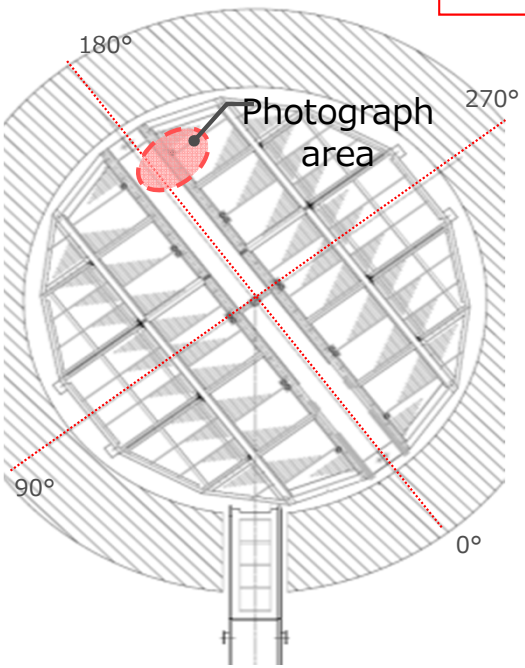
- Characteristics of appearance
  - A structure resembling the top tie plate※ was found at the bottom of the pedestal.
  - The size of the handle of this top tie plate looks to be almost the same as the width of the vertical part based on the photo, however, this could not be confirmed since photos were only taken from one angle.
- Estimated dimension
  - The dimensions could not be estimated because there were no other structures to use as reference.
- Results
  - This structure might be a fuel supporting bracket plug if the handle and the vertical part of the top tie plate are the same width. However, the widths could not be confirmed since the photos were only taken from one angle.

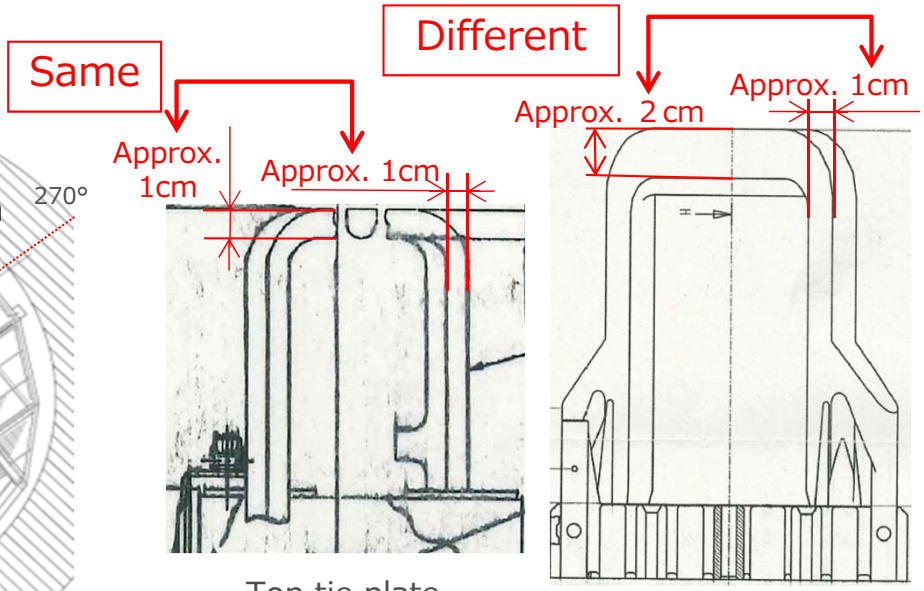
※Top tie plate fixes the top of fuel and possibly is a component for the following types of fuel:
- 9×9 Fuel (A-type)
- MOX Fuel
- Fuel supporting bracket plug (commonly called "dummy fuel")

Rear camera image<Camera angle : Horizontal>



Equipment	Material	Melting point
Fuel supporting bracket plug Top tie plate	Stainless Steel (SCS13A)	Approx. 1450℃





Top tie plate **Fuel supporting bracket plug**

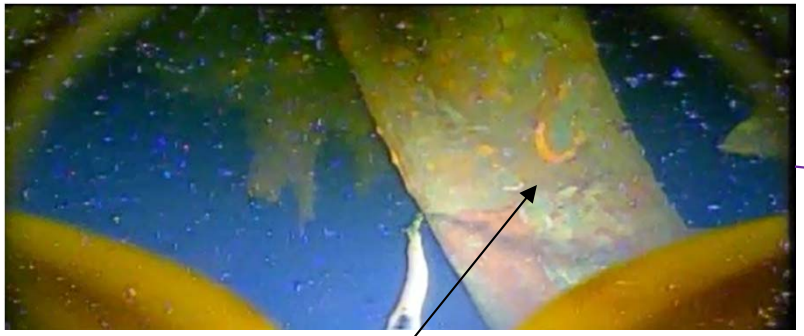
Top tie plate **9×9 fuel (A type) ※**

※ The dimensions of the relevant parts for MOX fuel are the same as 9×9 fuel (A-type)

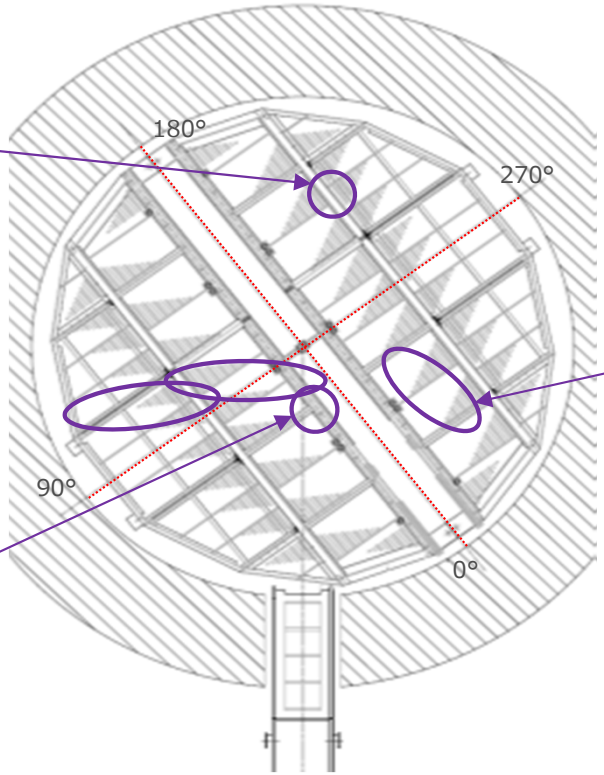
Image provided by International Research Institute for Nuclear Decommissioning (IRID)

Reference 1-3 Other structures found : Cylindrical structure (1/2)

- Characteristics of appearance
  - Cylindrical structures similar to the CR guide tube were found at multiple places in the pedestal.
- Dimension estimate
  - Dimensions could not be estimated because there were no structures to be used as reference.
- Results
  - Based on the their appearance it is assumed that these structures are the CR guide tubes but a positive identification was not possible because the dimensions could not be estimated.



Cylindrical structure



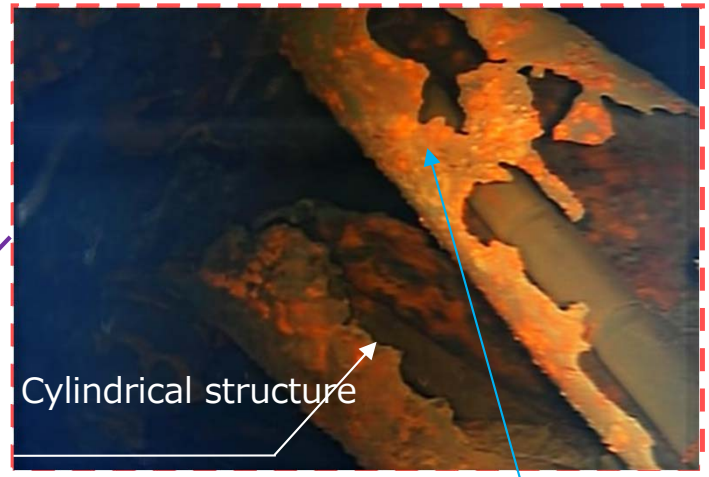
Cylindrical structure

<Camera angle : All horizontal>

Reference 1-3 Other structures found : Cylindrical structure (2/2)

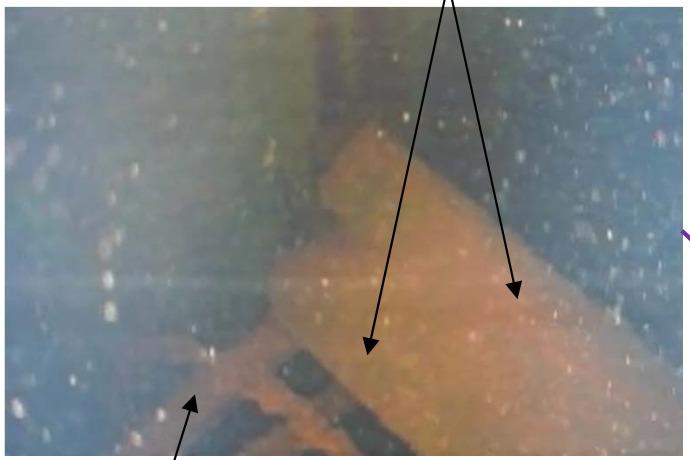
- Characteristics of appearance
  - Cylindrical structures similar to CR guide tubes were found at multiple places in the pedestal.
- Dimension estimate
  - Dimensions could not be estimated because there were no structures to be used as reference.
- Results
  - Based on the their appearance it is assumed that these structures are the CR guide tubes but a positive identification was not possible because the dimensions could not be estimated.

<Same as lower right photo on P. 3>



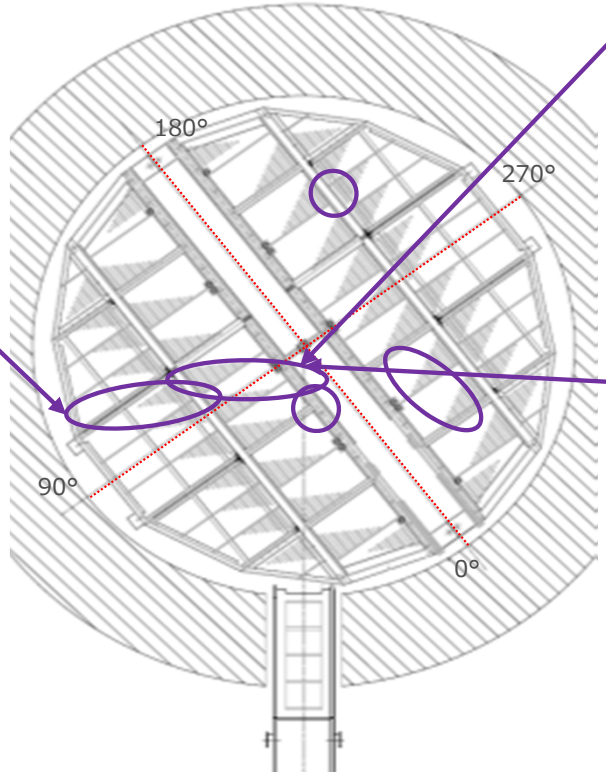
CR Guide tube with dimensions estimated

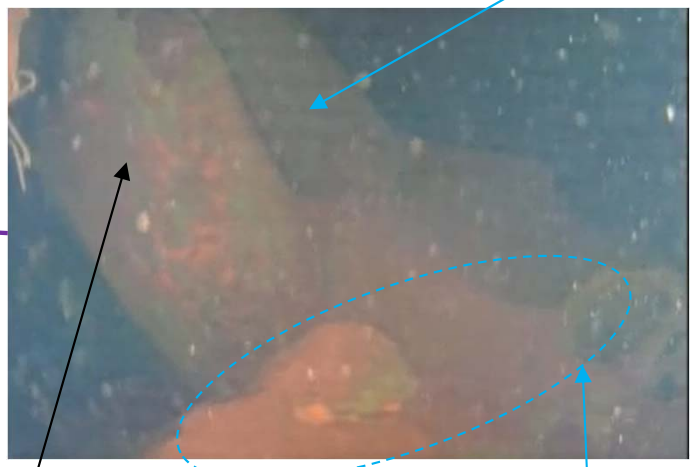
2 Cylindrical structures



Platform circling rail

<Camera angle : Downward>



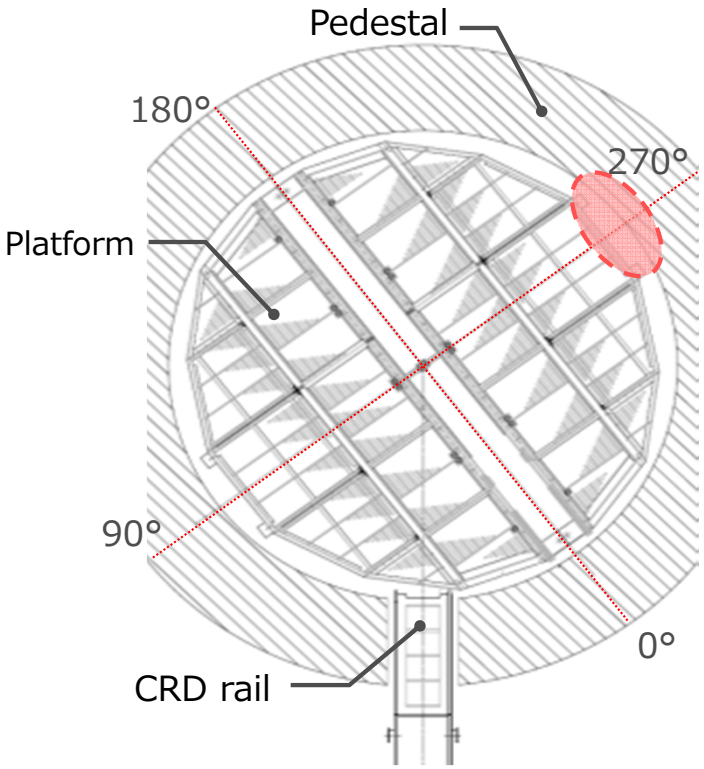


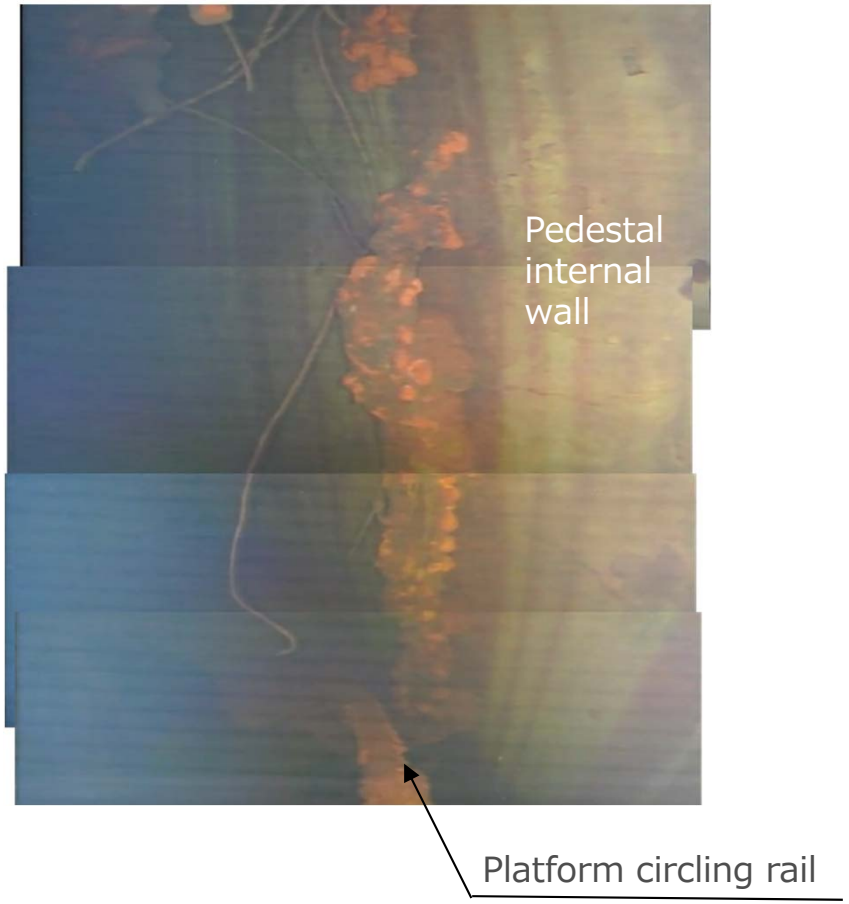
<Camera angle : Horizontal>

Image provided by International Research Institute for Nuclear Decommissioning（IRID）
Image processed by Tokyo Electric Power Company Holdings, Inc.

Reference 1-4. Other structures found : Cables

- Damaged cables were found along the pedestal internal wall near 270°.
- It is assumed that high-temperature molten material fell into the pedestal, attached to the cables and caused the damage.



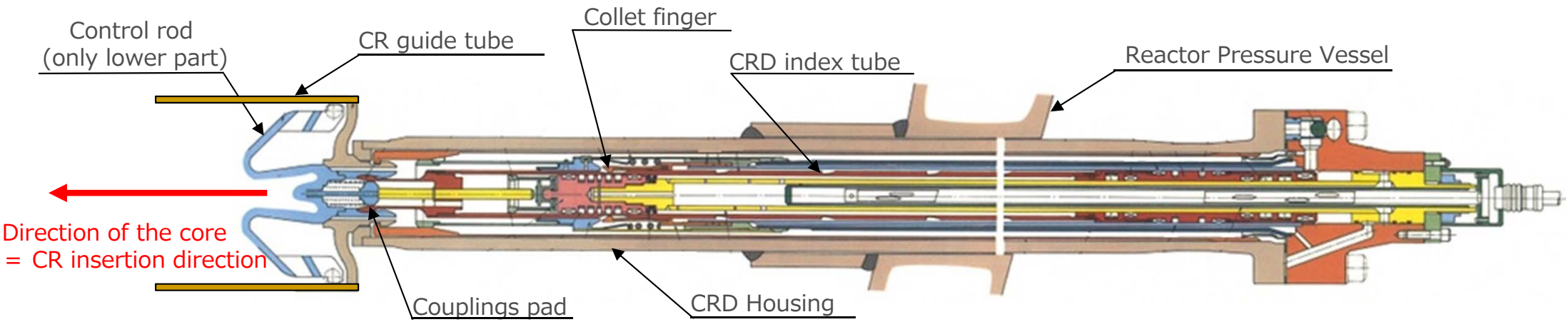


<Camera angle : Horizontal ～ downward>

Image provided by International Research Institute for Nuclear Decommissioning（IRID）

Reference 2-1. CR guide tube, CRD index tube

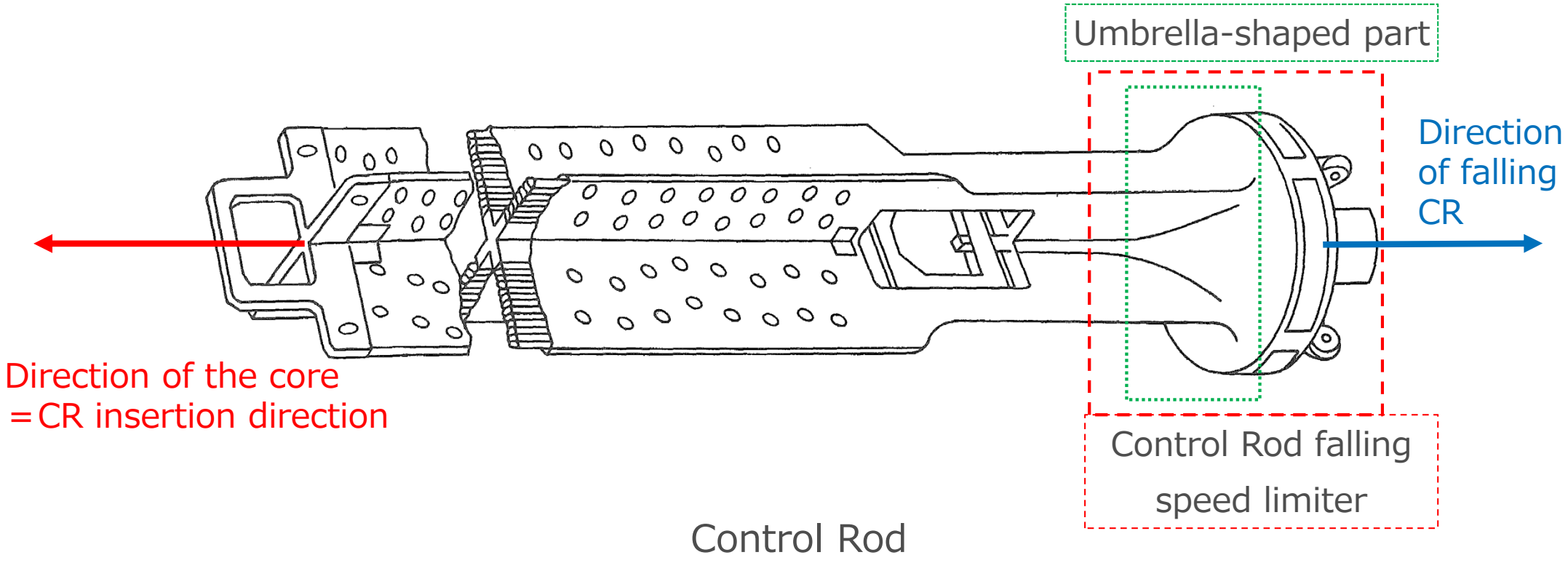
- CR guide tube
  - When the Control Rods (CR) are completely withdrawn they are stored in the CR guide tubes and when inserted they slide along the CR guide tube until they reach the core.
  - When the control rods are fully inserted the CRD index tube, which is the lower part of the control rod, is inside the CR guide tube.
- CRD index tube
  - The CRD index tube is connected to the control rod with a coupling called the couplings pad, which is at the top of the index tube.
  - There are notches in the CRD index tube to secure the CR using a collet finger when the CR is inserted.



Cross section of the Control Rod Drive Mechanism (with CR fully withdrawn)

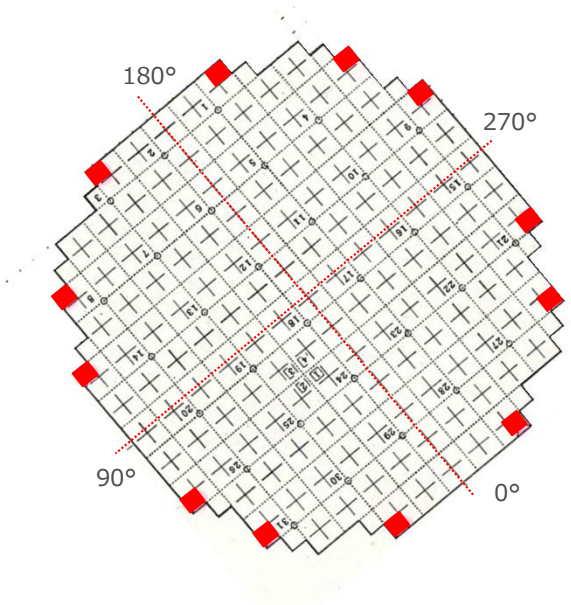
Reference 2-2. Control rod falling speed limiter

- Control rod falling speed limiter
  - In case of an accident involving a control rod drop, this part generates resistance thereby slowing the increase in speed of the fall and preventing drastic reactivity level changes inside the reactor.



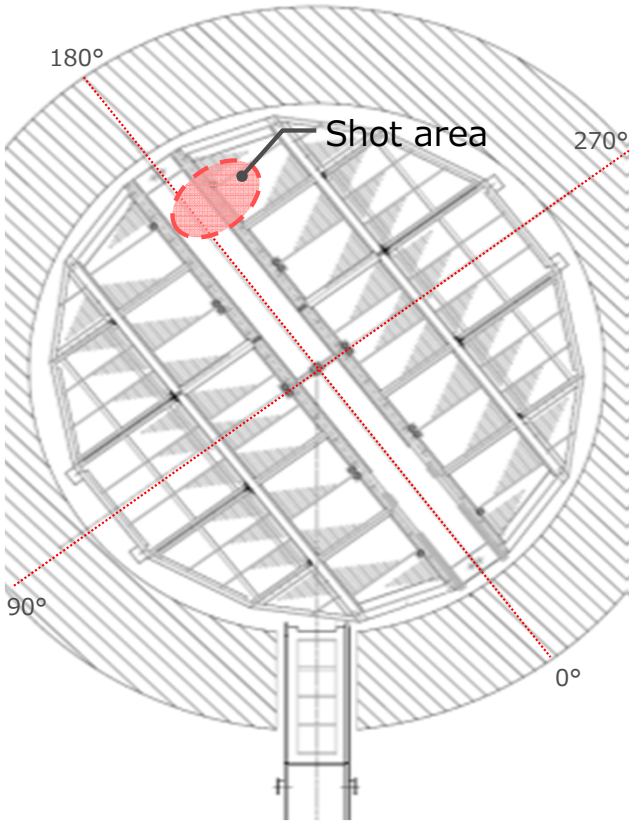
Reference 2-3. Fuel supporting bracket plug

- Function
  - Fuel supporting bracket plugs are installed to serve as “Control rod guides”, that guide the control rods during insertion and extraction.
- Loading points
  - Fuel supporting bracket plugs are loaded at 12 points along the circumference of the reactor core. (Red points in the cross-section of the reactor core shown below to the left)

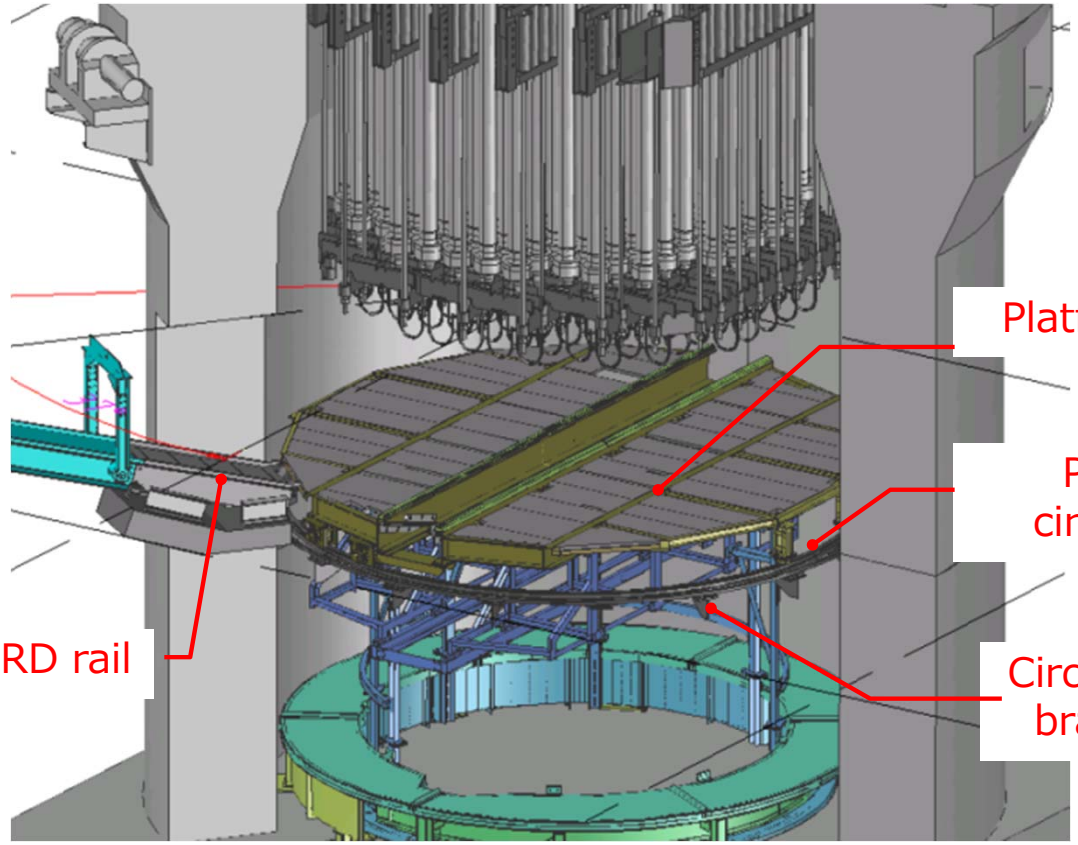


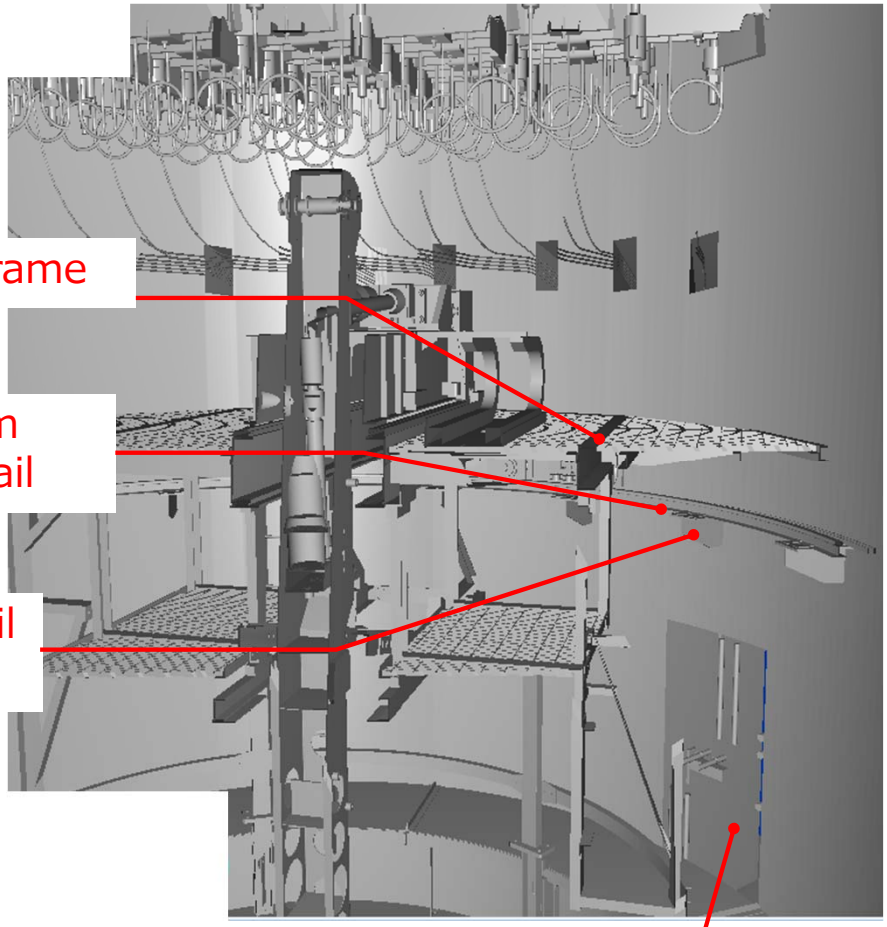
Cross-section of the reactor core

Red : Fuel supporting bracket plug loading points



Reference 2-4. Structure inside the pedestal





Reference 2-5. Structure inside the reactor