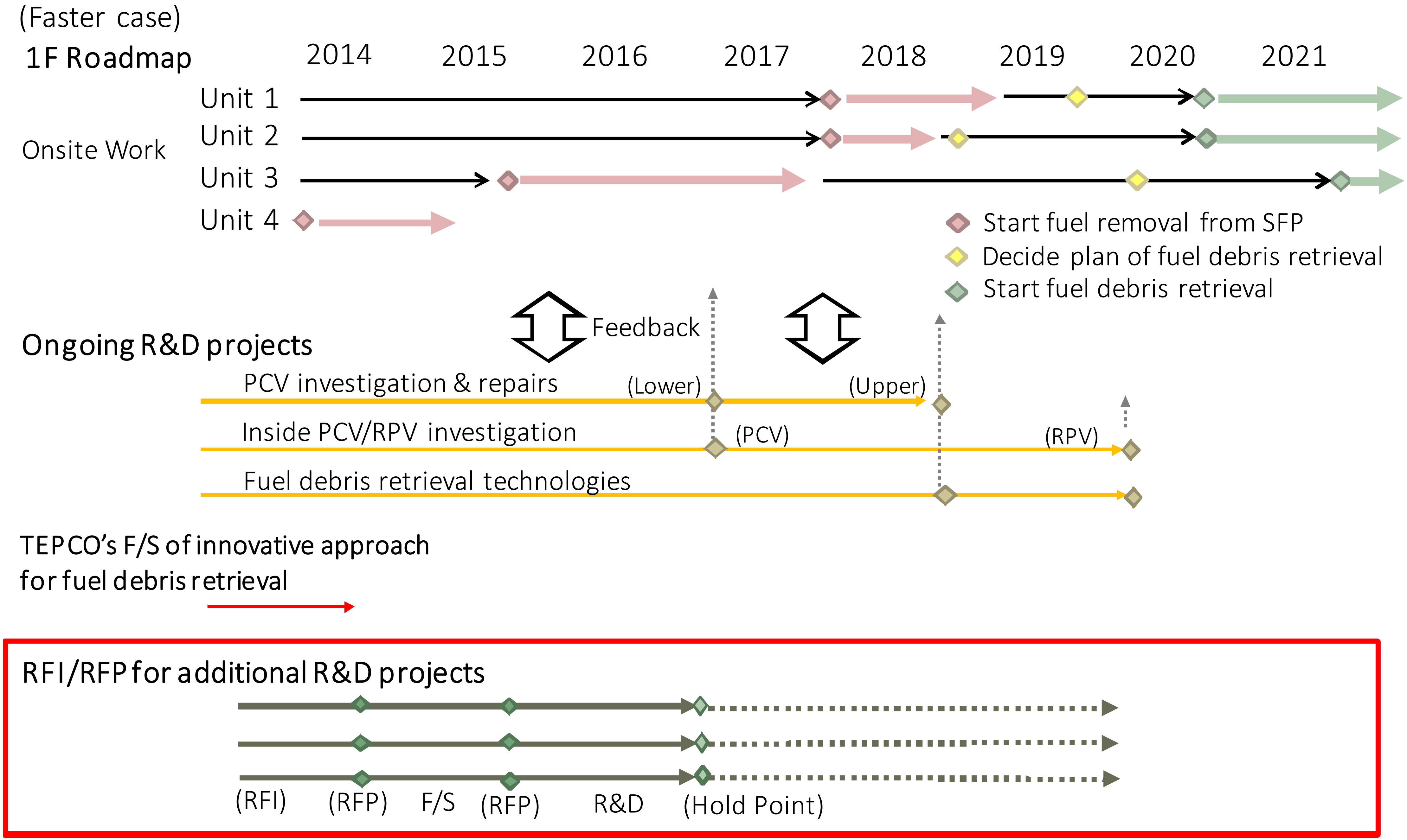
Request for Information (RFI) of Innovative Approach for Fuel Debris Retrieval

Items for “Request for Information”

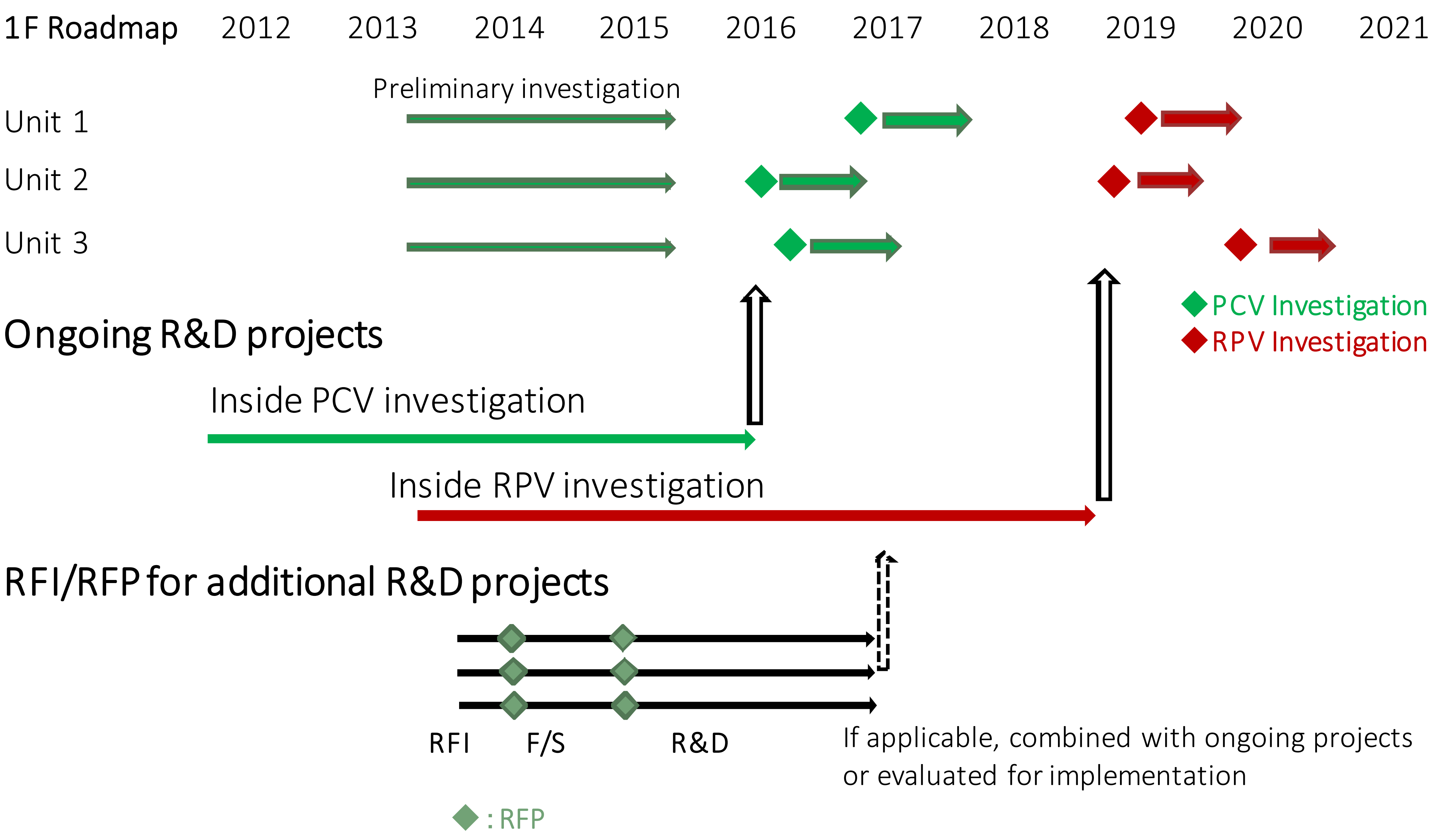
December 16th, 2013

International Research Institute for Nuclear Decommissioning

Mid and Long Term Roadmap and R&D Program



Roadmap and R&D Program focused on Internal PCV/RPV Investigation



RFI Topic for Additional R&D Projects

Topic-A: Inside PCV/RPV investigation

A-1: Conceptual study on innovative approaches

A-2: Technologies required for Internal PCV/RPV investigation

Topic-B: Fuel debris retrieval from PCV/RPV

B-1: Conceptual study on innovative approaches to fuel debris

B-2: Technologies required for Fuel debris Retrieval

Before discussing requested information;

- What are the current status confirmed / information not yet obtained by R&D outcomes and the current status on site operation?
- What are the challenges when planning additional R&D projects?

Current Status Confirmed and Information not yet Obtained

- Status inside PCV (temperature, water level, radiation dose)
- Core cooling status and potential criticality
- Estimation of core status based on analysis by severe accident code

→ Topic A: Internal PCV/RPV investigation

- Leakage status around lower PCV area (Unit 1)
- Leakage status around lower PCV area (Unit 2)
- Assessment of damage on PCV Penetrations

→ Topic B: Fuel debris retrieval from PCV/RPV

Status Inside PCV (Temperature, Water level, Radiation dose)

[Current status confirmed]

- Thermometer and dosimeter were inserted into the PCV, and the data has been measured continuously at unit 1 and 2.

[Information not yet obtained]

- Information about the status inside PCV at Unit 3.
- Inner area of RPV has not been observed.

PCV internal temperature survey results

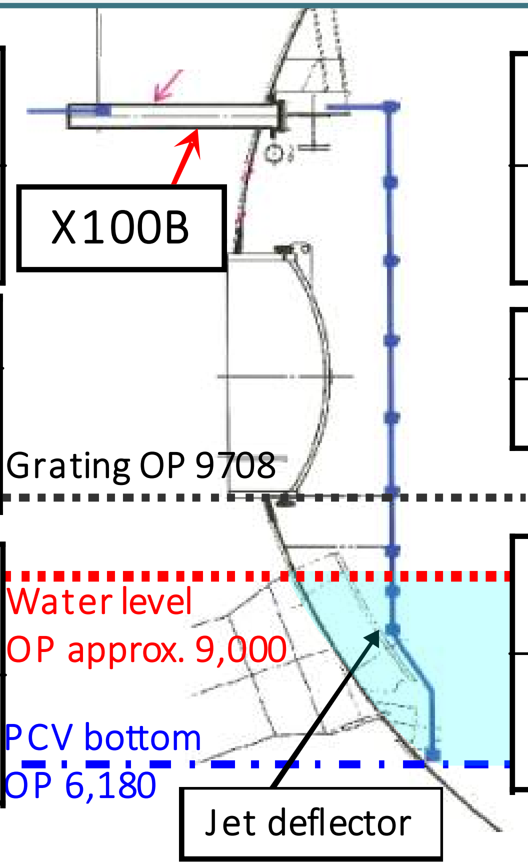
Atmosphere: 34.1～35.1 ℃
Under water: 37.0～37.4 ℃

PCV internal dose survey results

Atmosphere: 4.7～11.1 Sv/h
Under water: 0.5 Sv/h

PCV internal water level survey results

Approx. 280cm above bottom of PCV (approx. OP. 9,000)



PCV internal temperature survey results

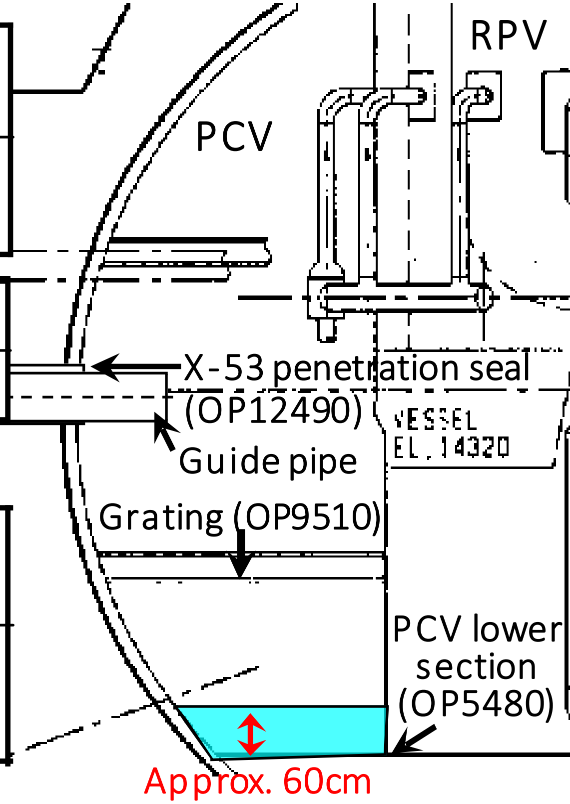
Atmosphere: 42.8-44.9 ℃
Under water: 48.5-50.0 ℃

PCV internal dose survey results

Atmosphere: 31.1-72.9 Sv/h

PCV internal water level survey results

Approx. 60cm above bottom of PCV (Approx. OP.6,080)



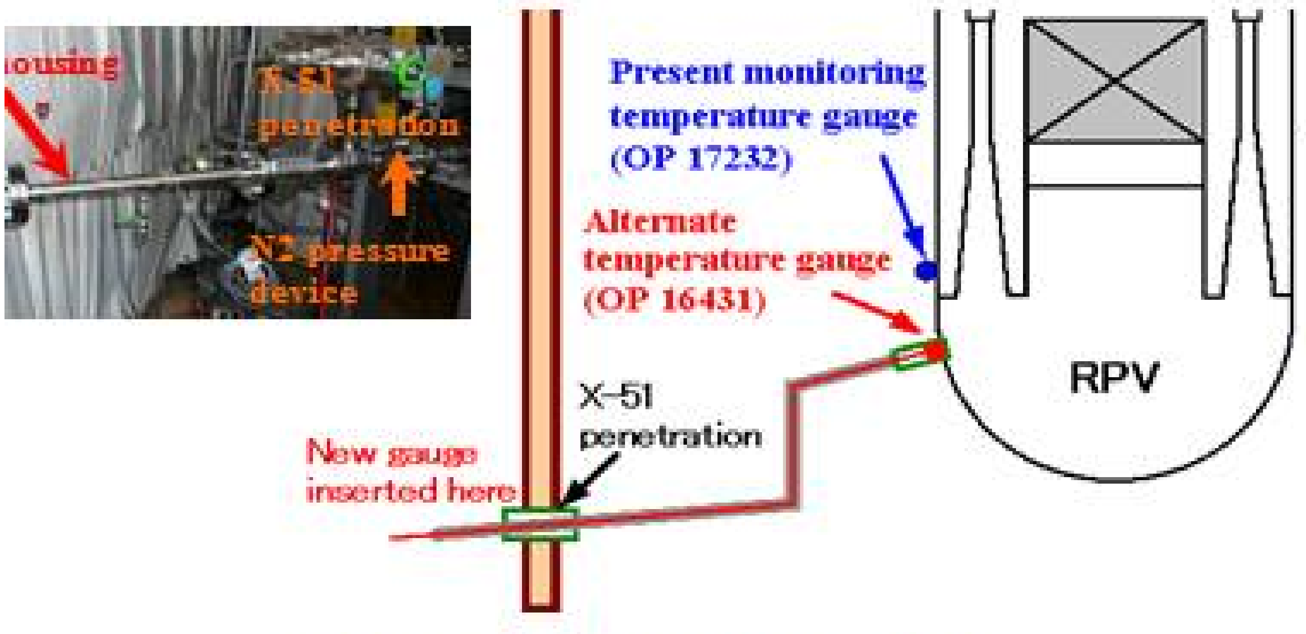
Core Cooling Status and Potential Criticality

[Current status confirmed]

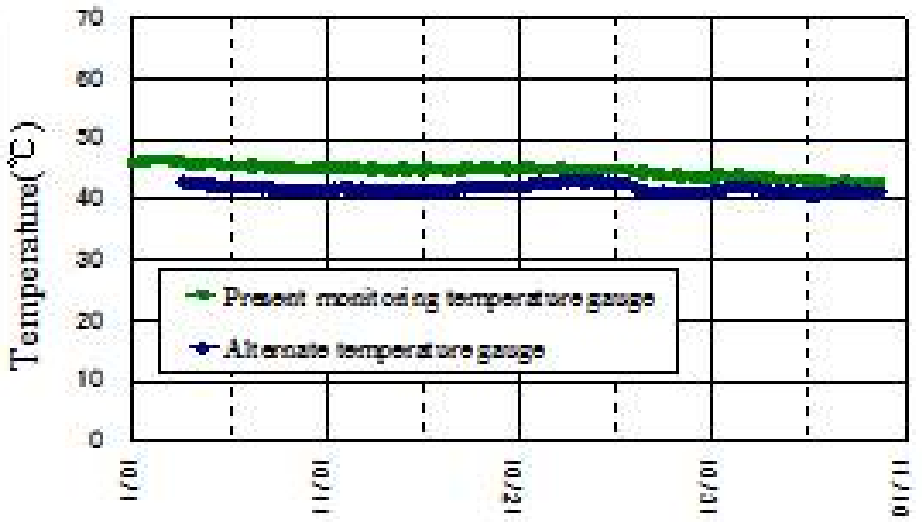
- Core is cooled continuously by water injection and the temperature is low. (around 40 ℃)
- No criticality is confirmed by monitoring temperature and noble gas.

[Information not yet obtained]

- How will cooling status be maintained while reducing injecting water.
- In retrieving fuel debris how will it affect potential criticality.



Installation of temperature gauges



Change in readings of present monitoring temperature gauge and alternate temperature gauge

Estimation of Core Status based on Analysis by Severe Accident Code

[Current status confirmed]

- The weight rate of fuel debris fallen to PCV bottom.

[Information not yet obtained]

- The exiting accident analysis code has uncertainties, so that detailed location, hardness and spread of fuel debris are not yet analyzed.

The weight of UO_2 in the core at first

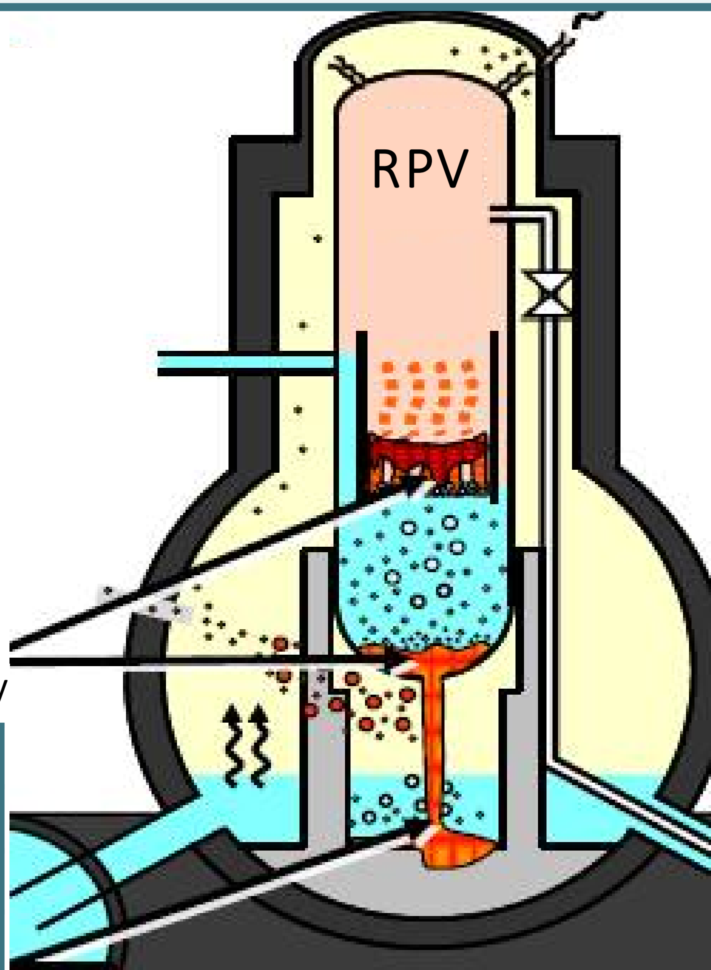
Unit 1	77t
Unit 2	107t
Unit 3	107t

The weight rate of UO_2 still remaining in RPV

	TEPCO	JAEA
Unit 1	0%	0%
Unit 2	43%	30%
Unit 3	37%	36%

The weight rate of UO_2 fallen from RPV

	TEPCO	JAEA
Unit 1	100%	100%
Unit 2	57%	70%
Unit 3	63%	64%



Evaluation by TEPCO：MAAP (May 2011)

Evaluation by JAEA：MELCOR

Leakage Status around Lower PCV Area (Unit 1)

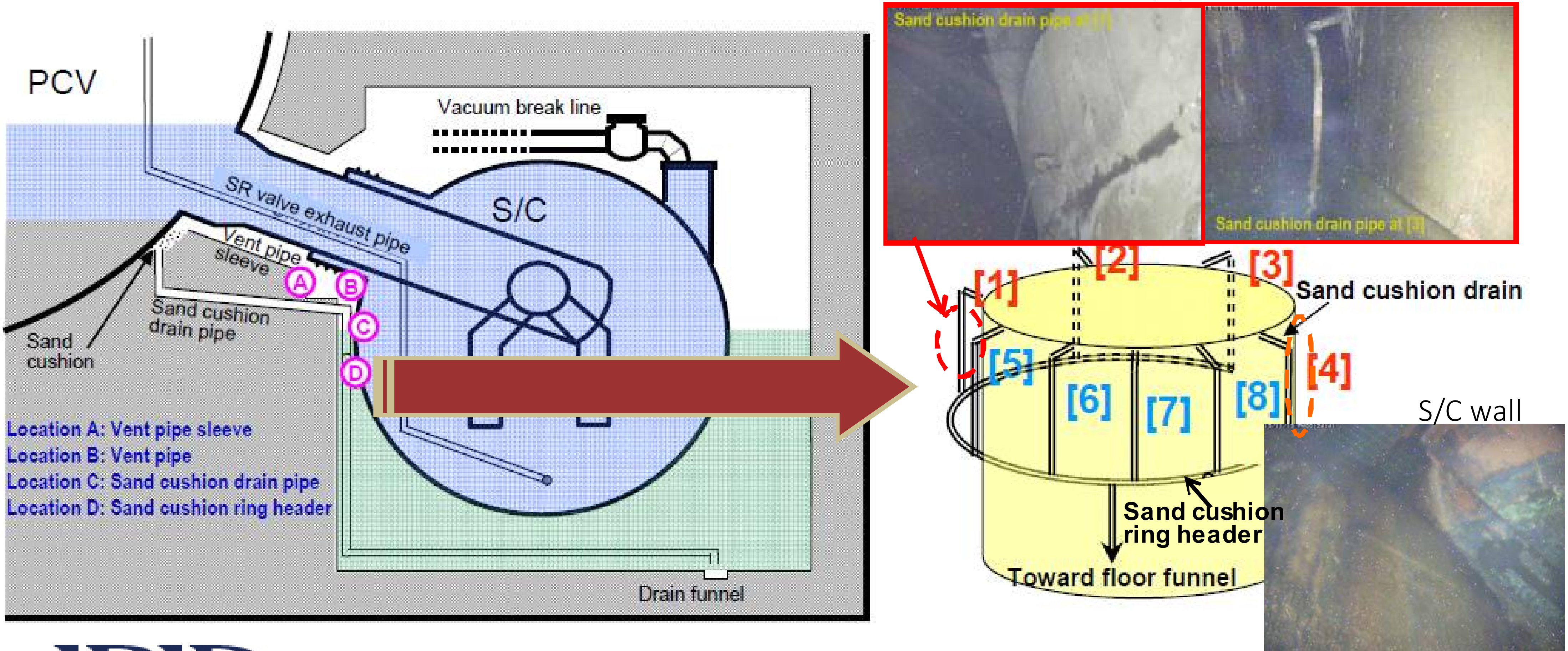
[Current status confirmed]

- Leakages are found at sand cushion drain pipe and on S/C wall in Unit 1 by cameras equipped on the boat.

[Information not yet obtained]

- Damaged points and existence of other leakage have not been confirmed.

Sand cushion drain pipe



S/C wall

Leakage Status around Lower PCV Area (Unit 2)

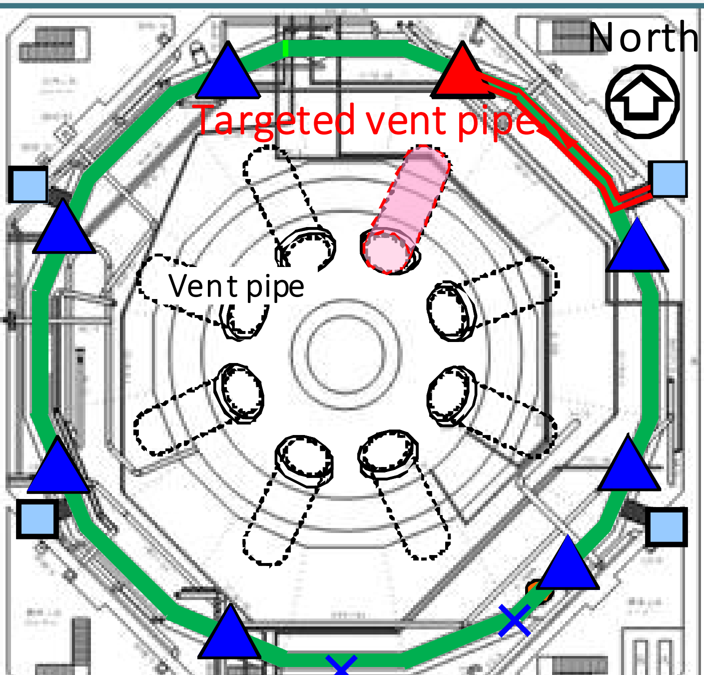
[Current status confirmed]

- Injected water has been accumulated into the bottom of torus room as a result of possible leakage in somewhere.

[Information not yet obtained]

- Leakage point is not found at Unit 2.

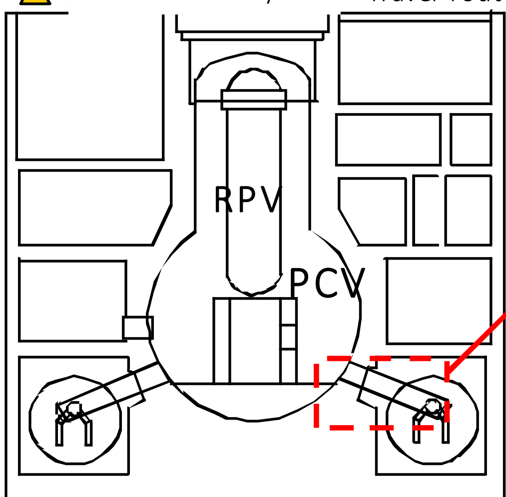
* Unit 3 is not yet investigated.



Torus diagram

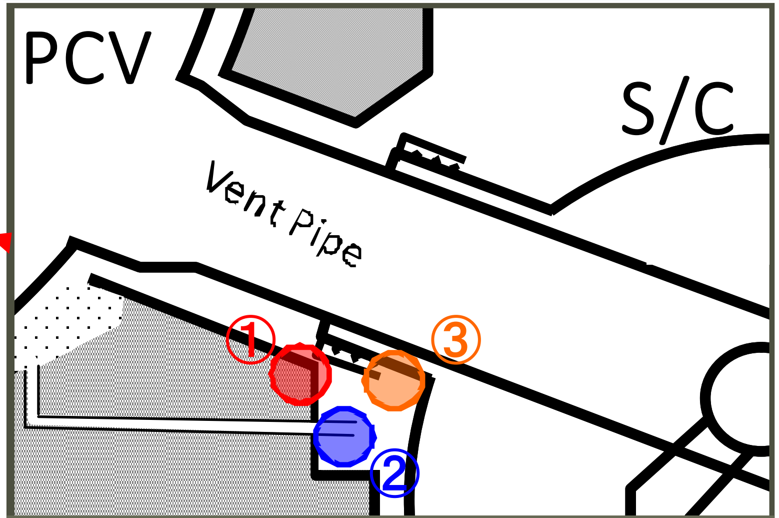
Quadruped robot arrival location (vent pipe survey location)

- : Locations surveyed this time (red)
- : Locations not yet surveyed (blue)
- : Locations surveyed (yellow)
- Travel route

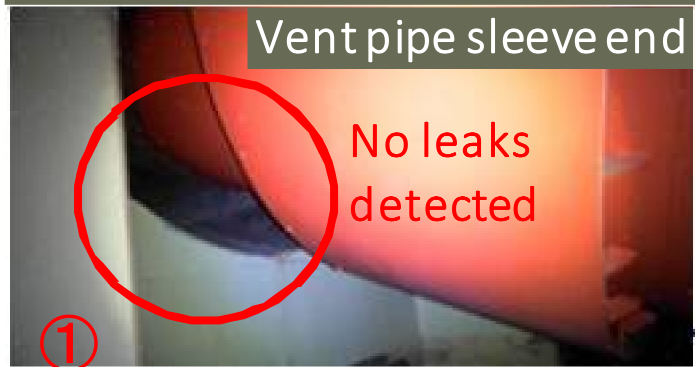


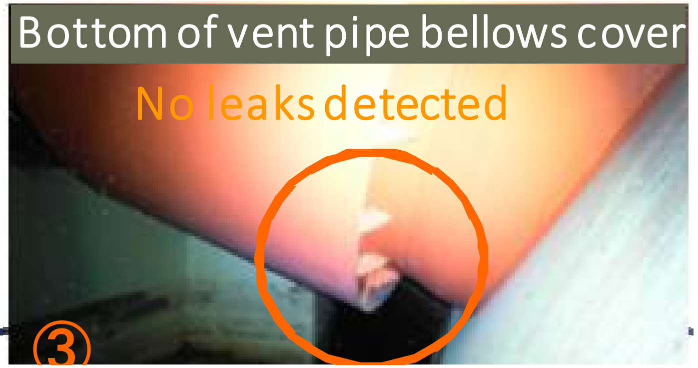
PCV cross-section

Implementation Date: December 11, 2012
Survey Target: Refer to left diagram



Enlarged view of area beneath pipes



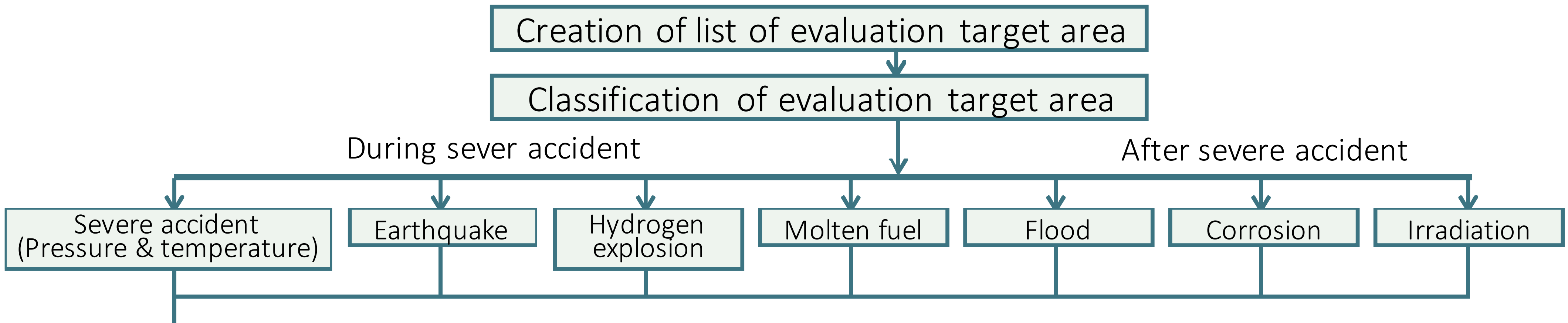


Assessment of Damage on PCV Penetrations

[Current status confirmed]
- Location and likelihood of damage at seal area by calculation.

[Information not yet obtained]
- Actual damaged point.

Estimation flow of damage on PCV penetrations



Evaluation	Action	Type of penetration
Low potential for damage	No leak survey.	Instrumental piping penetration
Possible potential for damage	Conduct leak survey on representative area.	Large diameter piping penetration
High potential for damage	Conduct repair work without conducting a leak survey. (Check situation before conducting repair work.)	Electrical penetration, Bellows

Challenges for Investigation Inside PCV/RPV and Fuel Debris Retrieval

Difficulties in fuel debris retrieval and investigation inside PCV/RPV on the premise that flooding is difficult due to the following reasons.

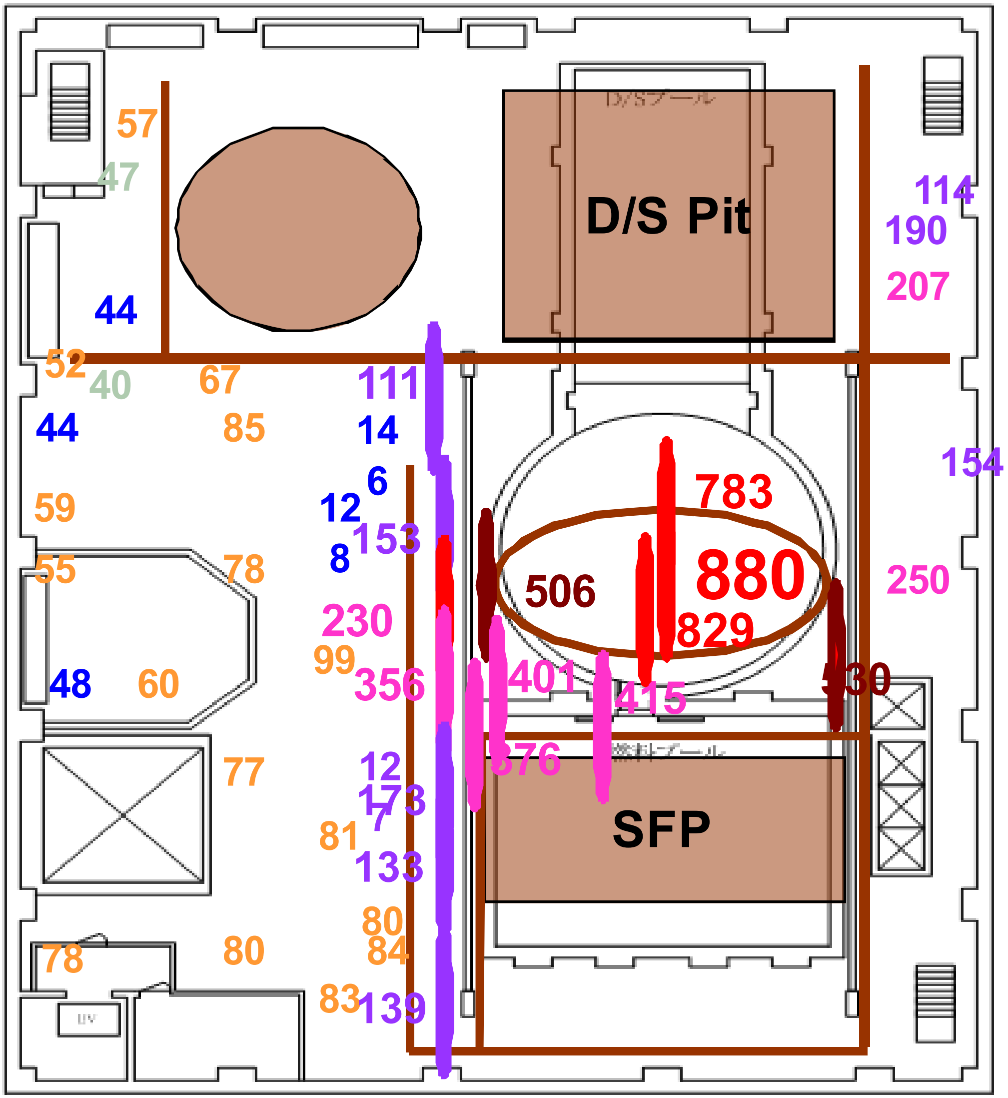
1. High dose rate (~880 mSv/h on the top of R/B)
2. Complicated core internal structure and little space of PCV
3. Difficulty of leakage stopping for a variety of PCV penetrations
4. Physical distance between refueling floor and PCV bottom

These challenges should be also taken into consideration when developing additional R&D projects.

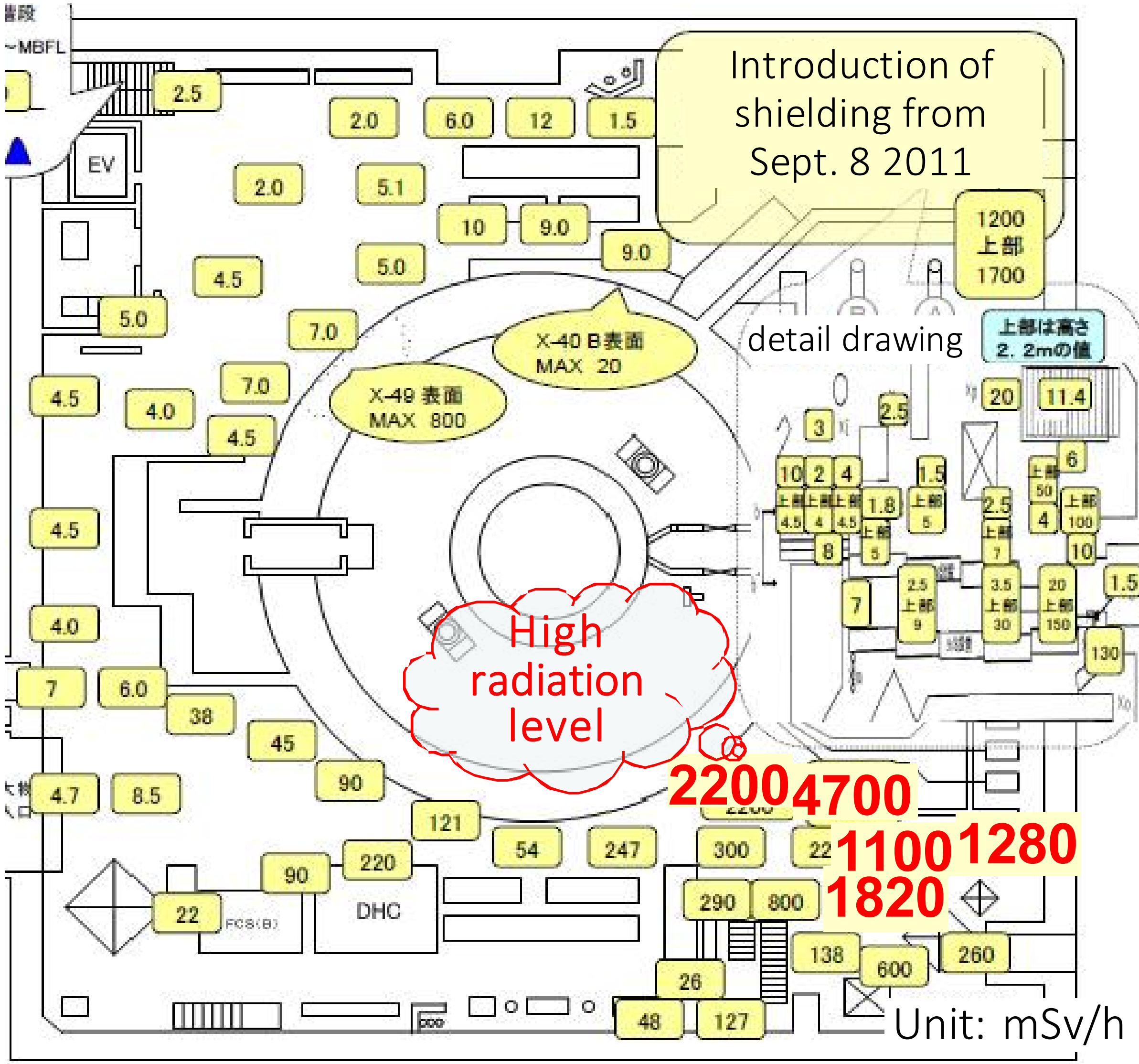
High Dose Rate

- High dose rate in reactor building makes it difficult to approach into PCV. (Max. 4,700mSv/h at 1st floor of Unit 1, 880mSV/h at top floor of Unit 2.)

Reactor Building refueling floor, Unit 2



Reactor Building 1st floor, Unit 1

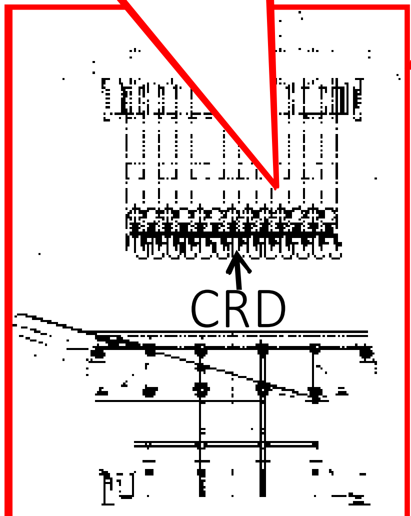


Unit: mSv/h

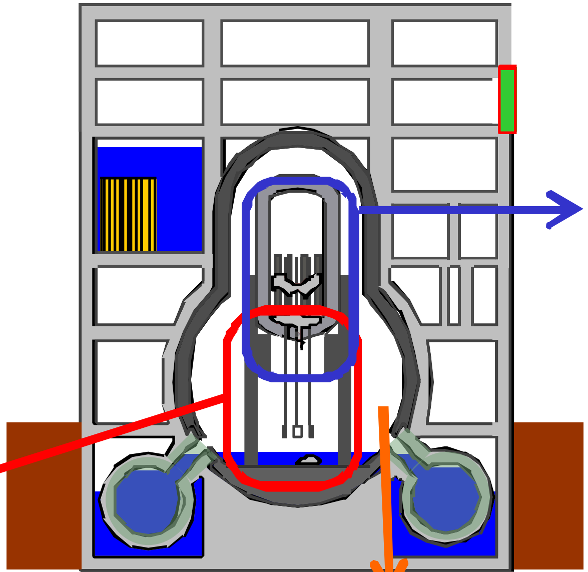
Complicated Structure and little room inside and outside PCV

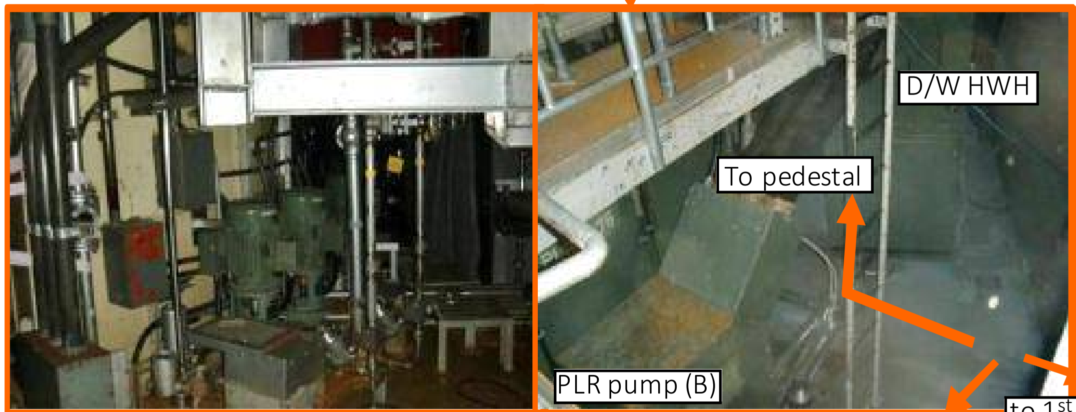
Internal structure is so complicated that access of observation equipment to inner PCV is not easy.

*Photos are taken at Unit 5 (Just for reference)



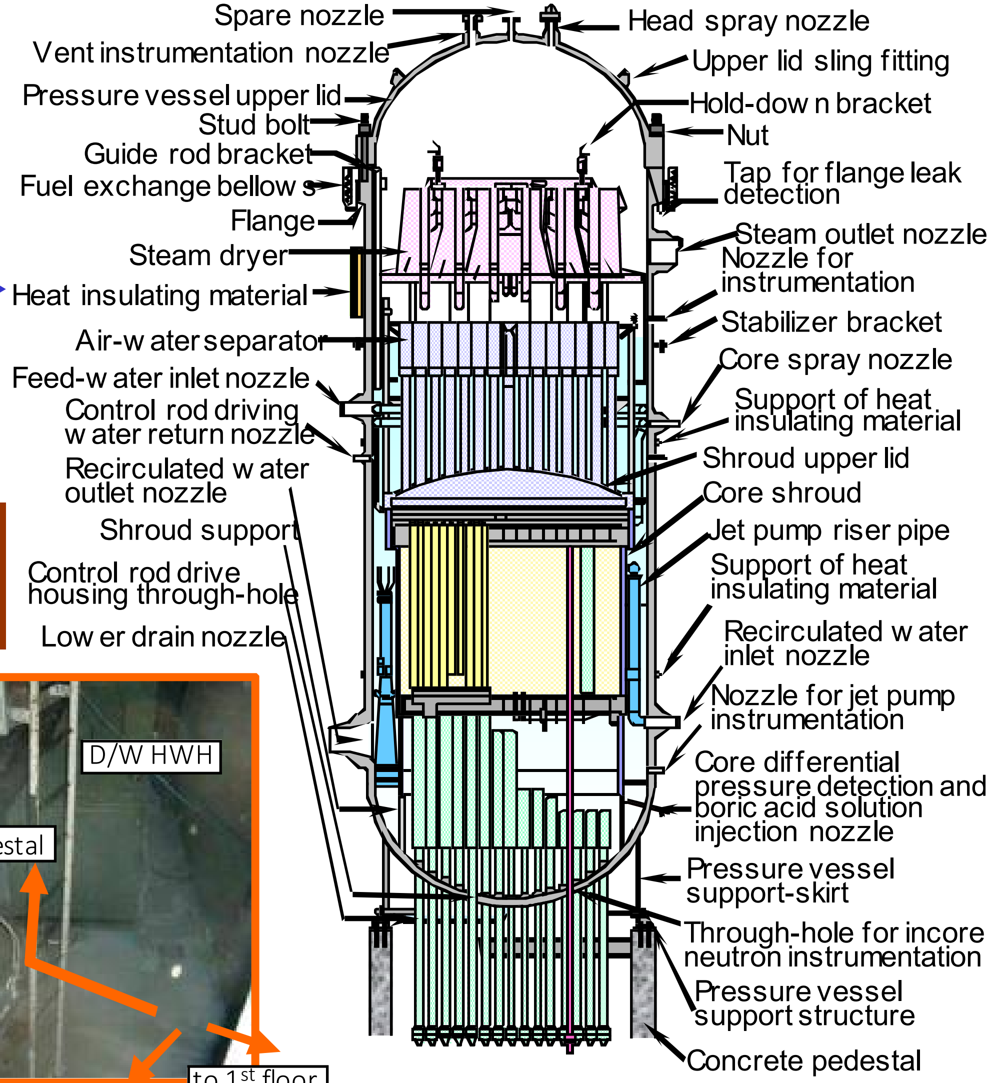
PCV pedestal





To MSIV

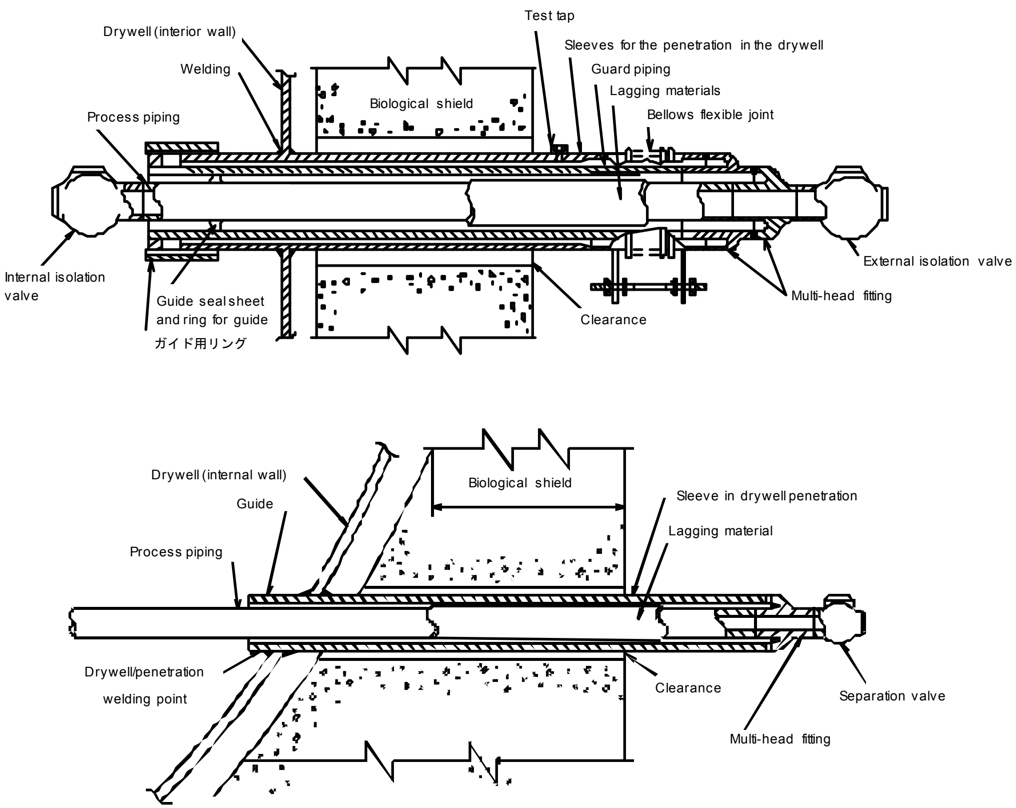
to 1st floor of R/B



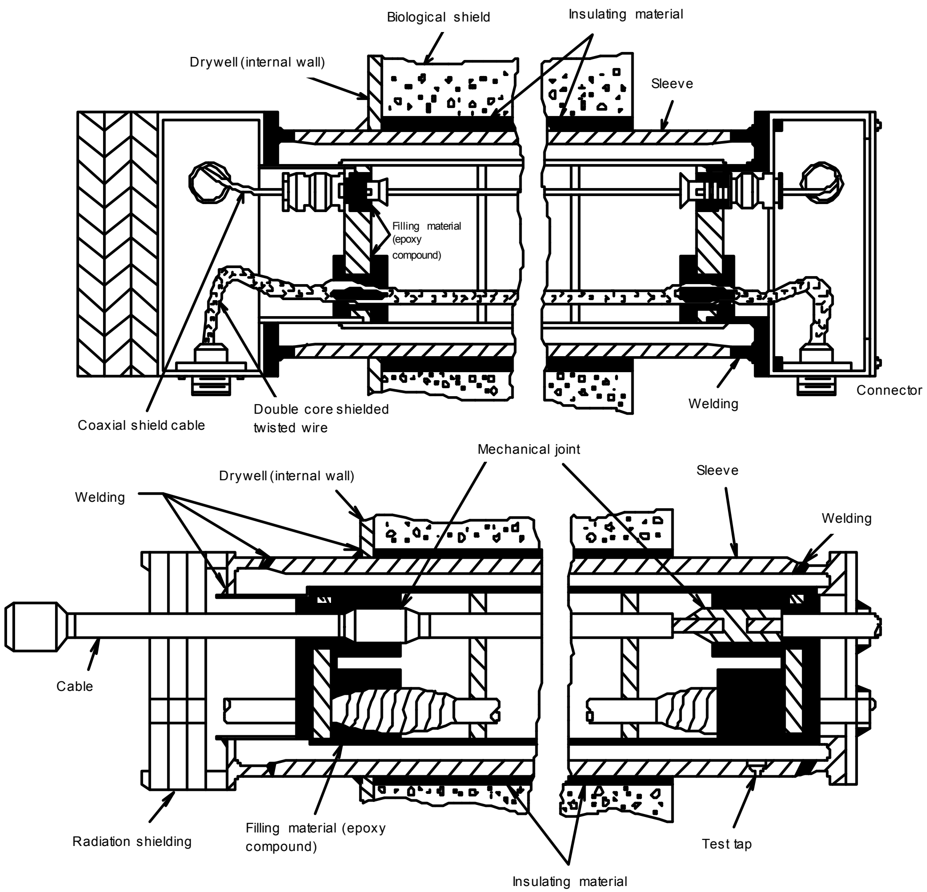
Internal Structure of RPV

Difficulty in Stopping Water due to Complex Penetration

- Large number and kinds of penetrations
  (Unit 1: about 150 spots, Unit 2: about 200 spots, Unit 3: about 190 spots)
  Total including hatches, vent pipes, piping penetrations and electrical penetrations
- The shape of some penetrations is complex, so stopping water is difficult.
- PCV penetrations have valves, which makes it difficult to inserting an equipment into PCV.



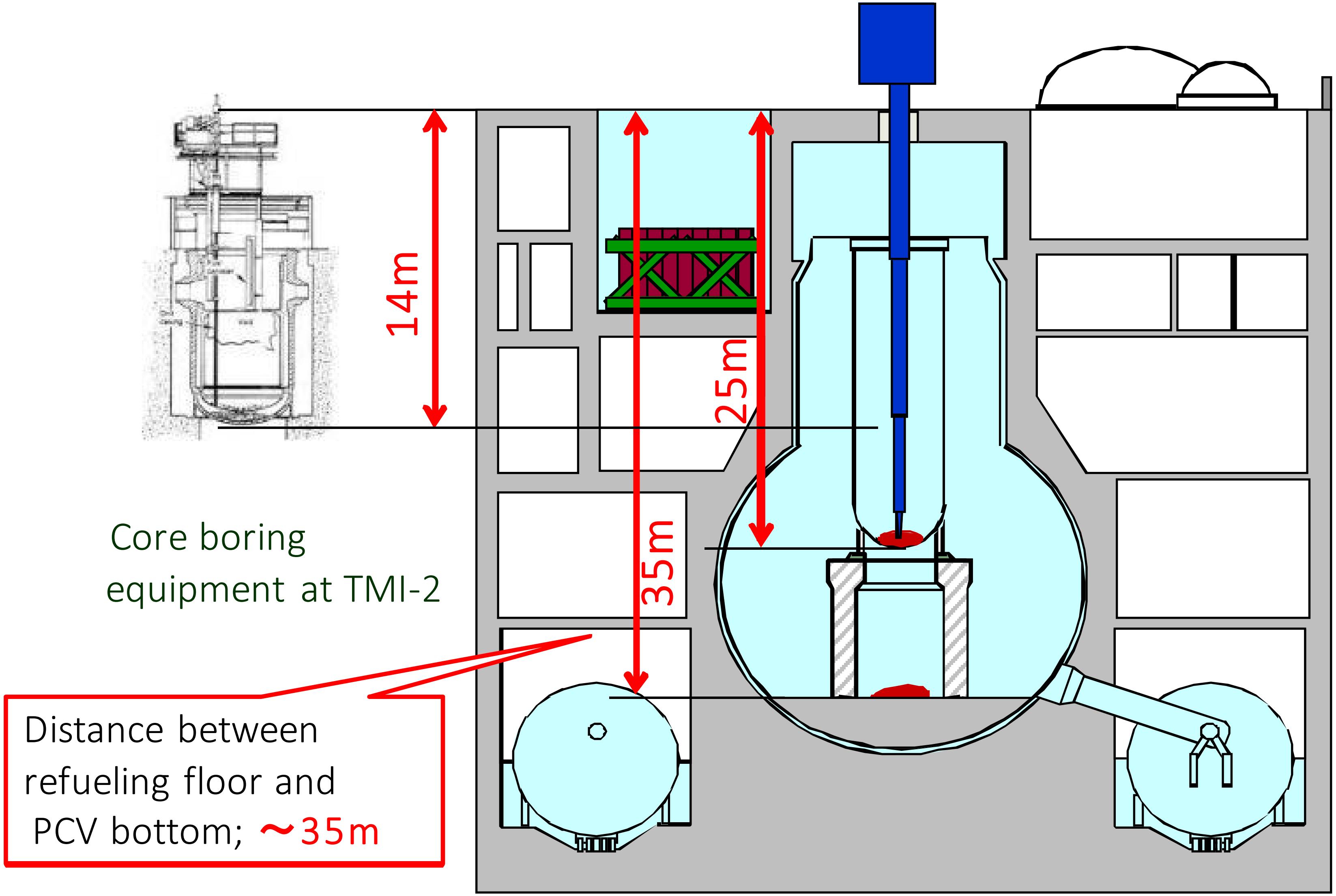
Schematic drawing of mechanical penetration



Schematic drawing of electrical penetration

Physical Distance Between Refueling Floor and PCV Bottom

- If water is filled into PCV successfully, devices for retrieval should be controlled from 35m distant.
- This requires more elaborate tools development compared to TMI.



Requested Information

the challenges presented as precondition in the previous slides are following 4 items.

1. High dose rate (~880 mSv/h on the top of R/B)
2. Complicated structure and little room inside and outside PCV
3. Difficulty of stopping leakage for a variety of PCV penetrations
4. Physical distance between refueling floor and PCV bottom

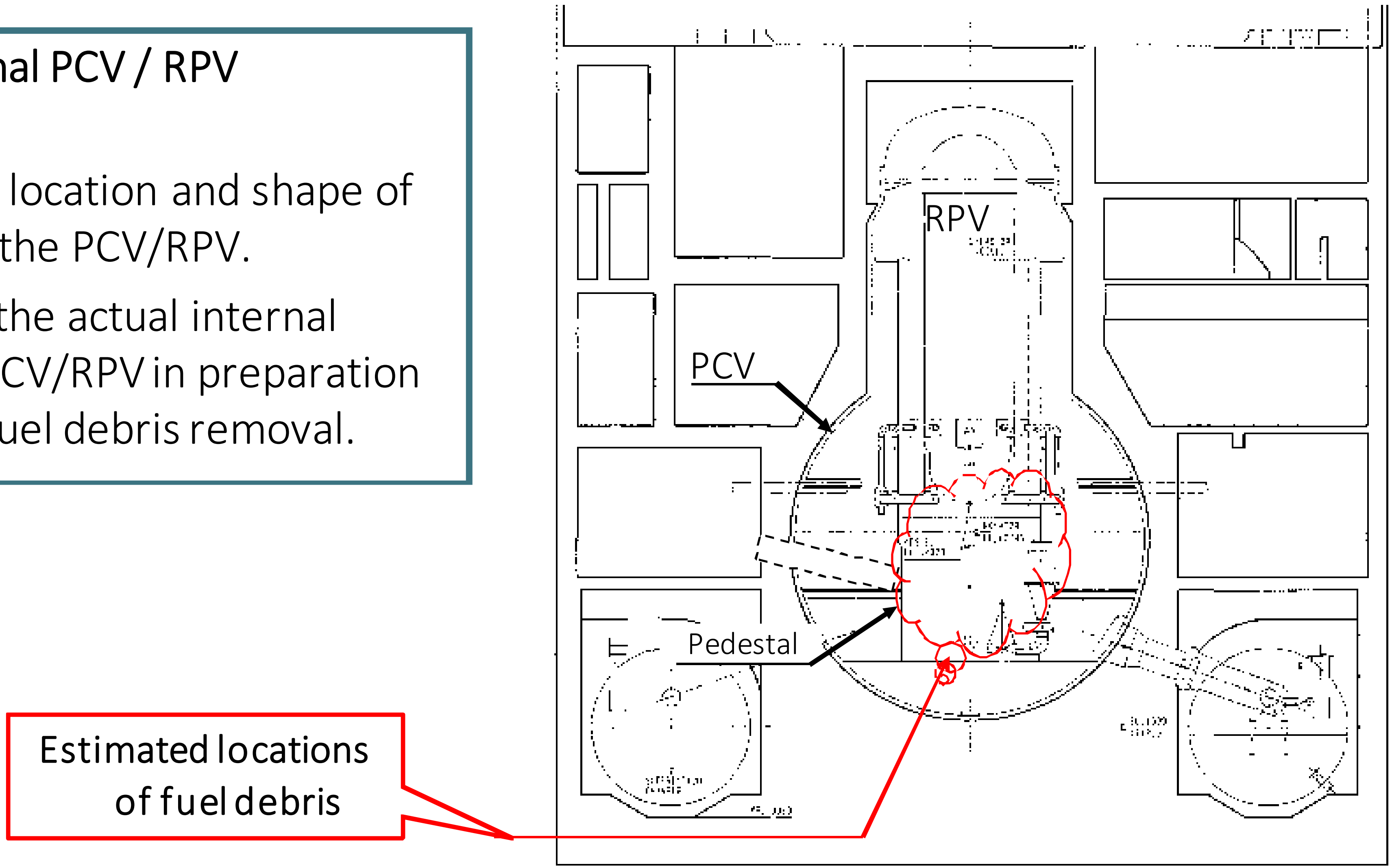
We would like to request information on innovative conceptual ideas / technologies to overcome these challenges.

Requested Information (for Topic A)

Topic A: Internal PCV/RPV investigation

Purpose of internal PCV / RPV investigation

- Detecting the location and shape of fuel debris in the PCV/RPV.
- Investigating the actual internal structure of PCV/RPV in preparation for planning fuel debris removal.



Requested Information (for Topic A)

Topic A: Internal PCV/RPV investigation (conceptual study / technologies)

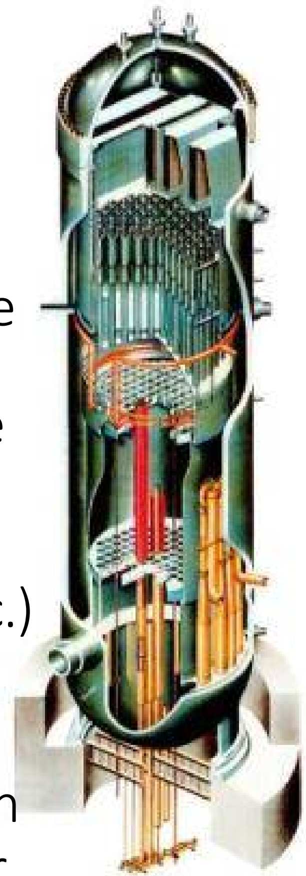
To overcome challenges such as high dose rate and complicated structure inside and outside PCV;

A-1: Conceptual study on alternative approaches [Example]

- Conceptual ideas to put investigation equipment such as cameras into PCV/RPV.
  - Applying existing through-bore such as piping and penetrations.
  - Boring new penetration.
  - Method for shielding of through-bore and operation of equipment with the object of reduction of radiation exposure.
- Methods of estimating the position of fuel debris by measuring from outside of PCV.

A-2: Technologies required for Internal PCV/RPV investigation [Example]

- Advanced measurement technologies (camera, dosimeter, thermometer etc.)
  - high performance optical instrument (camera etc.)
  - Other technology for measurement (ultrasonic wave, laser etc.)
  - Technology for controlling measuring instrument, information transmission
- Technology of identifying whether a material in the core and PCV is debris or not by evaluating its nature.



Internal Structure of RPV

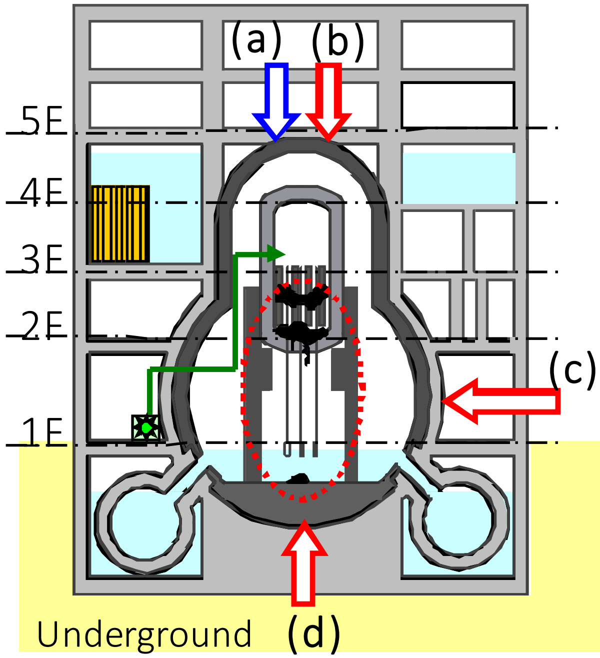
Requested Information (for Topic B)

Topic B: Fuel-debris retrieval from PCV/RPV

To overcome challenges such as physical distance between refueling floor and PCV bottom and high dose rate when accessing from top side of PCV;

B-1: Conceptual study on innovative approaches to fuel debris [Example]

- Conceptual idea of retrieving fuel debris from PCV and RPV without submerging PCV, the comparison to the submersion scenario, etc.
  - (a) Accessing and removal of fuel debris from Top side of PCV/RPV under water.
  - (b) Accessing and removal of fuel debris from Top side of PCV/RPV in atmospheric condition*.
    - By letting down operation room shielded enough.
  - (c) Accessing and removal of fuel debris from lateral side of PCV/RPV in atmospheric condition*.
    - By applying existing penetrations.
    - By boring new penetrations.
    - Methods to work under high radiation and little space environment.
  - (d) Accessing and removal of fuel debris from bottom side of PCV/RPV in atmospheric condition*.
    - By boring new penetrations.
    - Methods to work under high radiation and little space environment.



Innovative approach

* Including partial under water condition

Requested Information (for Topic B)

Topic B: Fuel-debris retrieval from PCV/RPV

We would like to request information on innovative approaches considering the challenges presented in the previous slides.

B-2: Technologies required for fuel-debris retrieval [Example]

- Technologies especially required for the innovative approaches. (approaches from atmospheric condition)
  - Technologies of removing fuel debris. (cutting, suction etc.)
  - Equipment/Facilities such as remote controlled manipulator which can be well controlled even from long distance.
  - Technologies of shielding radiation emitted by high-dose fuel debris.
  - Equipment/Facilities that operate under the high radiation environment.
  - Equipment/Facilities for boring building concrete or PCV wall to access from lateral side or bottom side of PCV/RPV.
  - Technologies of stable storage of fuel debris in PCV/RPV prior to retrieval.