Workshop for technical catalog study regarding the development of equipment to remove fuel debris for decommissioning of Fukushima Daiichi Nuclear Power Station, Tokyo Electric Power Company

The auditorium on the second basement of Ministry of Economy, Trade and Industry (Main Building) February 24, 2012

Current Status and Needs for Technical Findings

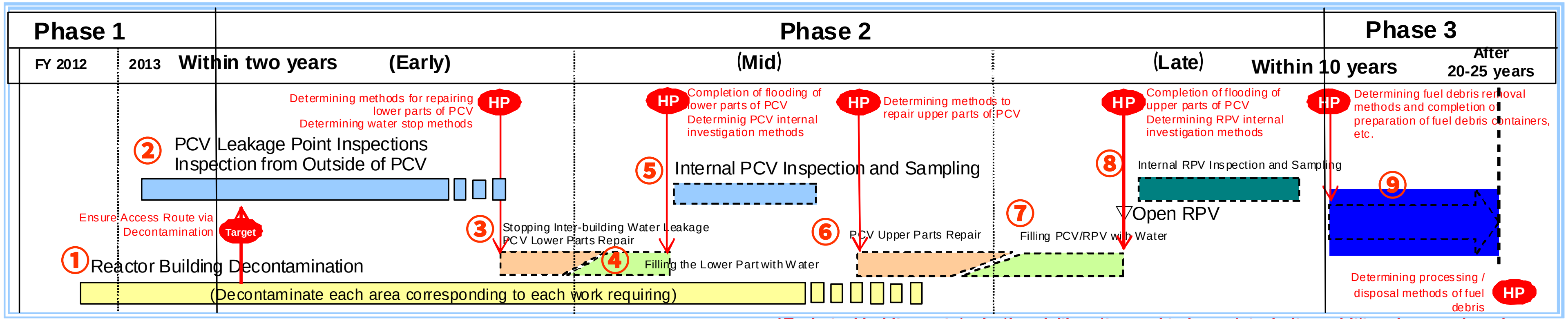
February 24, 2012

Tokyo Electric Power Company

東京電力

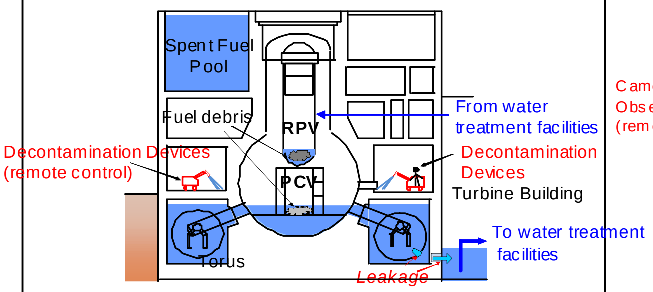
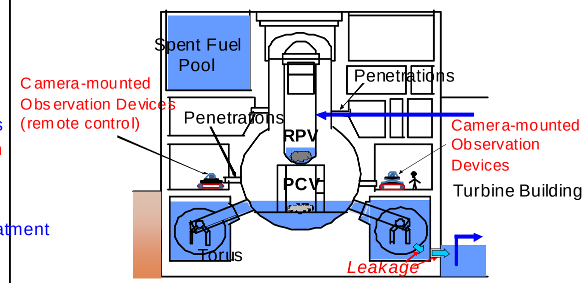
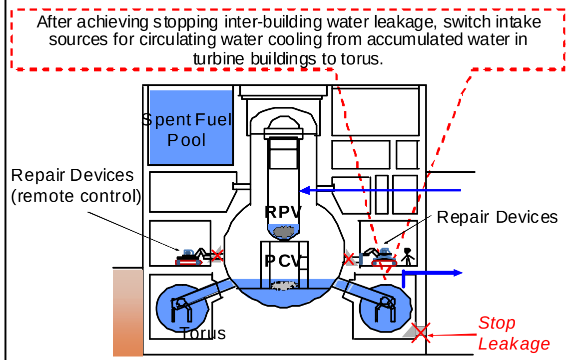
TEPCO

Work Steps Involved in Fuel Debris Removal (1/3)

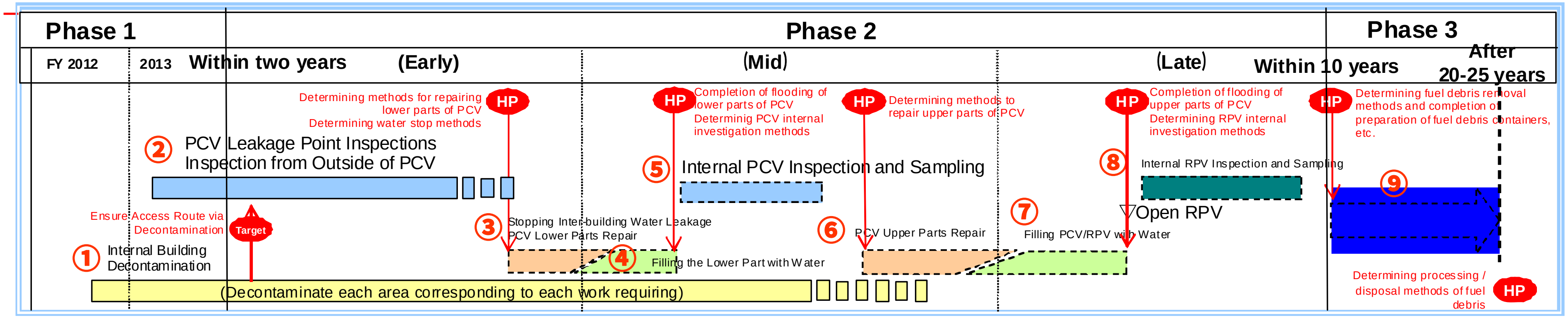


※ Work steps of removing the fuel debris underwater (as was done at TMI-2)

HP : Technical holding points. further deliberation and judgment, including additional research and development and revision of process and task content

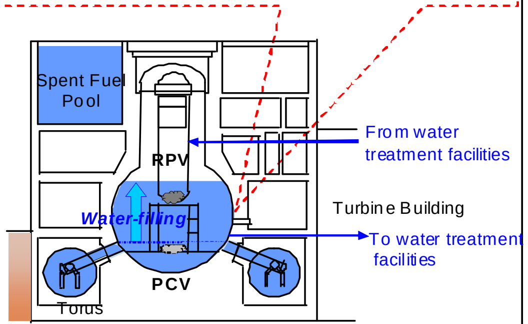
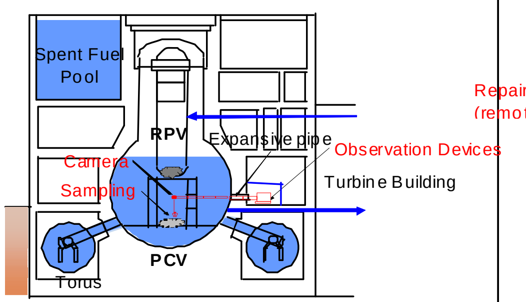
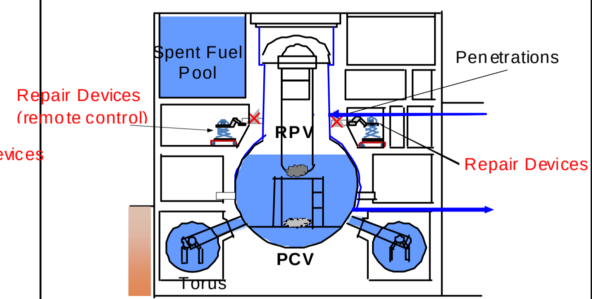
Steps	① Reactor Building Decontamination (Decontaminate each area corresponding to each work following ② sequentially)	② PCV Leakage Point Inspections Inspection from Outside of PCV	③ Stopping Inter-building Water Leakage PCV Lower Parts Repair
Images			
Contents	In order to easily access PCVs, decontaminate work area via high-pressure washing, coating, and scraping, etc.	Inspect leakage points in the PCV and reactor building via manual or remote dose measurement, and camera, etc. Estimate and inspect the status of PCV inside via measurement of gamma ray from outside of PCV, and acoustic inspection, etc.	Repair PCV leakage points and then stop water leakage because it is believed that removing debris while underwater with the radiation shielding advantage will be a reliable method. First, repair points at lower parts of PCV for internal inspection.
Points to Note on Development	◆The existence of areas of high dosage (several hundred to 1,000 mSv/h). ◆Access restriction due to rubble scattered about inside R/B. ・ Remote decontamination methods corresponding to the above need to be considered and established.	◆Inspection areas may be located in highly radioactive environments, under contaminated water, and in narrow space. ・Develop leakage point inspection methods and devices. ・Develop methods and devices for internal inspection from outside of PCV.	◆While continuing water injection for circulating water cooling, stop water leakage under highly radioactive and water flowing conditions. ・Develop technologies and methods to repair leakage points and stop water leakage. ・Consider and develop alternatives.
Points to Note on Ensuring Safety	・Maintain RPV cooling in a stable state ・Prevent radioactive materials scattering during decontamination ・Reduce workers' exposure (remote control, shielding, etc.)	・Maintain RPV cooling in a stable state ・Reduce workers' exposure (remote control, shielding, etc.)	・Maintain RPV cooling in a stable state ・Reduce workers' exposure (remote control, shielding, etc.)

Work Steps Involved in Fuel Debris Removal (2/3)

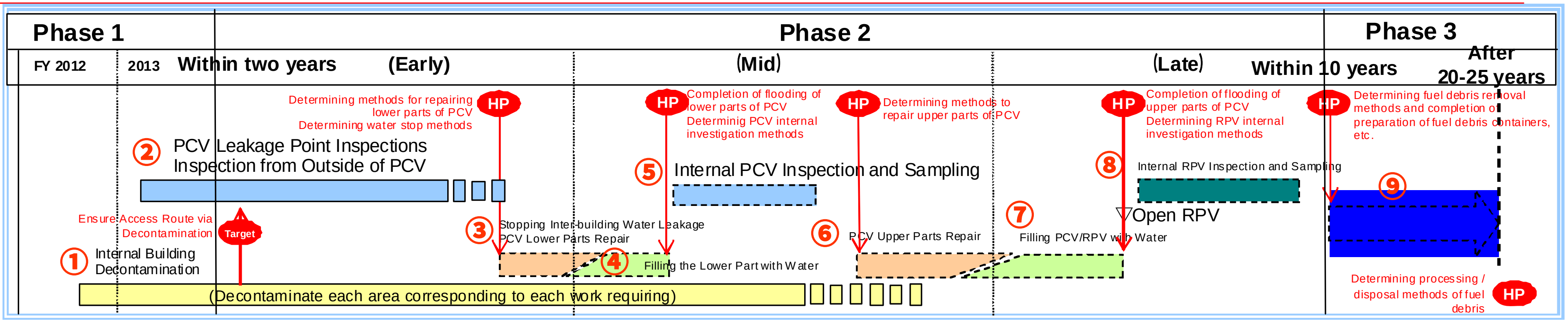


※ Work steps of removing the fuel debris underwater (as was done at TMI-2)

HP :Technical holding points. further deliberation and judgment, including additional research and development and revision of process and task content

Steps	④ Filling the Lower Part with Water	⑤ Internal PCV Inspection and Sampling	⑥ PCV Upper Parts Repair
Images	After establishing boundaries at the lower parts of PCV, switch the water intake sources for circulating cooling from torus room to PCV.  	 	
Contents	Partially fill the lower parts of PCV with water before starting PCV internal inspection.	Ascertain distributions of fuel debris flowed from RPV by internal PCV inspections and samplings etc.	In order to fill the PCV full with water, repair leakage points at the upper parts of PCV by manual or remote methods.
Points to Note on Development	◆Same as ③ ・Place top priority on establishing boundaries at the lower parts of PCV (including filling torus room with grout materials).	◆ Access restriction due to high radioactive conditions and unknowing PCV internal conditions (clearness of internal water, existence of debris, etc.) ・Develop remote inspection methods and sampling methods corresponding to the above.	◆ Same as ② ・Develop technologies and methods to repair PCV leakage points and stop water leakage (same as ③).
Points to Note on Ensuring Safety	・Maintain RPV cooling in a stable state ・Subcritical assessment	・Maintain RPV cooling in a stable state ・Subcritical assessment ・Prevent radioactive substances release from PCVs ・Reduce workers' exposure (remote control, shielding, etc.)	・Maintain RPV cooling in a stable state ・Reduce workers' exposure (remote control, shielding, etc.)

Work Steps Involved in Fuel Debris Removal (3/3)



※ Work steps of removing the fuel debris underwater (as was done at TMI-2)

HP :Technical holding points. further deliberation and judgment, including additional research and development and revision of process and task content

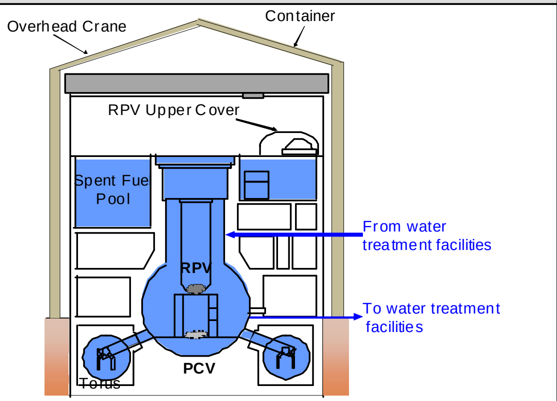
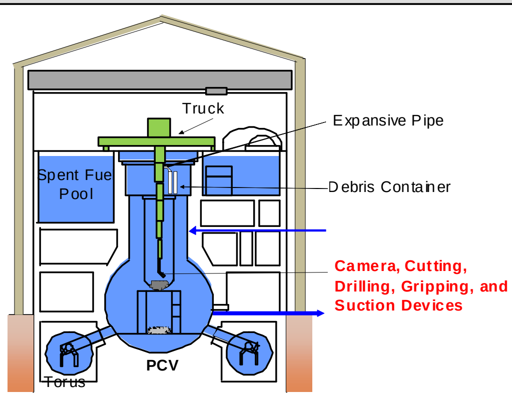
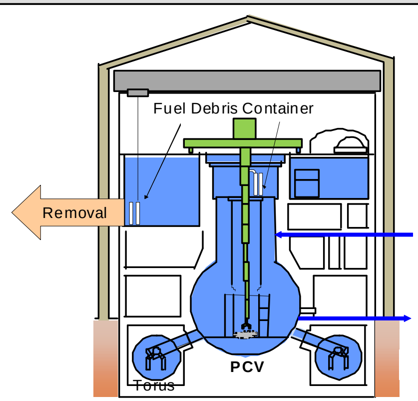
Steps	⑦ Filling PCV and RPV with Water ⇒ Open the upper cover on RPV	⑧ Internal RPV Inspection and Sampling	⑨ Fuel Debris Removal
Images			
Contents	After filling PCV/RPV with enough water to ensure shielding, open the upper cover on RPV.	Ascertain conditions of fuel debris and internal RPV structures by internal RPV inspections and samplings etc.	Remove debris inside RPV and PCV
Points to Note on Development	(Place top priority on establishing PCV boundaries as per ⑥)	◆Restricted access route due to high radioactive conditions and unknown internal RPV conditions (clearness of internal water, existence of debris, etc.) ・Develop remote inspection methods and sampling methods based on the above.	◆Expand technology development scope depending on distribution status of fuel debris (No experience of fuel removal of inside PCV at TMI) ・Develop more sophisticated technologies and methods than those of TMI
Points to Note on Ensuring Safety	・Maintain RPV cooling in a stable state ・Subcritical assessment ・Prevent radioactive substances release from PCVs	・Maintain RPV cooling in a stable state ・Subcritical assessment ・Store the removed fuel debris (containment etc.) ・Reduce workers' exposure (remote control, shielding, etc.)	・Maintain RPV cooling in a stable state ・Subcritical assessment ・Store the removed fuel debris (containment etc.) ・Reduce workers' exposure (remote control, shielding, etc.)

Image of Main R&D Issues related to Fuel Debris Removal

■ Development of technologies for remote decontamination of the reactor building interior

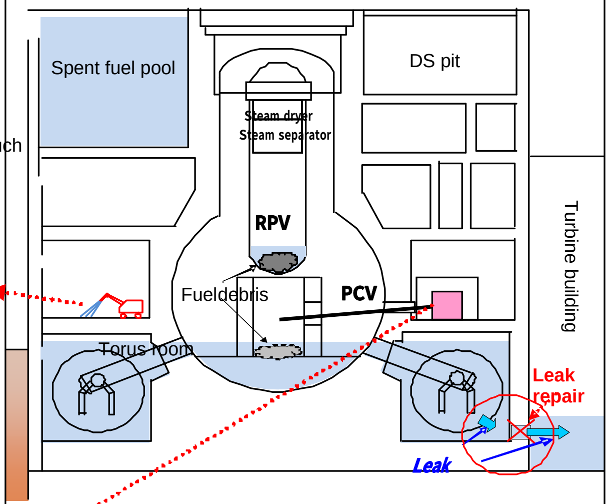
◆ Overview

Remote decontamination devices that match onsite contamination conditions will be developed to improve the work environment for surveying and repairing leak areas, etc.

◆ Technical development issues

- Assessment and development of effective decontamination techniques in response to contamination type
- Development of remote decontamination devices for severe environments, such as high-dose areas, narrow spaces, etc.

Decontamination technologies (examples)



■ Development of technologies for identification of leak areas in the PCV

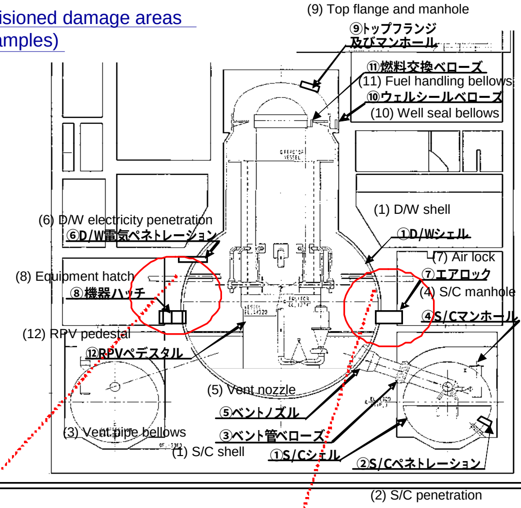
◆ Overview

Technologies for remote identification of leak areas in the PCV, etc. will be developed.

◆ Technical development issue

- Development of remote survey technologies for severe environments, such as high -dose areas, narrow spaces, etc.

Envisioned damage areas (examples)



■ Development of technologies for investigation of the PCV interior

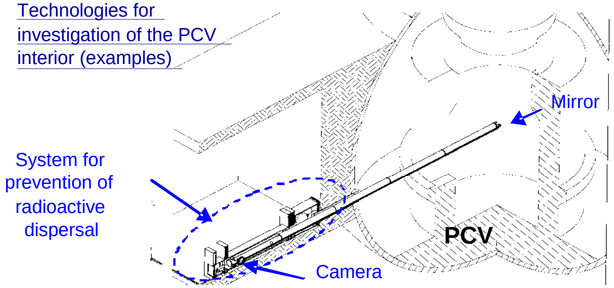
◆ Overview

Remote investigation methods and devices will be developed to grasp the conditions and the state of fuel debris inside the PCV.

◆ Technical development issues

- Development of remote investigation technologies for high -temperature, high-humidity, and high -dose environments
- Development of a system to prevent the dispersal of radioactive materials

Technologies for investigation of the PCV interior (examples)



■ Development of PCV Repair Technologies

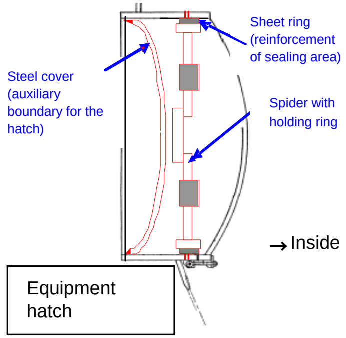
◆ Overview

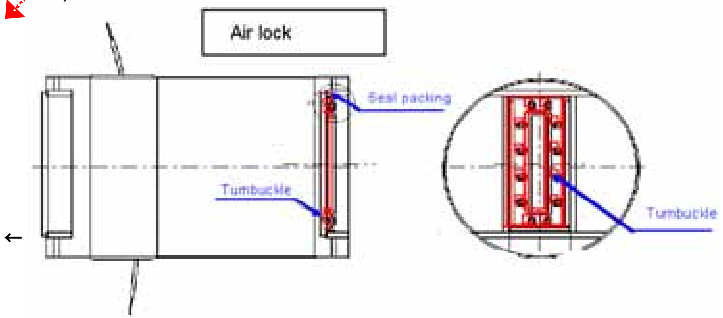
Remote measures and technologies will be developed to repair and stop leaks in leaking areas (Torus room, PCV, etc.).

◆ Technical development issues

- Development of remote repair technologies for severe environments, such as high -dose areas, narrow spaces, etc.
- Repair technologies applicable to underwater environments (lower part of the PCV, etc.)

Penetration hole repair technologies (examples)





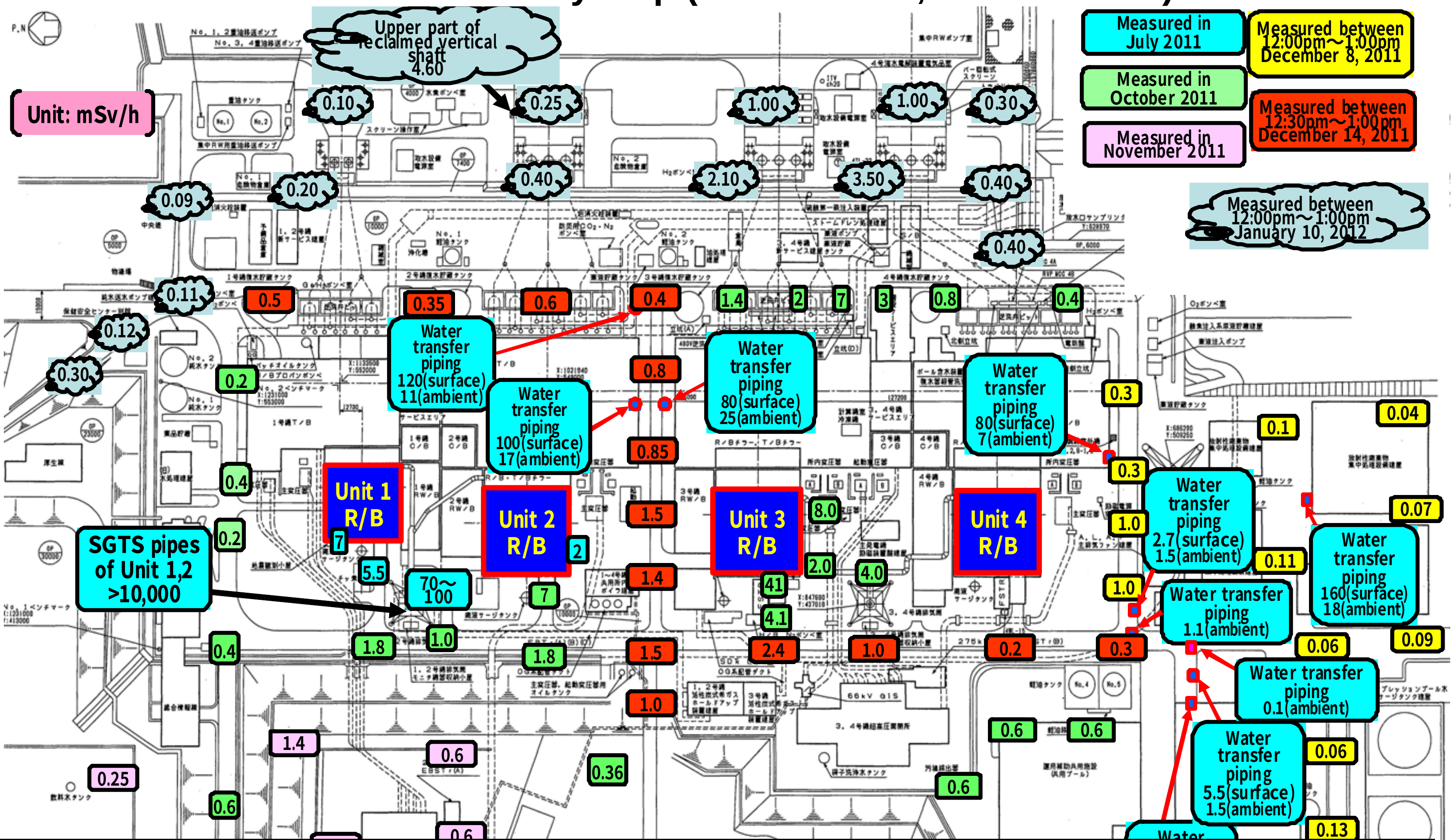
Status of Contamination (Airborne Radiation Rate) in Reactor Buildings

Current Status of Unit 1 – 4 of Fukushima Daiichi Nuclear Power Station

Around 10:24 on January 31, 2012, Photograph by GeoEye-1 (C)GeoEye /Japan Space Imaging Corporation)

Current Status of Airborne Radiation Rate in the Power Station

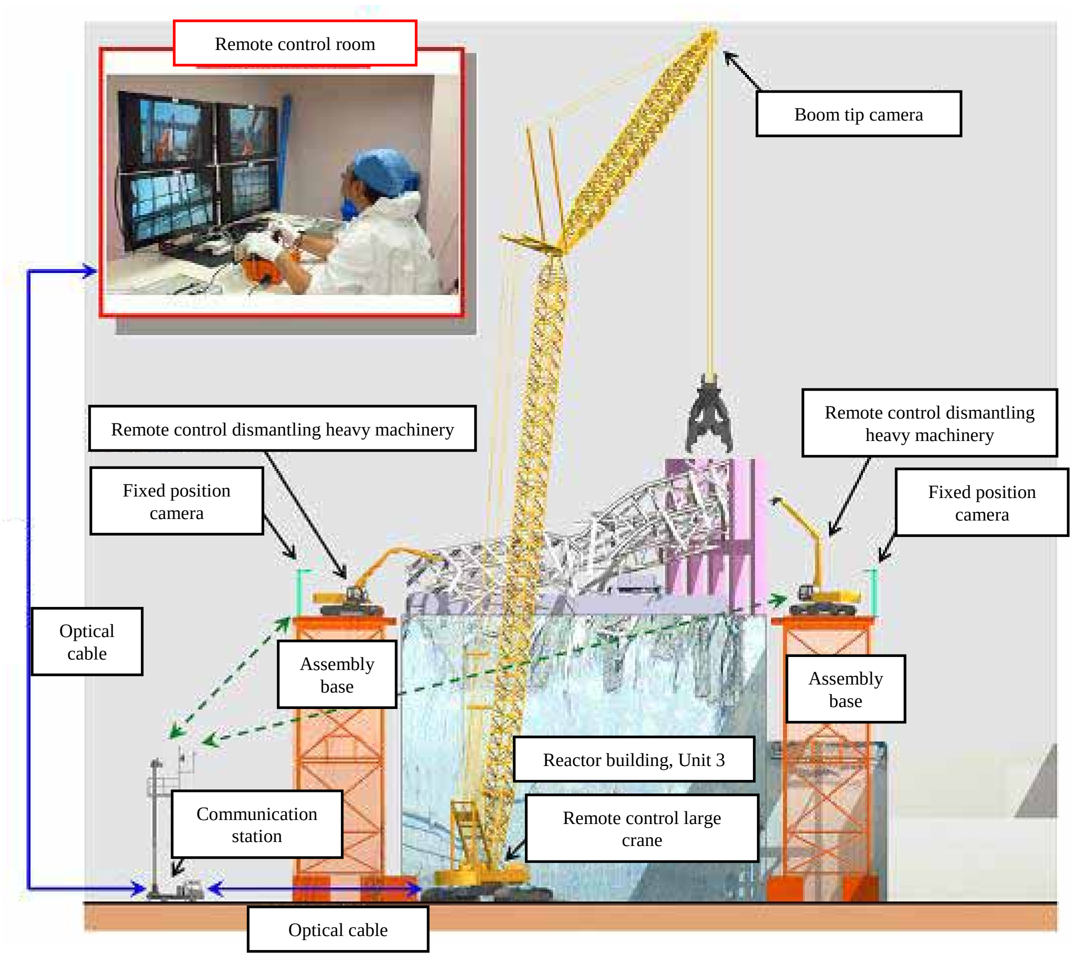
Fukushima Daiichi survey map (as of Jan. 10, 2012 at 17:00)



Although some places around the reactor buildings are high radiation dose, airborne radiation on the site is around 1～2mSv/h.

東京電力 TEPCO

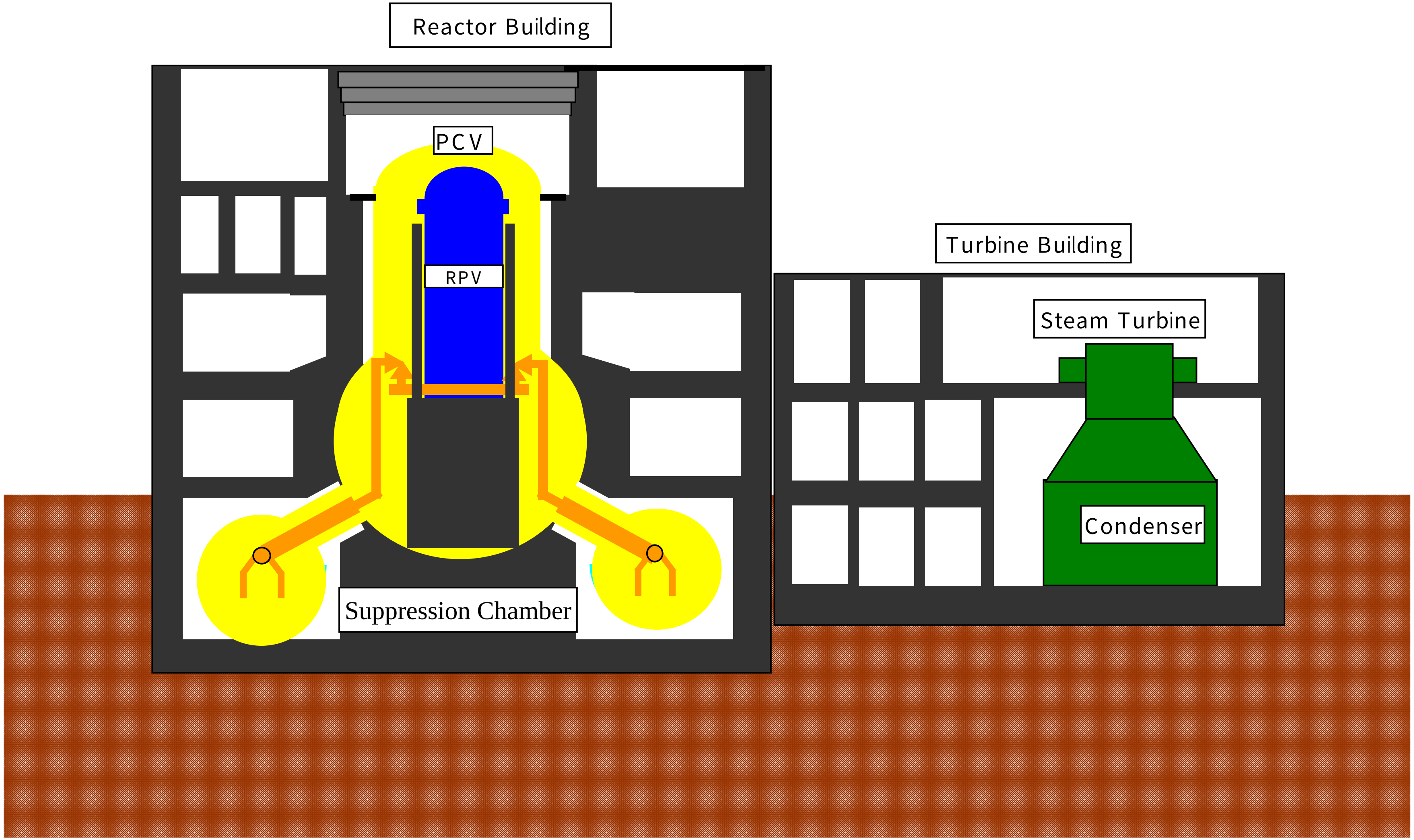
Removal of debris in the power station by remote control system



Removal of debris of Unit 3

Removal of debris on the ground

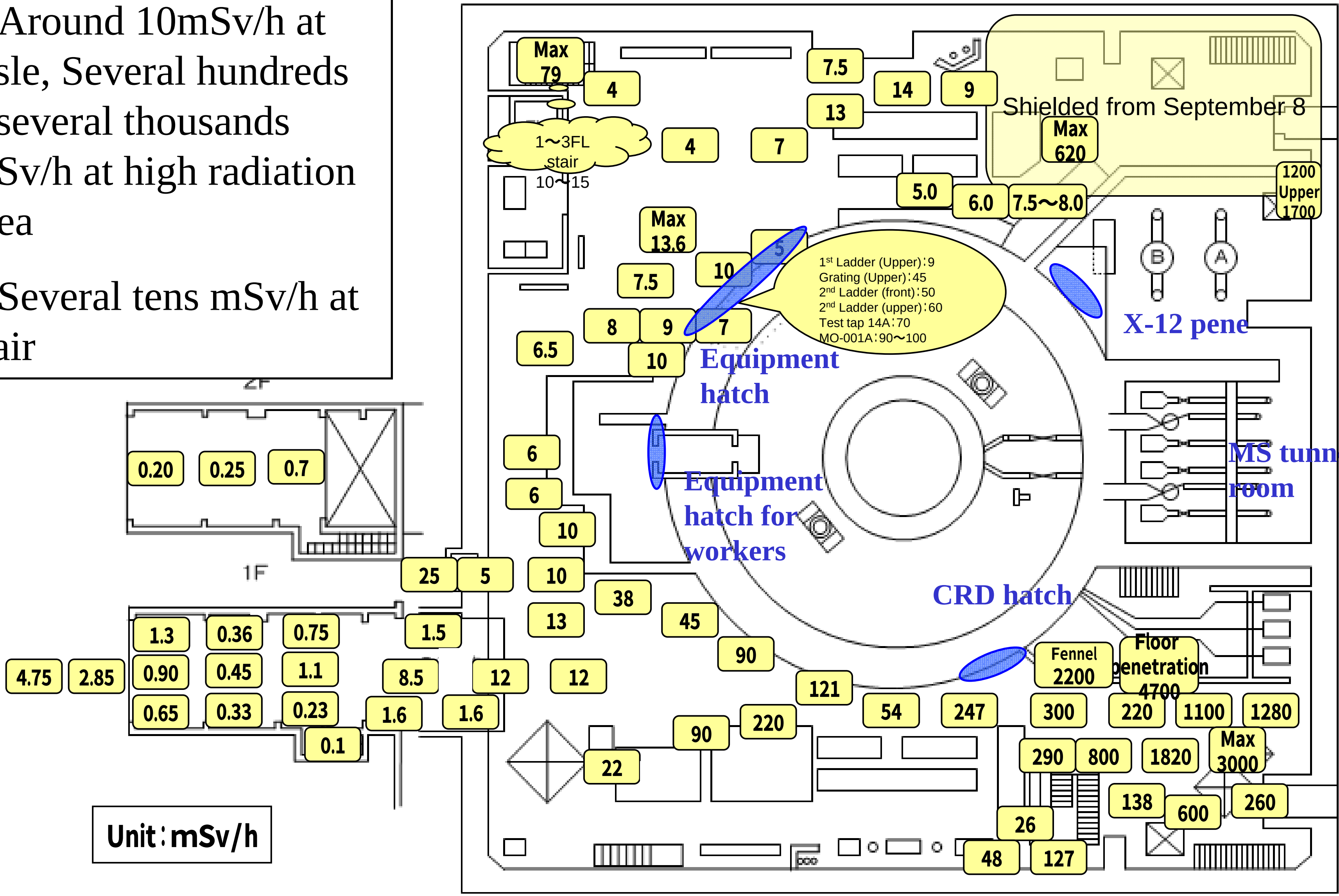
Structure of reactor building and turbine building



Airborne radiation rate of reactor building (1^{st} floor , Unit 1)

- Around 10mSv/h at aisle, Several hundreds – several thousands mSv/h at high radiation area

- Several tens mSv/h at stair

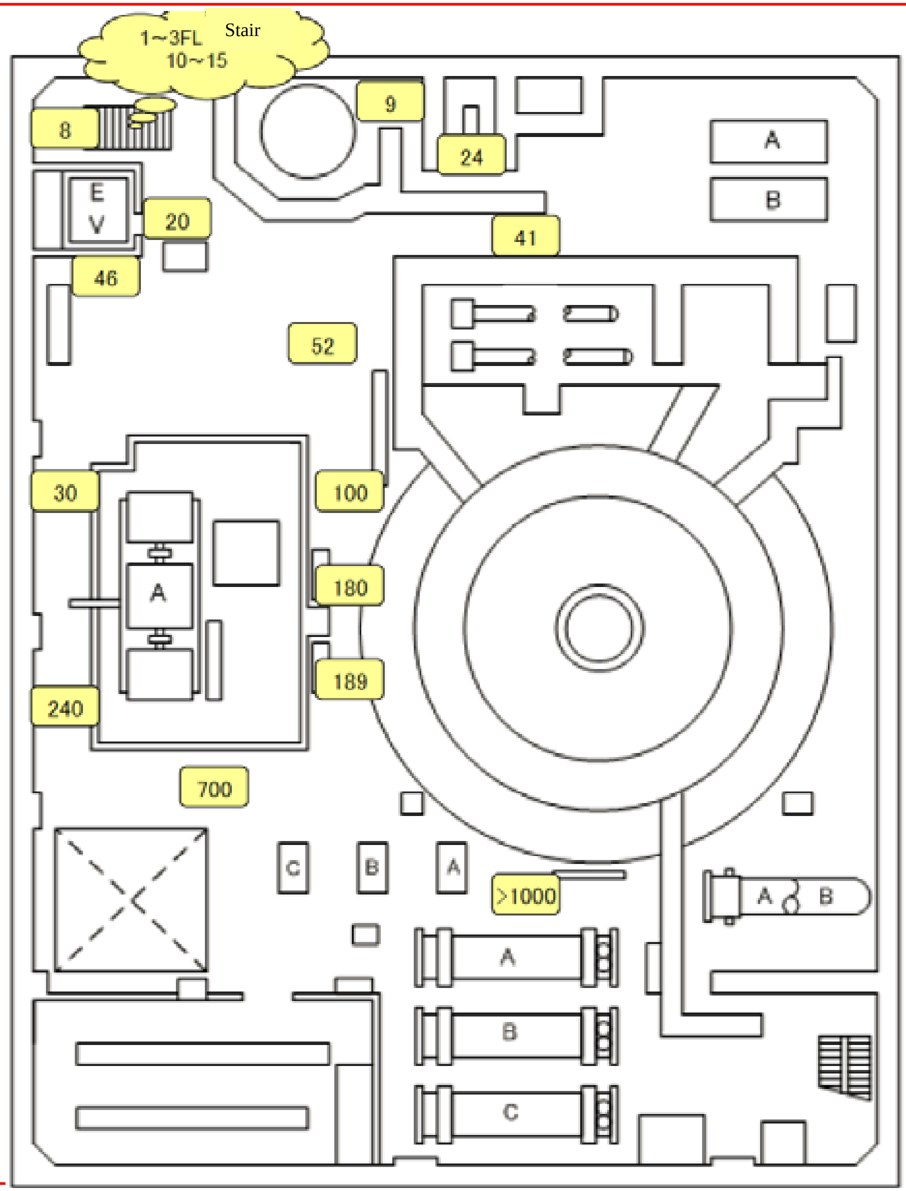


Unit:mSv/h

Data obtained from April to November 2011

Airborne radiation rate of reactor building (2nd floor , Unit 1)

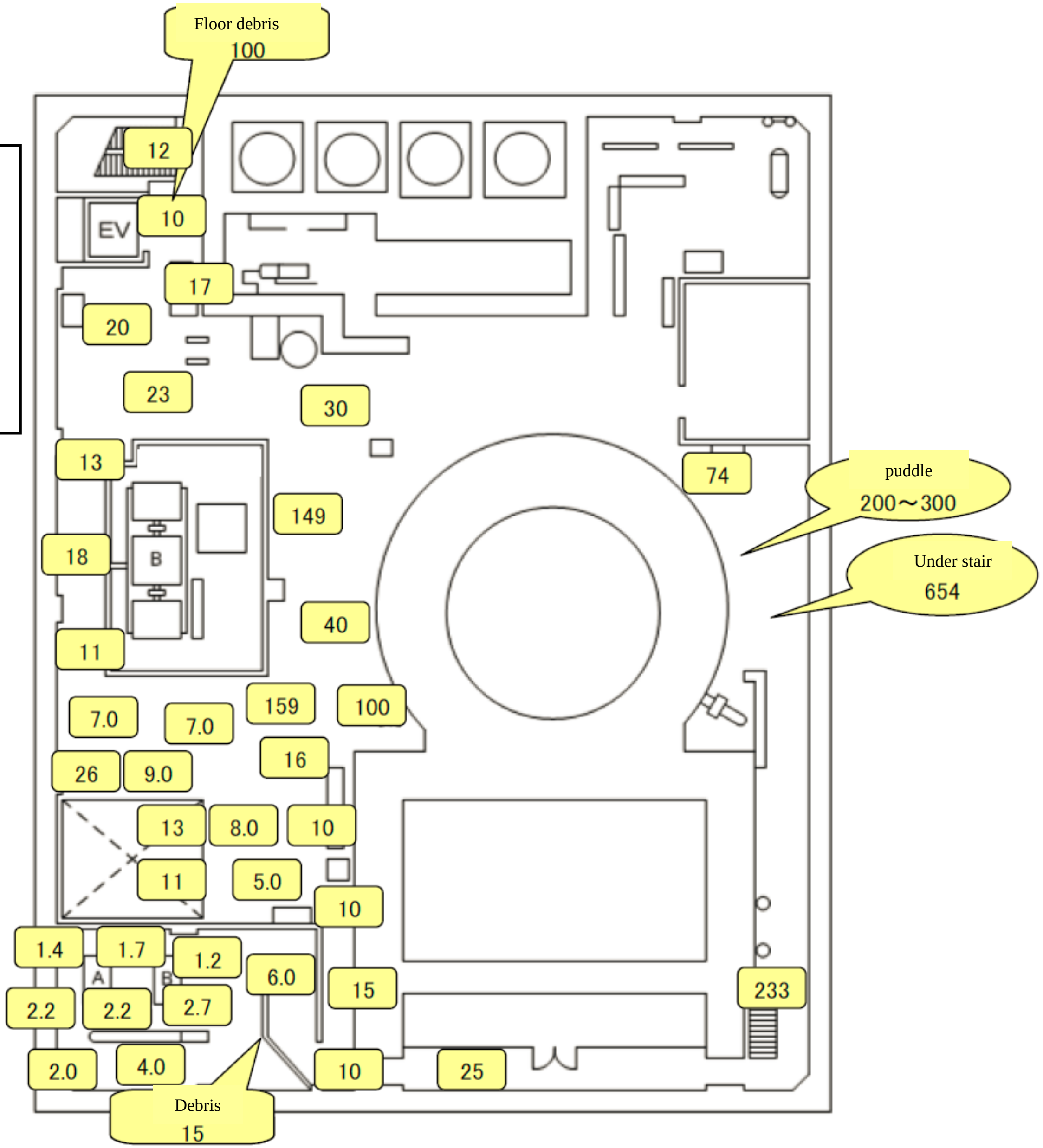
- Around several tens – several hundreds mSv/h at aisle
- More than 1000mSv/h at high radiation areas



Data obtained from April to November 2011

Airborne radiation rate of reactor building (3rd floor , Unit 1)

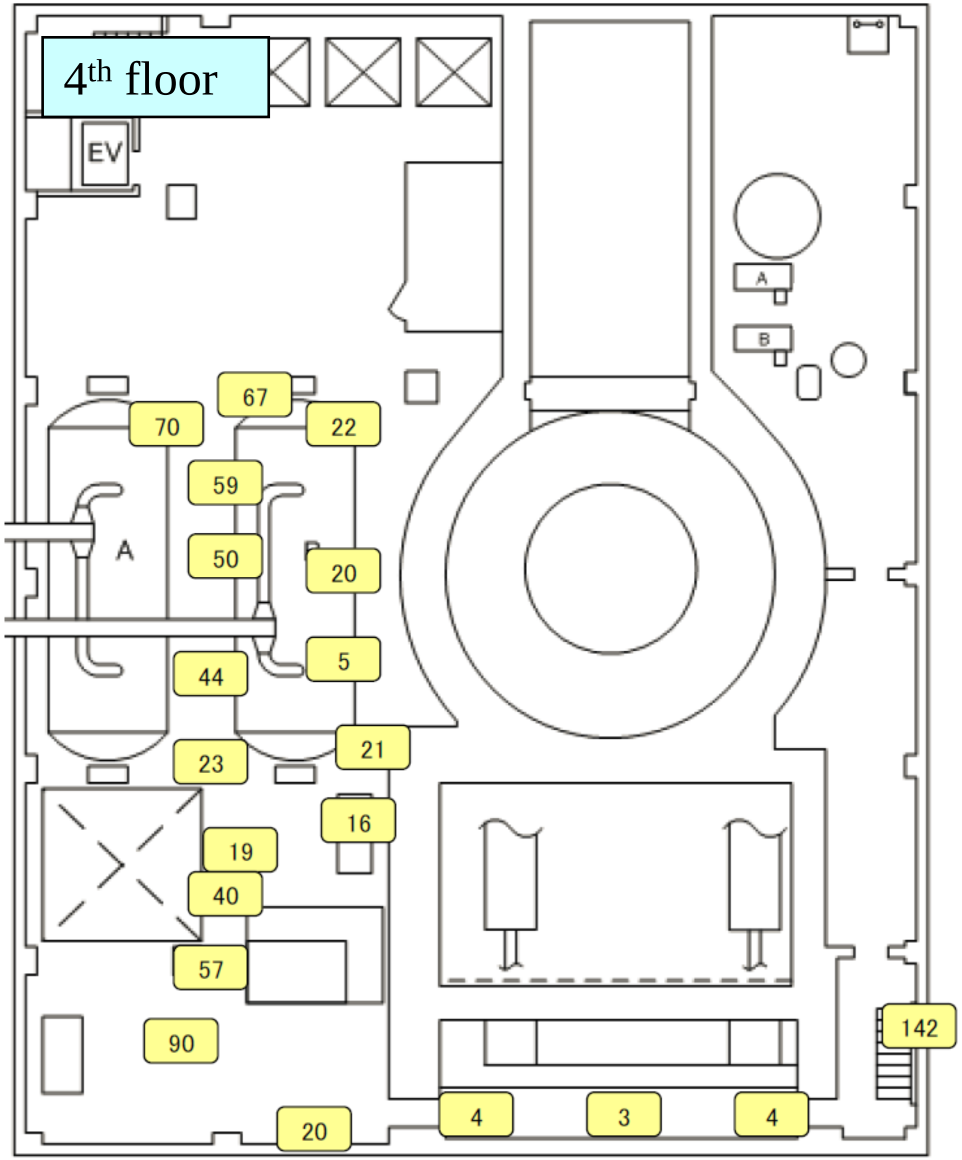
- Around several tens – several hundreds mSv/h at aisle
- Several hundreds mSv/h in accumulated water

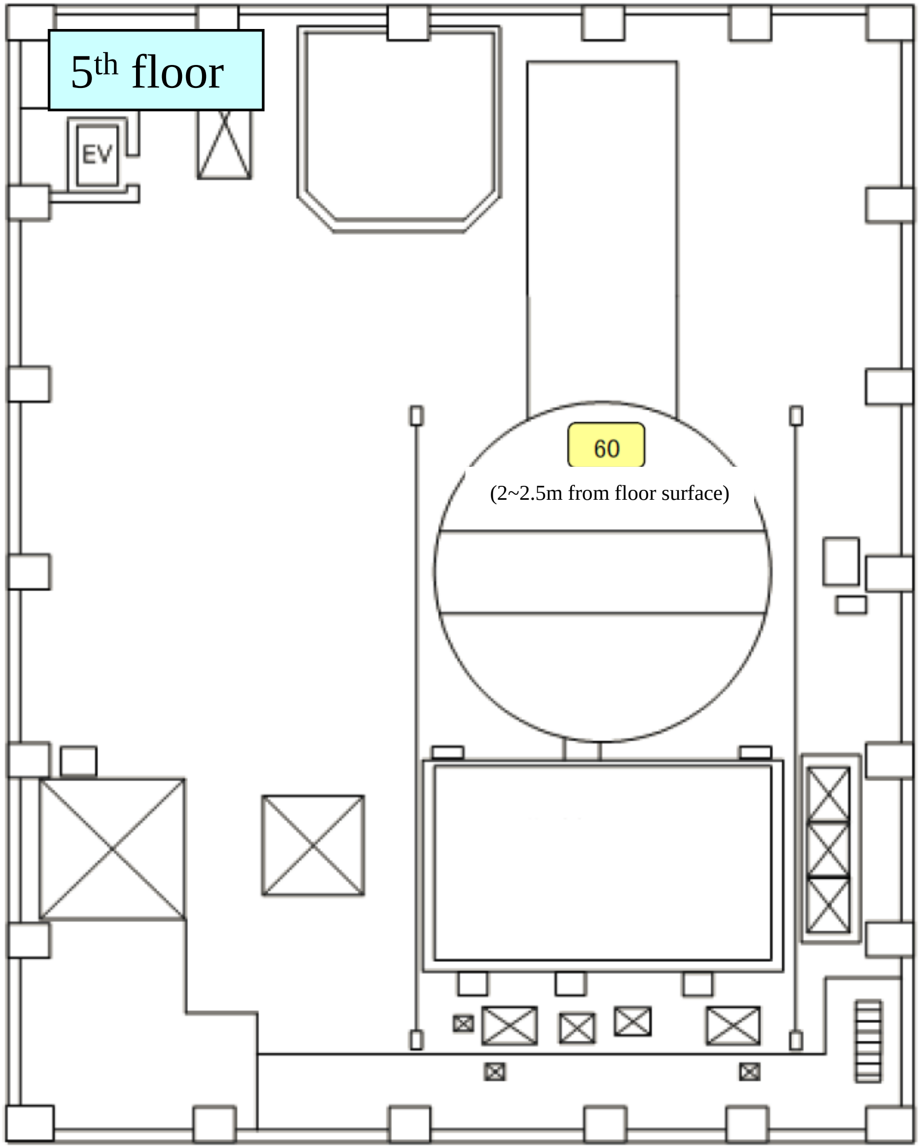


Data obtained from April to November 2011

東京電力 TEPCO

Airborne radiation rate of reactor building (4th and 5th floor , Unit 1)





Data obtained from April to November 2011

Summary of Status of Contamination (Airborne Radiation Rate) in Reactor Buildings

✓There are many area that has several tens – several hundreds mSv/h

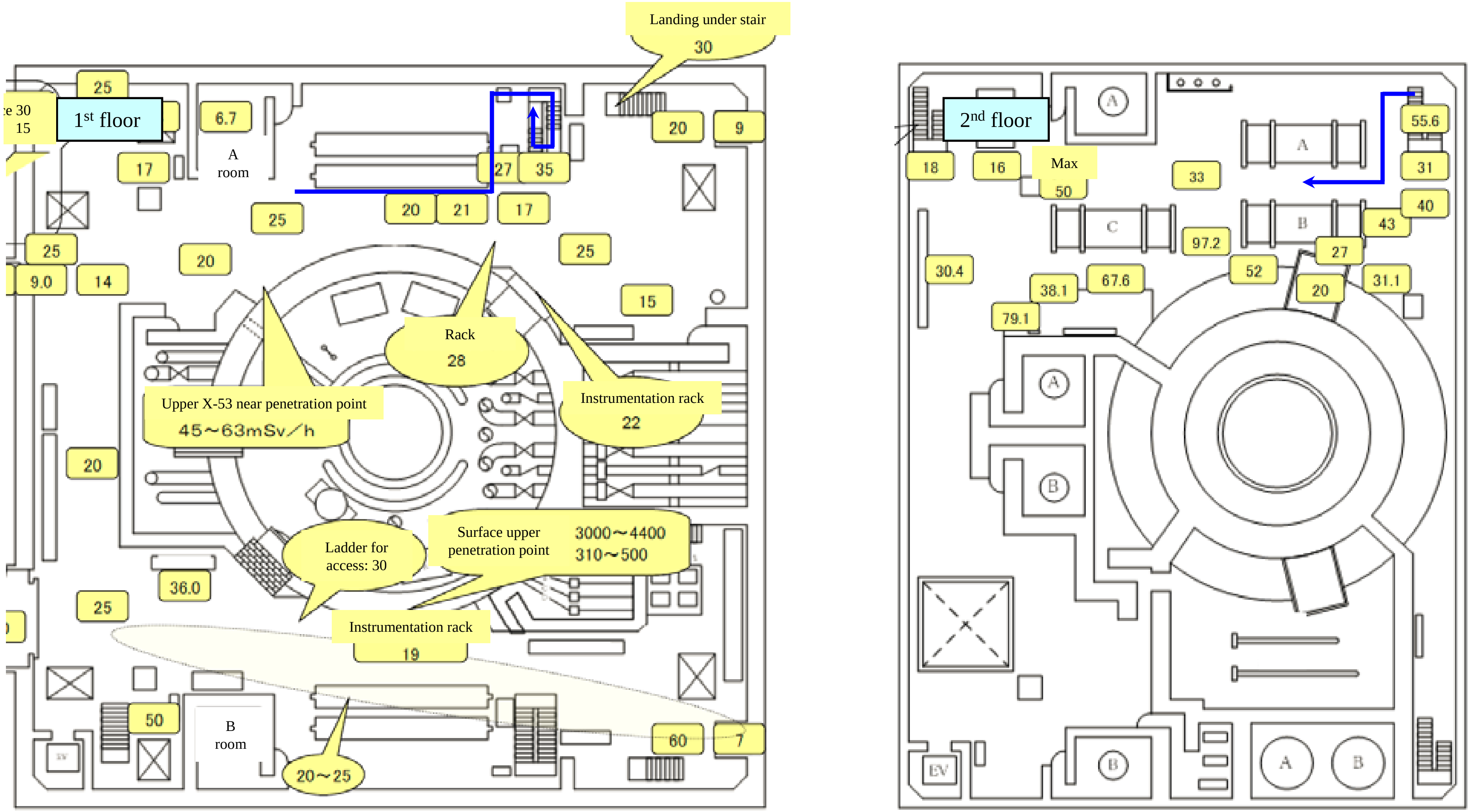
✓Some high radiation area has several thousands mSv/h

✓There is not much difference of airborne radiation rate regardless of whether or not reactor building exploded. (There is not clear difference among Unit 1, Unit 2, and Unit 3.)

Status of inside reactor buildings

Status of inside reactor buildings (Unit 2)

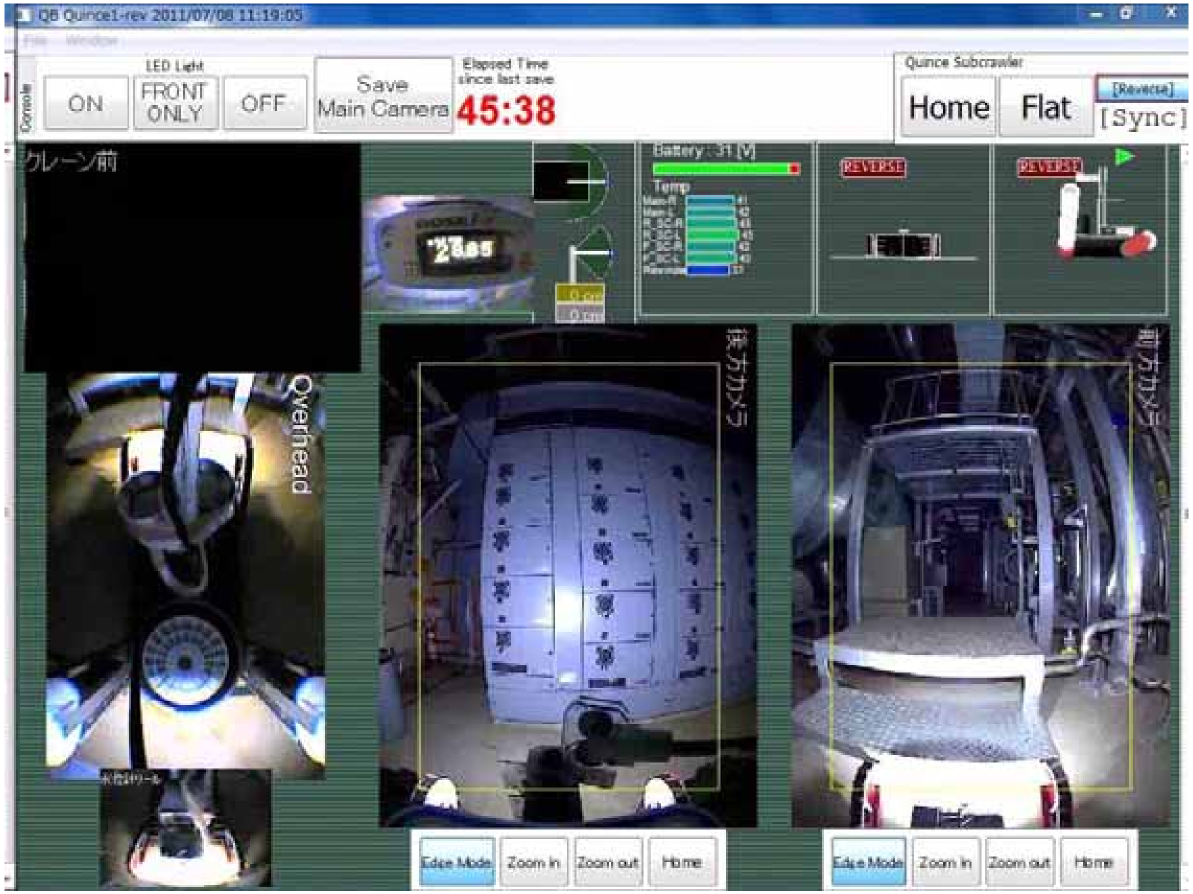
〔Image by Quince〕 Overcoming of the difference 1st floor〜Stair〜2nd floor



Data obtained from April to November 2011

Status of inside reactor buildings (Unit 2)

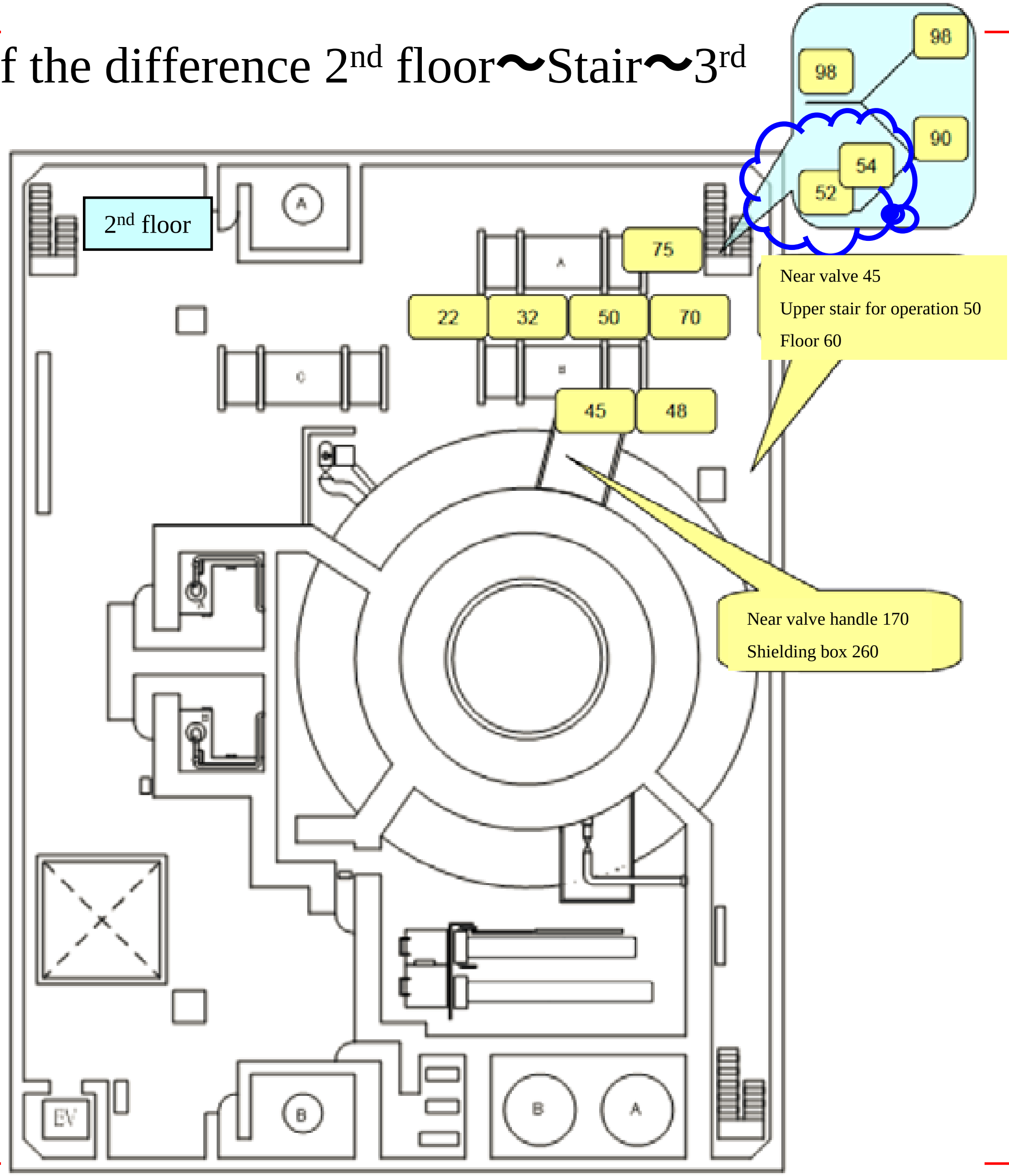
〔Image by Quince〕 Overcoming of the difference 1st floor～Stair～2nd floor



Photograph on July 8, 2011

Status of inside reactor buildings (Unit 3)

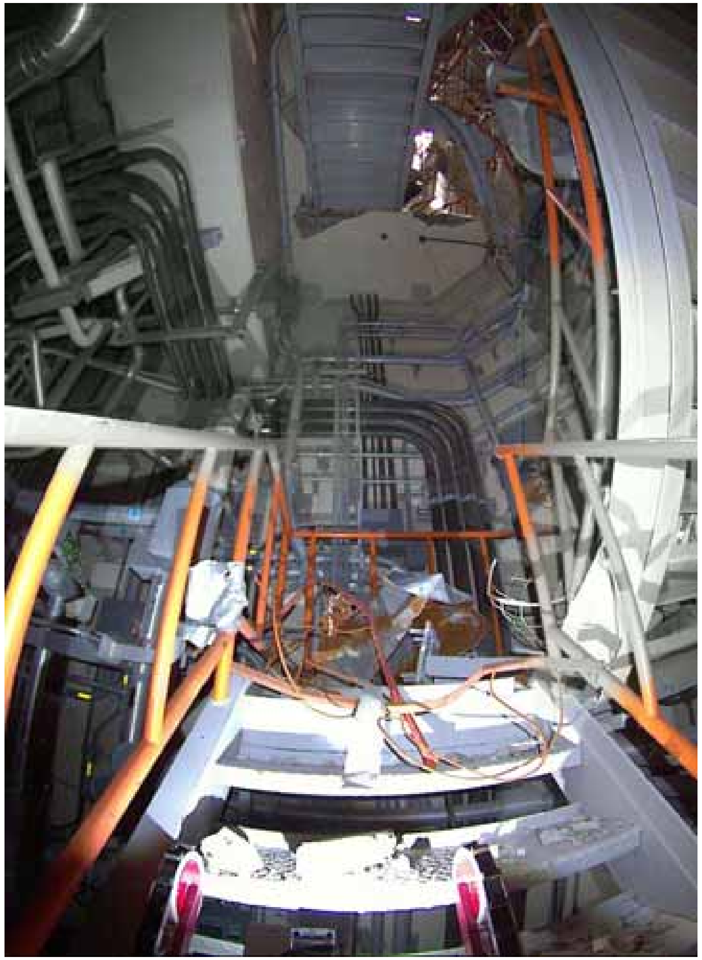
〔Image by Quince〕 Overcoming of the difference 2nd floor〜Stair〜3rd floor, stair is hardly passable



Data obtained from April to November 2011

Status of inside reactor buildings (Unit 3)

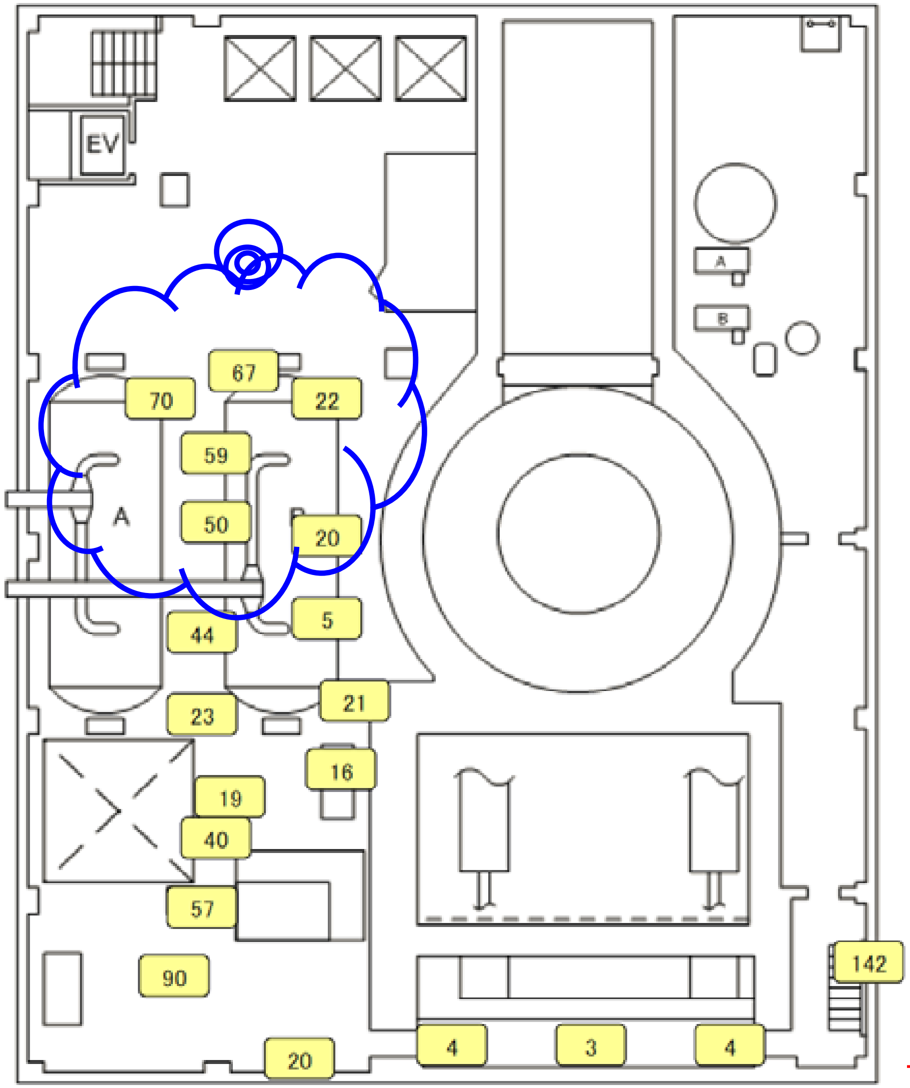
〔Image by Quince〕 Overcoming of the difference 2nd floor～Stair～3rd floor, stair is hardly passable



Photograph on July 26, 2011

Status of inside reactor buildings (Unit 1)

Debris are scattered around isolation condenser



Data obtained from April to November 2011

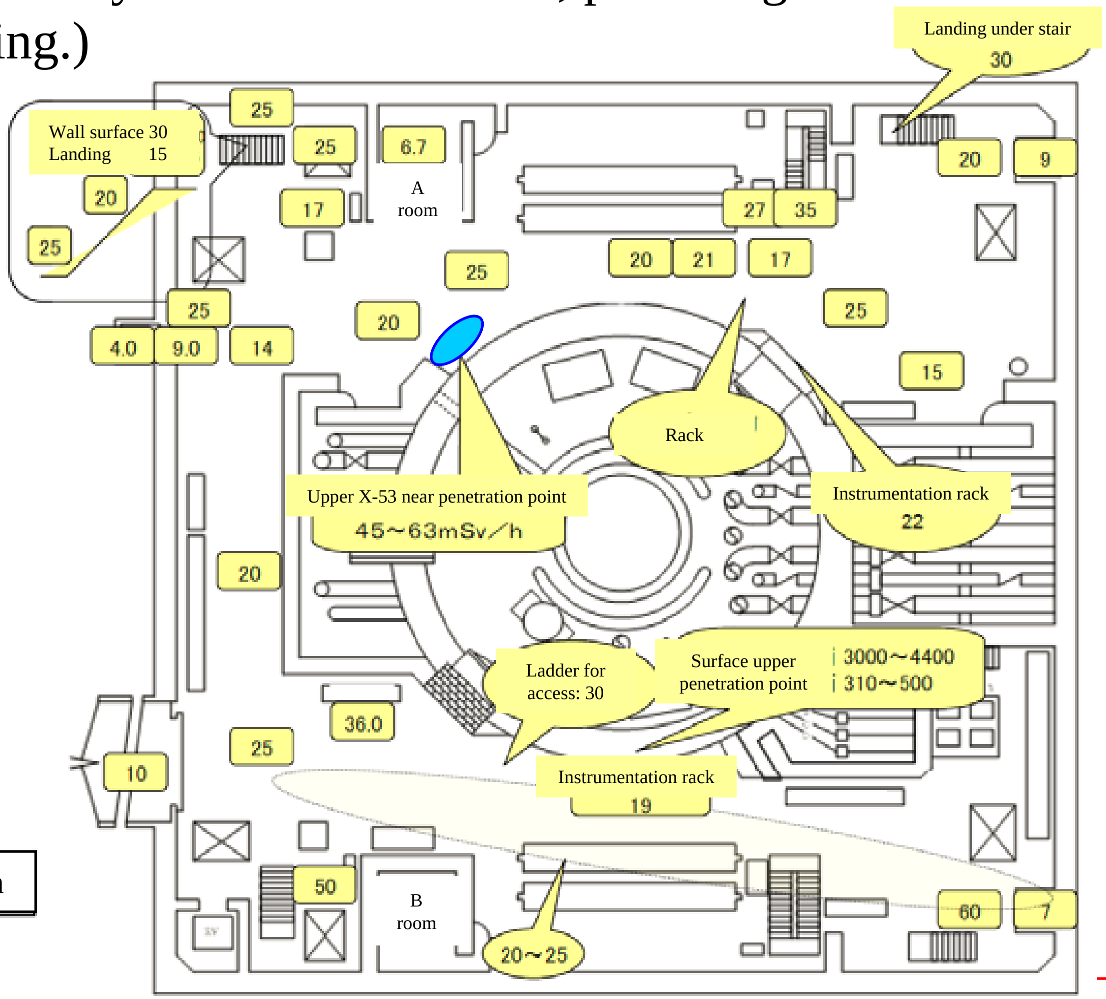
Status of inside reactor buildings (Unit 1)

Debris are scattered around isolation condenser on 4th floor

Photograph on October 18, 2011

Status of inside Primary Containment Vessel (Unit 2)

Although measurement of temperature was implemented, the image is not clear due to the affect of much vapor and noise caused by water drop or radiation. (we confirmed inner wall of primary containment vessel, plumbing around the camera, and upper surface of grating.)



Unit: mSv/h

Data obtained from April to November 2011

Status of inside Primary Containment Vessel (Unit 2)

Although measurement of temperature was implemented, the image is not clear due to the affect of much vapor and noise caused by water drop or radiation. (we confirmed inner wall of primary containment vessel, plumbing around the camera, and upper surface of grating.)

Photograph on January 19, 2012

【Reference】 inside Primary Containment Vessel of Unit 4, Kashiwazaki-Kariwa

✓Instruments are concentrated in primary containment vessel. Pluming roots are also complicated and so small.

✓It is not flat and has many ups and downs.

✓Inside of primary containment vessel of Unit 1 - 4, Fukushima Daiichi is narrower, and has not stairs but vertical ladders.

Summary of Status of inside Reactor Buildings

✓It is impossible to smoothly pass the inside reactor buildings due to scattered debris.

✓There are differences in level on aisles.

✓It is difficult to pass some places such as stairs due to scattered debris.

Technical problems for the removal of fuel debris (No.1)

〔Decontamination of reactor buildings〕

- There are many kinds facilities for decontamination (floor, wall, ceiling)
- Accumulated water and air inside as well as buildings are expected to be decontaminated.
- Mapping technique for contamination status is needed.
- High-pressure water cleaning, and regarding surfaces, in addition to “removal of contamination” such as hanging, “shielding of radiation source” technique such as coating and installment of shield is also necessary.

〔Investigation of primary containment vessel / leak points in reactor buildings〕

- Most works are conducted in contaminated water and narrow places. (for example, video shooting, measurement of radiation dose, and acoustic diagnosis)
- It is necessary to work in high temperature and high humidity environment, air and water.
- Video equipment need to shoot in high radiation dose environment.
- Remote operation is needed for relatively long distance. Thus, relay technique is needed in communication.

Technical problems for the removal of fuel debris (No.2)

[Water stops from the Reactor Building/ Repair the PCV]

- Need for the water stops technology and method under the environment of contaminated water and high radiation dose

- Need for the repairing technology and method under the condition of water flowing with high radiation dose

- Need for the development of the vehicle for high lift work and lifter, because debris in the floor and stairs made the access difficult

Need for technical knowledge based on field status

For the development of equipment, useful technical knowledge should be obtained based on the following difficulties.

✓There are several tens – several hundreds mSv/h radiation environment. Some place has several thousands mSv/h high radiation.

✓Because debris are scattered, and there are differences over pluming, it is difficult to smoothly pass in whole areas including stairs.

✓Inside is very narrow, and has high temperature and high humidity areas in addition to accumulated water.

Some delicate work in short time is suitable for manual operation, and all works should not be conducted by remote control. Thus, development should be implemented considering the following point as shown below.

✓***Optimal segregation of Manual operation / remote control (including autonomous and automation)***