Tackling Decommissioning and Contaminated Water at Fukushima Daiichi NPS by ATOX

Shohei KATO

Engineering R & D Center

ATOX Co. Ltd

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Presentation Outline

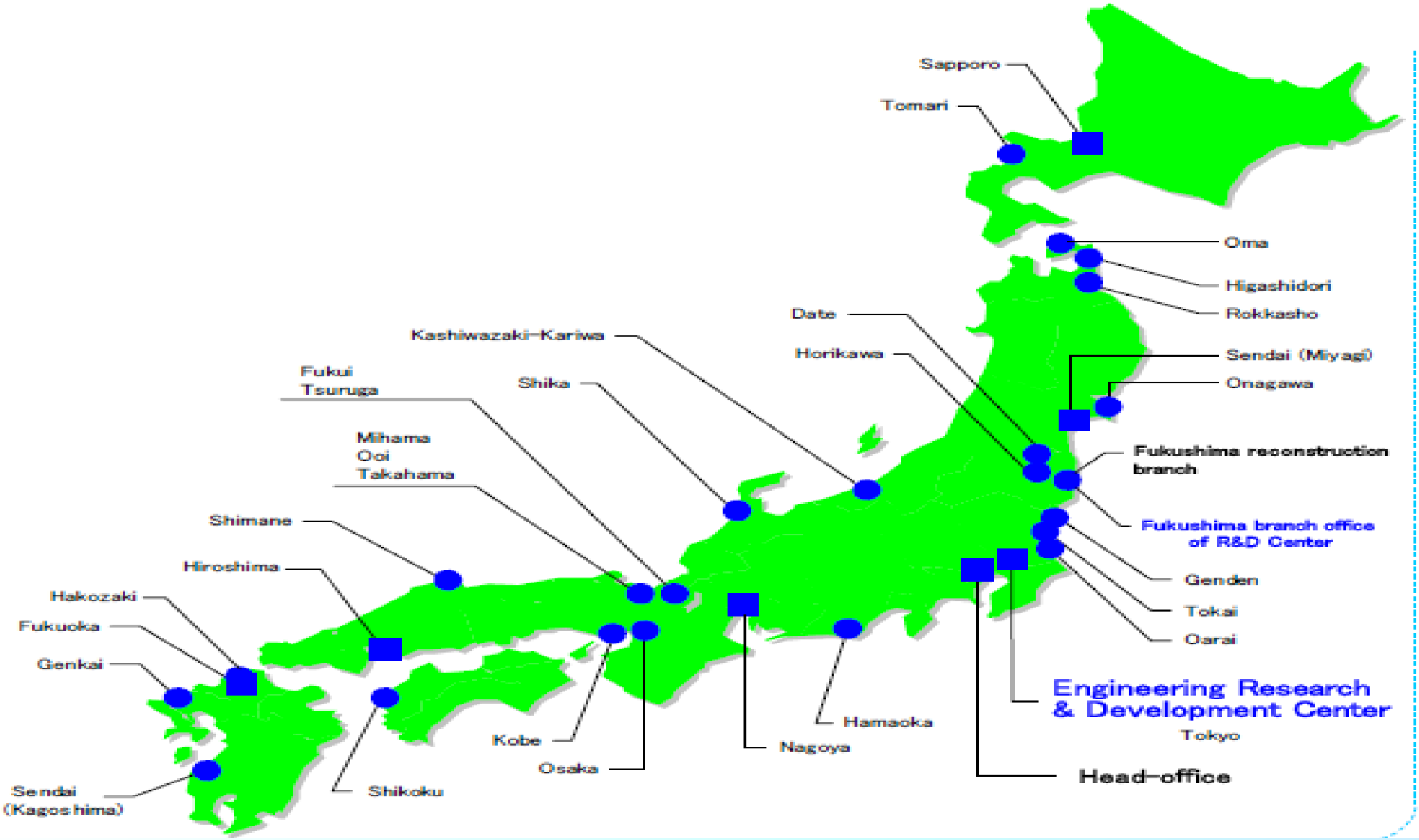
1. Brief introduction of ATOX Co. Ltd.
2. Tackling Reconstruction at Fukushima by ATOX
3. Development of technologies for decommissioning and contaminated water
   - Dose reduction planning
   - Decontamination technologies
   - Observation/Measurement Technologies
4. Verification Test/Conceptual Study as Subsidy Project

ATOX Co. Ltd.

ATOX Co. Ltd. is a pioneer in the field of maintenance business at nuclear power station, nuclear fuel cycle facility and institutes handling radioactive material and radiation in Japan

- Working environmental measurement
- Decontamination
- Radiation control/Dosimetry monitoring
- Maintenance services in facilities
- Sale and maintenance of nuclear equipments

ATOX Network in Japan



Tackling Reconstruction at Fukushima (1)

- Since the Great East Japan Earthquake and the Fukushima Daiichi nuclear disaster, ATOX has positioned the recovery of Fukushima as the top priority task.

- Since the accident, we have been engaged in activities such as the operation of the water treatment equipment and radiation control at the sites.

- We have also engaged in decontamination activities in surrounding areas from stages of experimentation and examination.

Tackling Reconstruction at Fukushima (2)

- Treatment of accumulated water

  We have been engaged from the very beginning in the operation of the systems used for the treatment of highly radioactive accumulated water at the Fukushima Daiichi Nuclear Power Station:

  - AREVA system,
  - Kurion system,
  - Simplified Active Water Retrieval and Recovery System (SARRY),
  - the Advanced Liquid Processing System (ALPS) for the removal of multiple radioactive nuclides.

- Radiation control

  We conduct radiation control at the site of the Fukushima Daiichi Nuclear Power Station, including access control for workers who need to enter worksites.

- Decontamination

Tackling Reconstruction at Fukushima (3)

Off-site decontamination

- Sewage treatment

  We conduct volume reduction processing of sludge from the sewage system that contains highly concentrated radioactive materials.

- Environmental restoration

  We are involved in regional-level activities for radiation control and decontamination.

Development of Technology for decommissioning and contaminated water in Fukushima Daiichi NPS

- Dose reduction planning in reactor building
- Remote decontamination technology
  - Compact Equipment for Remote
  - Remote Washing Device of Tank Bottom
- Remote observation and measurement technology
  - Remote Measurement Device of Water Level in the Cylindrical Vessel
  - Aerial Radioactivity Survey System using Unmanned Helicopter
- Verification Test/Conceptual Study as subsidized projects
  - Seawater Purification Technology
  - Technology for Capturing Radioactive Substance from Soil
  - Conceptual Study of Innovative Approach for Fuel Debris Retrieval

1. “Integrated Dose Reduction Planning”*

Background

***Mid-and-Long-Term Roadmap* towards the Decommissioning of TEPCO‘s Fukushima Daiichi NPP（Nov. 9th, 2011）**

– Phase 1：Period to the start of fuel removal from the spent fuel pool (Within 2 years)

– Phase 2： Period to the start of fuel debris removal (Within 10 years)

– Phase3：Period to the end of Decommissioning (After 30–40years)

- Removal of spent fuel
- PCV investigation & repair work
- Preparations for the removal of fuel debris

Dose reduction of areas related to the work

1. “Integrated Dose Reduction Planning”*

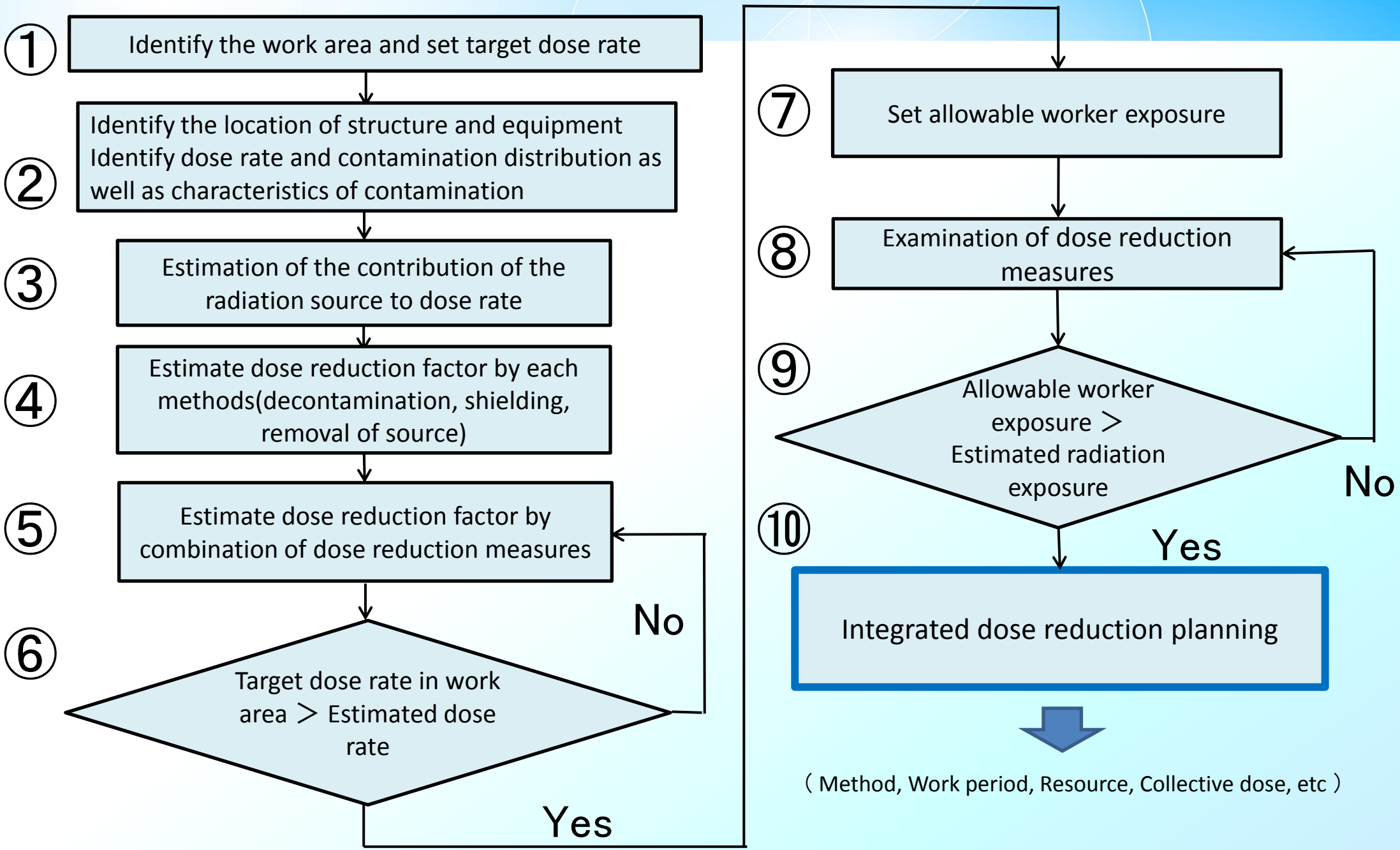
Purpose

① Reduce the radiation exposure to workers engaged in the investigation and repair works of PCVs.

② Reduce the radiation exposure to workers engaged in the works toward the dose reduction inside the R/B.

*Note: This project has been carried out as the subsidy project of METI

Procedure for dose reduction planning



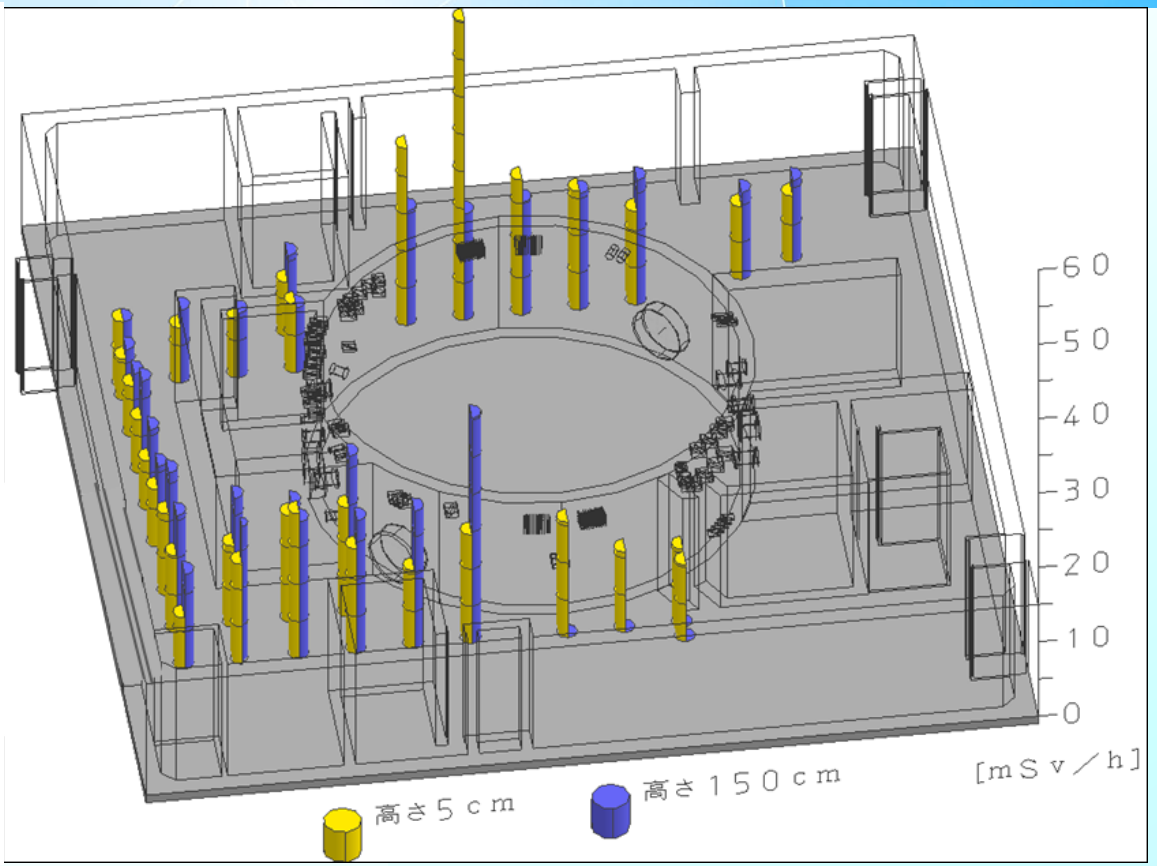
Environment inside R/B

① Dose rate

- Unit 1: approx. 1-10mSv/h
  a part of south side about 5Sv/h
- Unit 2: approx. 2-60mSv/h
- Unit 3: approx. 20-100mSv/h

② Hot spot

Main hot spots are pipe penetration, HCU, equipment hatch rail, etc...



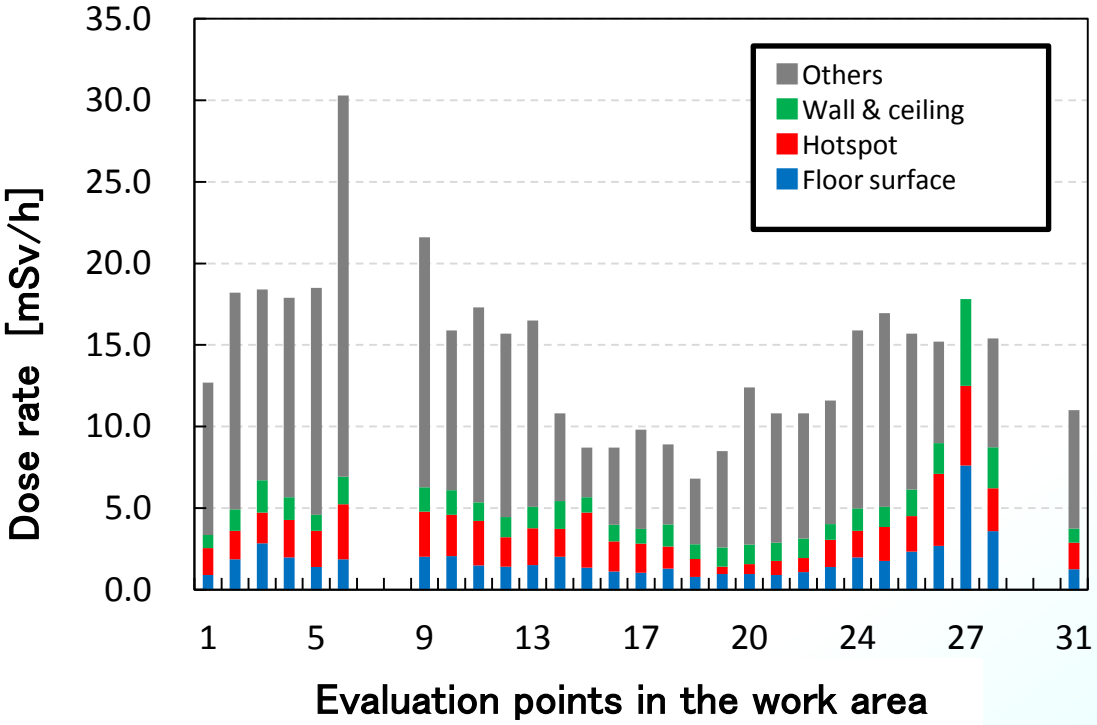
Measurement points in R/B Unit 2
(31 points)

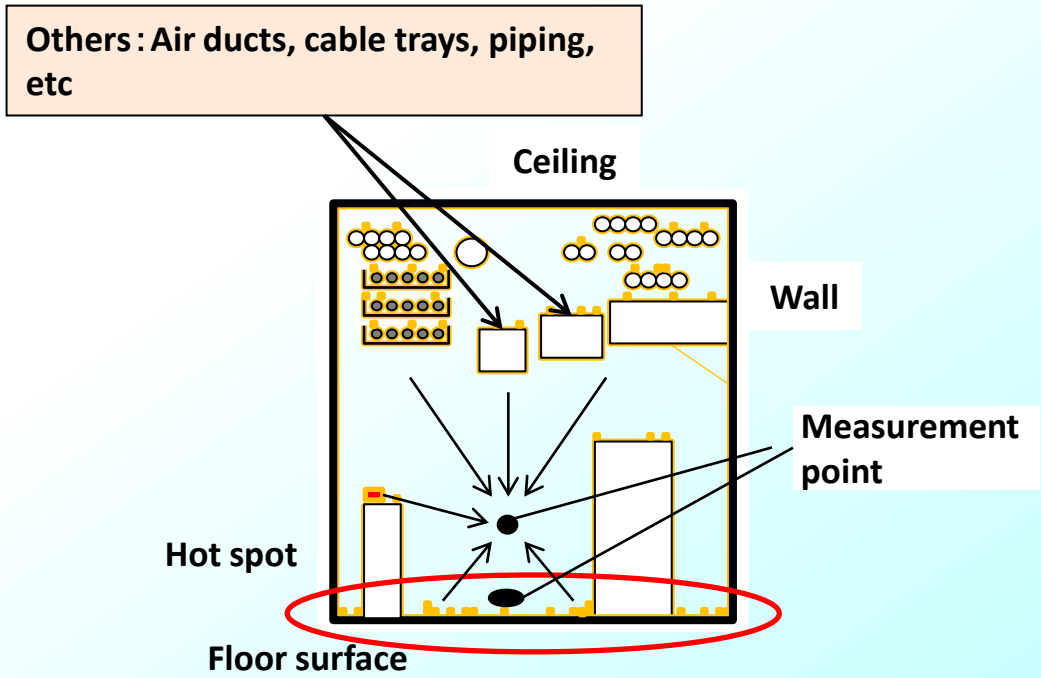
③ Contamination characteristics as of 2013

- The main radionuclides are Cs-134 and Cs-137
- Significant α -nuclide is not detected.
- No observation of penetrated contamination on floor, epoxy paint, and concrete

Analysis of dose distribution

Contribution ratio of the radiation source in the work area at 1st floor in R/B of Unit-2





Dose rate distribution model

④ Radiation distribution (Contribution to ambient dose rate)

- 20% from the floor
- 10% from walls, ceiling, and hot spots.
- 70% from others such as high-place air ducts, cable tray, piping, etc

Contribution from high-place equipment is larger than from floor surfaces, walls, ceiling, and hotspots.

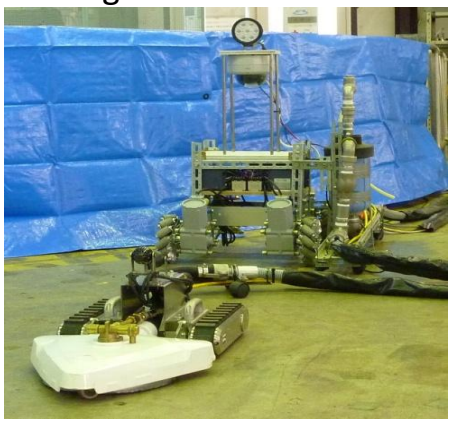
Dose Reduction Techniques of the Decontamination, Removal and Shielding

- Technical catalogs etc. of the remote controlled equipments applicable in Fukushima-Dai-ichi NPP
- Results in "Development of the remote controlled e
- Techniques from foreign countries

Decontamination

Selection of decontamination equipment (example)

- Remote controlled decontamination equipment（dry ice blast）※
- Decontamination equipment for the experimental demonstration (high pressure water)※
- Suction collection type blast decontamination equipment※
- Remote controlled equipment for the jet cleaning and collection etc



Raccoon

Removal

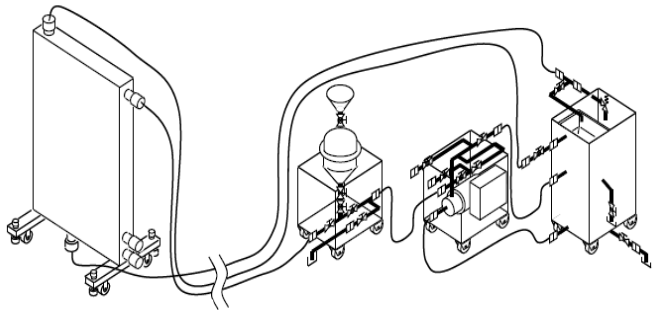
Selection of remote controlled equipment for removal (example)

- ASTACO *Sora*（Hitachi）
- BROKK （Sweden）
- HUSQVARNA（Sweden）

ASTACO *Sora*

Shielding

- **Shielding target will be the selected 60 hotspots**
- **Remote shielding method has been considered to be separately by position (height) and shape (horizontal and vertical distribution)**

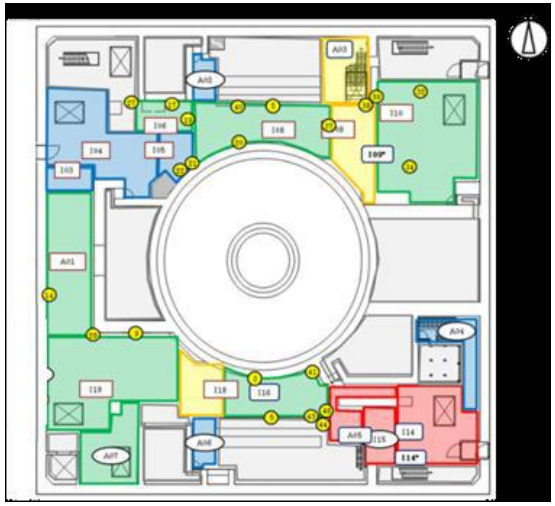


Jacket type shielding

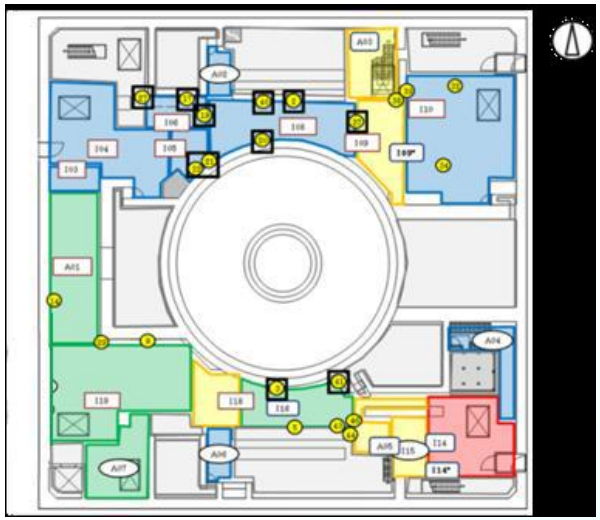
Clarified the application conditions and problems of the decontamination, removal and shielding techniques for the contaminated floor and wall etc and evaluated the technical effectiveness.

Consideration about the dose reduction measures (Target dose rate：3mSv/h)

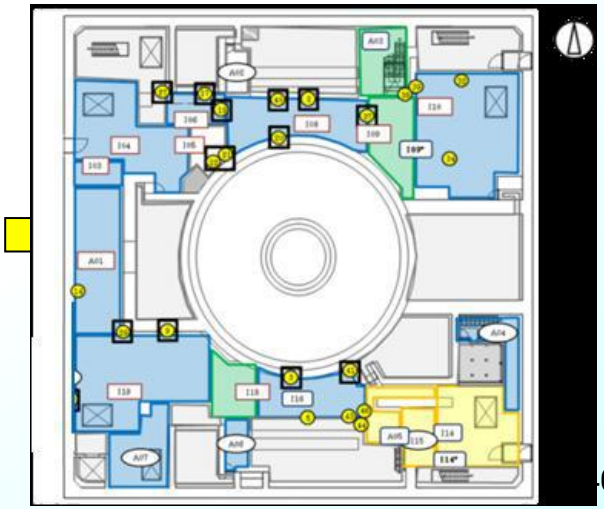
Current dose distribution



Measure 1（Decontamination of under part）



Measure 2（50% decontamination of upper part）



0–50%）

Measure 3（ 90% decontamination of upper part ）

（Reduction rate: approximately 60–90%）

1. It is necessary an equipment which is able to be used for the decontamination, removal and shielding of the installations directed to ceiling by remote control operation. Because, the almost of dose is from the high area (ceiling etc) in the reactor building.
2. It is necessary to investigate in detail about the radiation sources couldn’t be exami sources adhered to the installations directed to ceiling etc.

Collaboration with Overseas Organization

（1）Purpose

To obtain specific solutions for dose reduction method for the consideration targets from overseas organizations based on rich their work experiences and track records such as decontamination work under high radiation dose at nuclear facilities.

（2）Identification of the challenges to be solved and selection procedure of the organizations.

①Identification of the challenges requiring solutions
②Establish selection criteria
③Publicized on the ATOX web site
④ Assessment and selection by Implementation committee

Organization and Subject (2013)

	Subject	Organization
1	3D remote measurement method of contamination distribution and dose contribution under high dose environment	AREVA NC (France)
2	Remote analytical method of contamination characteristics at high radiation area	Babcock (UK)
3	Decontamination of cabele try, duct and grating, electric panels under high dose rate contition	CH2M HILL International, BV (USA)
4	Remote closing and removal method of pipes and duct	ONET (France)
5	Decontamination method of ceiling in 5th floor of R/B Unit-2	Perma-Fix (USA)
6	Movable Sheltering method	Plejades (Germany)

Organization and Subject (2014)

	Subject	Organization
1	Method for accessing upstairs under high dosage, including carry-in of devices	CH2M HILL International, BV (USA)
2	Methods for remote-control investigation of the situation of narrow areas and removal of interfering obstacles under high dosage	ONET TECHNOLOGIES NUCLEAR DECOMMISSIONING (France)
3	Methods for remote-control investigation of the situation of narrow areas and removal of interfering obstacles under high dosage	AREVA NC (France)

2. Development of Compact Equipment for Remote Decontamination “R A C C O O N ”

Objective

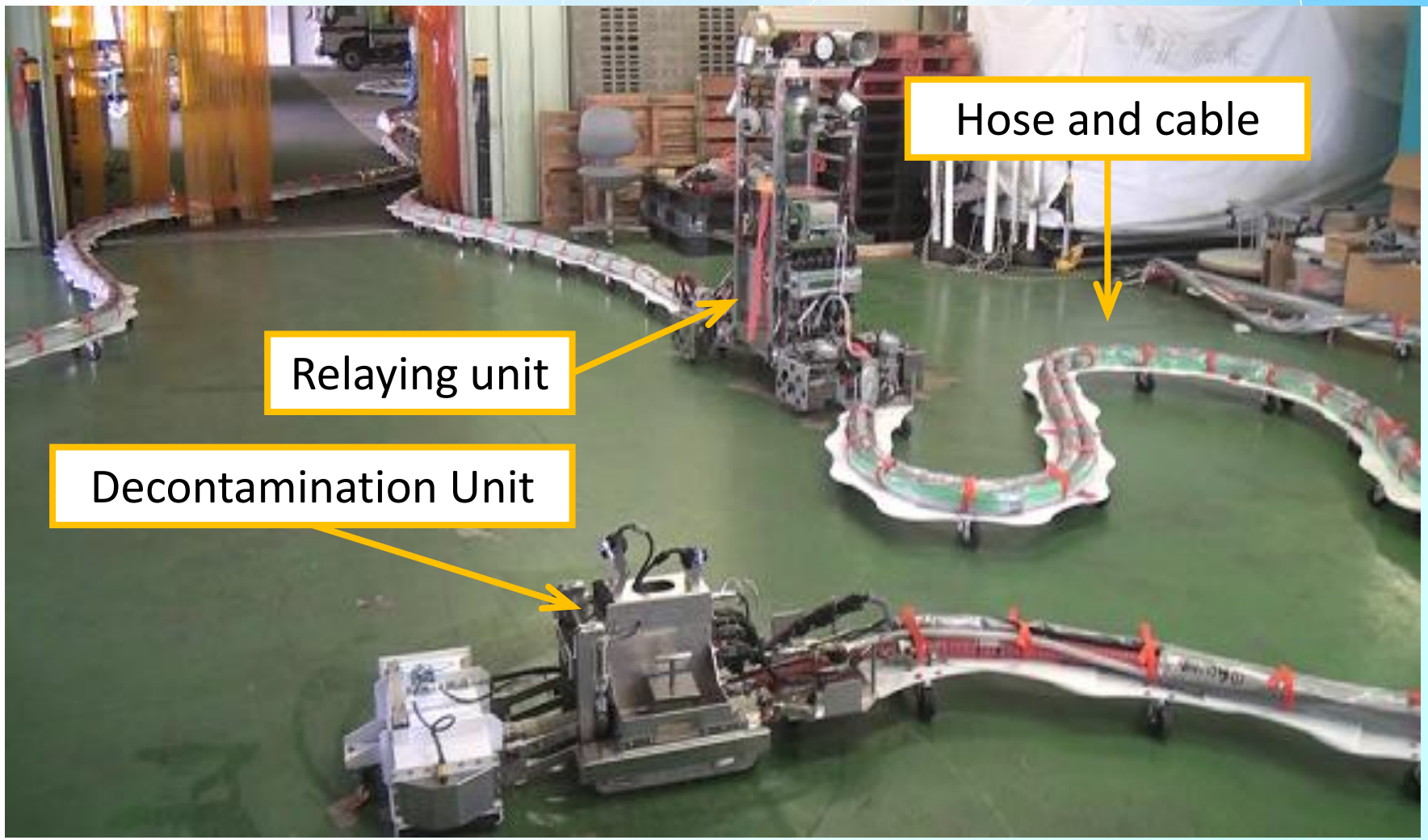
To developed compact equipment for remote decontamination of floors

Requirements of development

Based on the requests from the workers on the site the detailed items are summarized.

- Enables cleaning floor surfaces on the entire first floor (50 square meters) by remote controlling more than 100m.
- Enables collection and transportation more than 100 meters of liquid waste generated by cleaning.
- Compact and lightweight
- Enables smooth handling of hoses and cables in a reactor building.

RACCOON Ⅱ



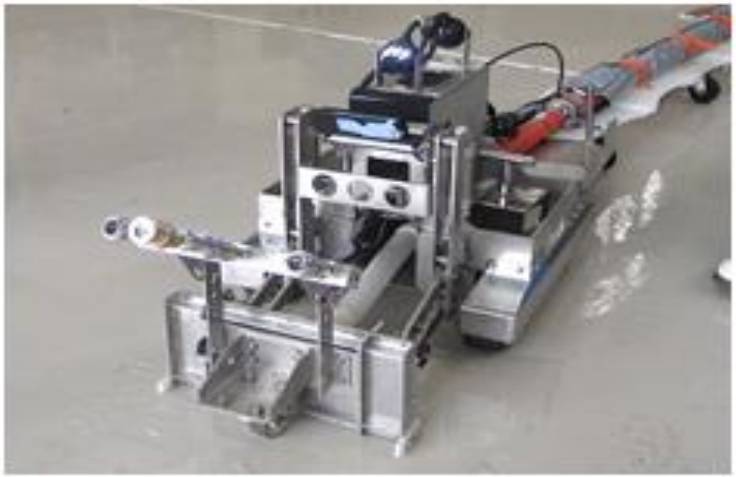
- Decontamination with high pressure water
- Remote control away from more than 100 m by LAN

20

Decontamination Unit

Brush

Water Jet



Spray and Water Recover

Concrete Debris Pushing

Remote control of RACCOON

RACCOON is introduced for decontamination of floor in Reactor Building of Unit-2 and Unit-3 at Fukushima Daiichi NPS

3. Development of Remote Washing Device for Tank Bottom

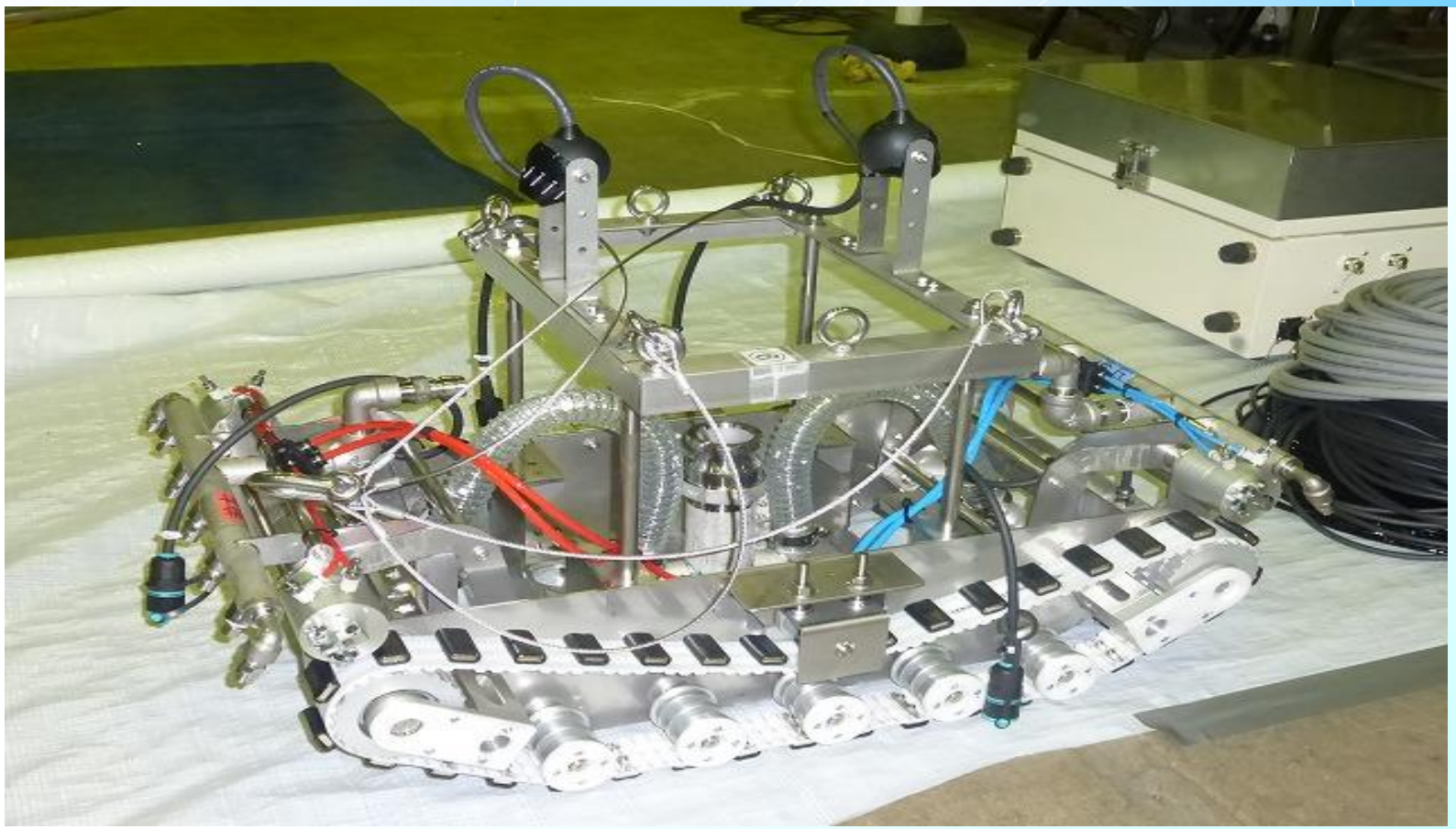
Objective

- To remove sediment deposited in the bottom of the steel cylindrical and vertical tanks set at the Fukushima Daiichi Nuclear Power Station.

Requirements

- Enables work under water around the bottom part of tank.
- Enables removal of the sediment deposited in the bottom and attached to joint parts.
- Enables insertion in the tank by hand by smaller and lighter device.
- Capable of pulling hose and cables smoothly in the tank.

Remote Washing Device for Tank Bottom



The cleaning device consists of traveling unit, absorption unit and decontamination unit and is operated by a controller device connected to a wire cable.

Removal test of sediment by Remote Washing Device

Sediments deposited in the bottom is suctioned by the suction nozzle and transferred to a different tank through diaphragm pump.

The Remote washing device is introduced into tanks at Fukushima Daiichi NPS.

4. Remote Measurement Device of Water Level in the Cylindrical Vessel *

Purpose

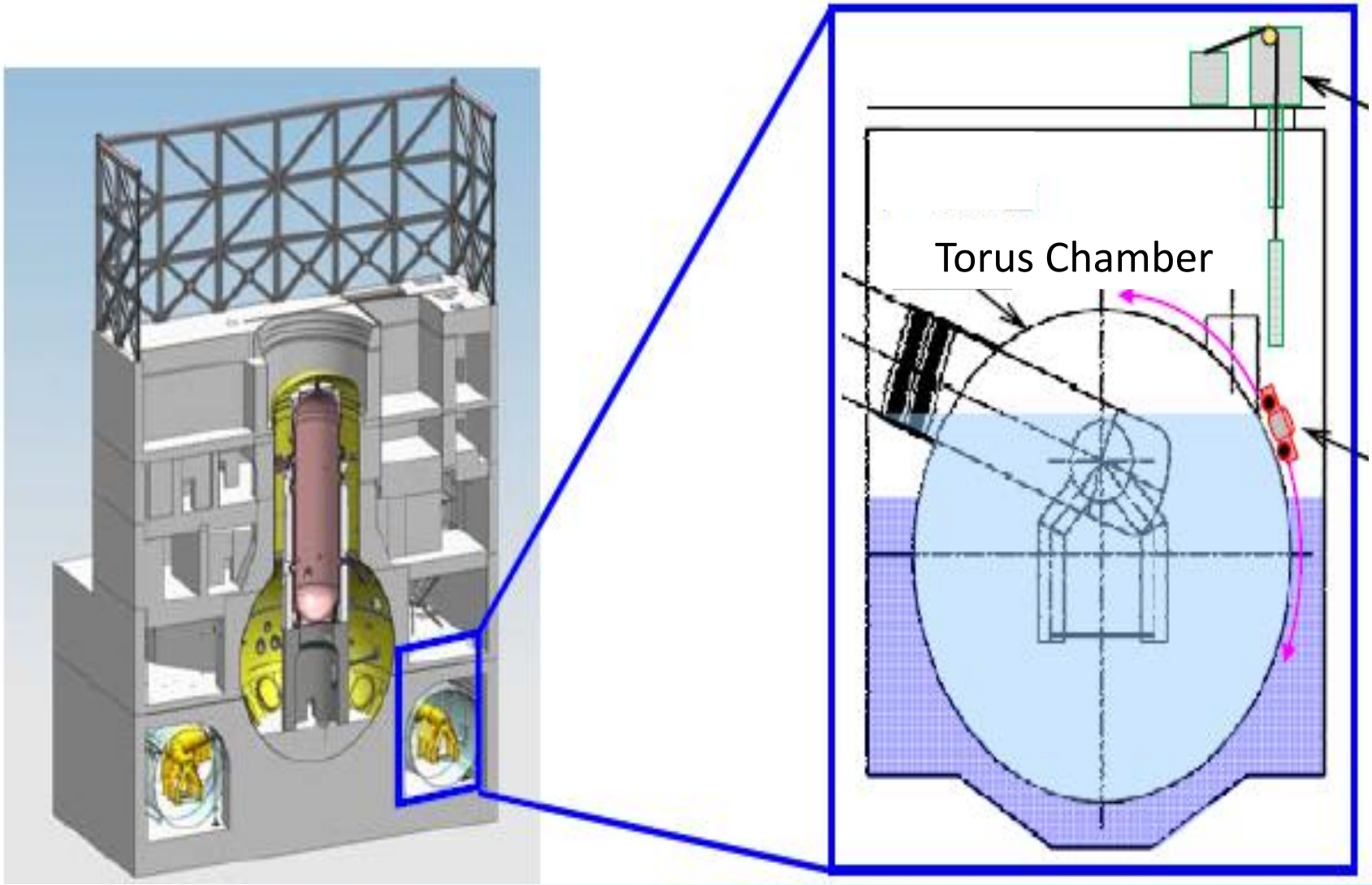
To develop measuring method of water level from outside using probing includes remote control technology for searching of the leakage of the suppression chamber (S/C for short) in the reactor building.

Required Technologies

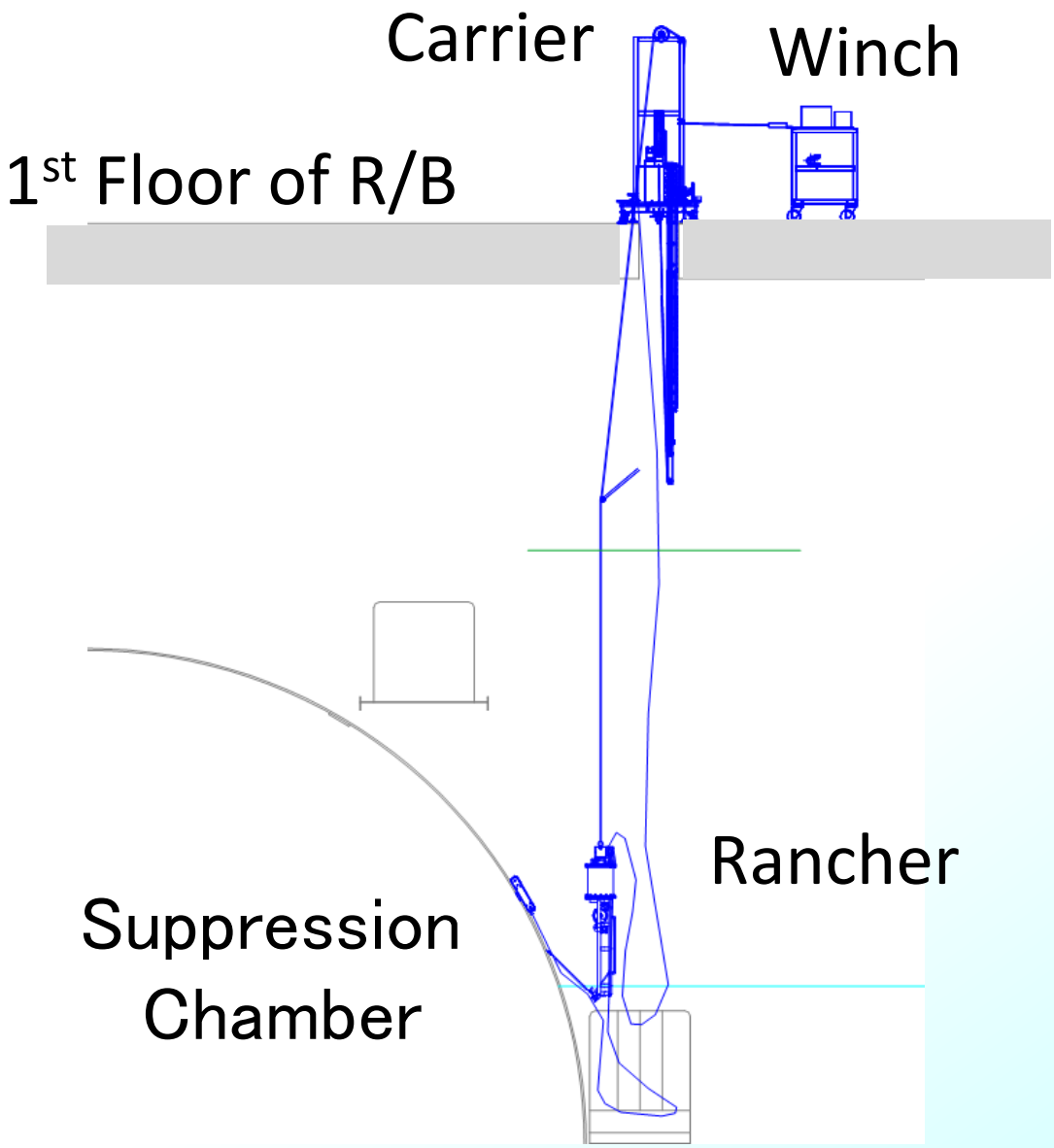
- Ultrasonic flaw detection system in order to detect water level.
- Traveling technology of robot with permanent magnet crawler to carry ultrasound probe around S/C.
- Technique to detect the posture of robot and convert into the height and a technique to detect location by laser irradiation for obtaining accurate data by remote control measurement.
- Access method to a measurement spot at S/C.

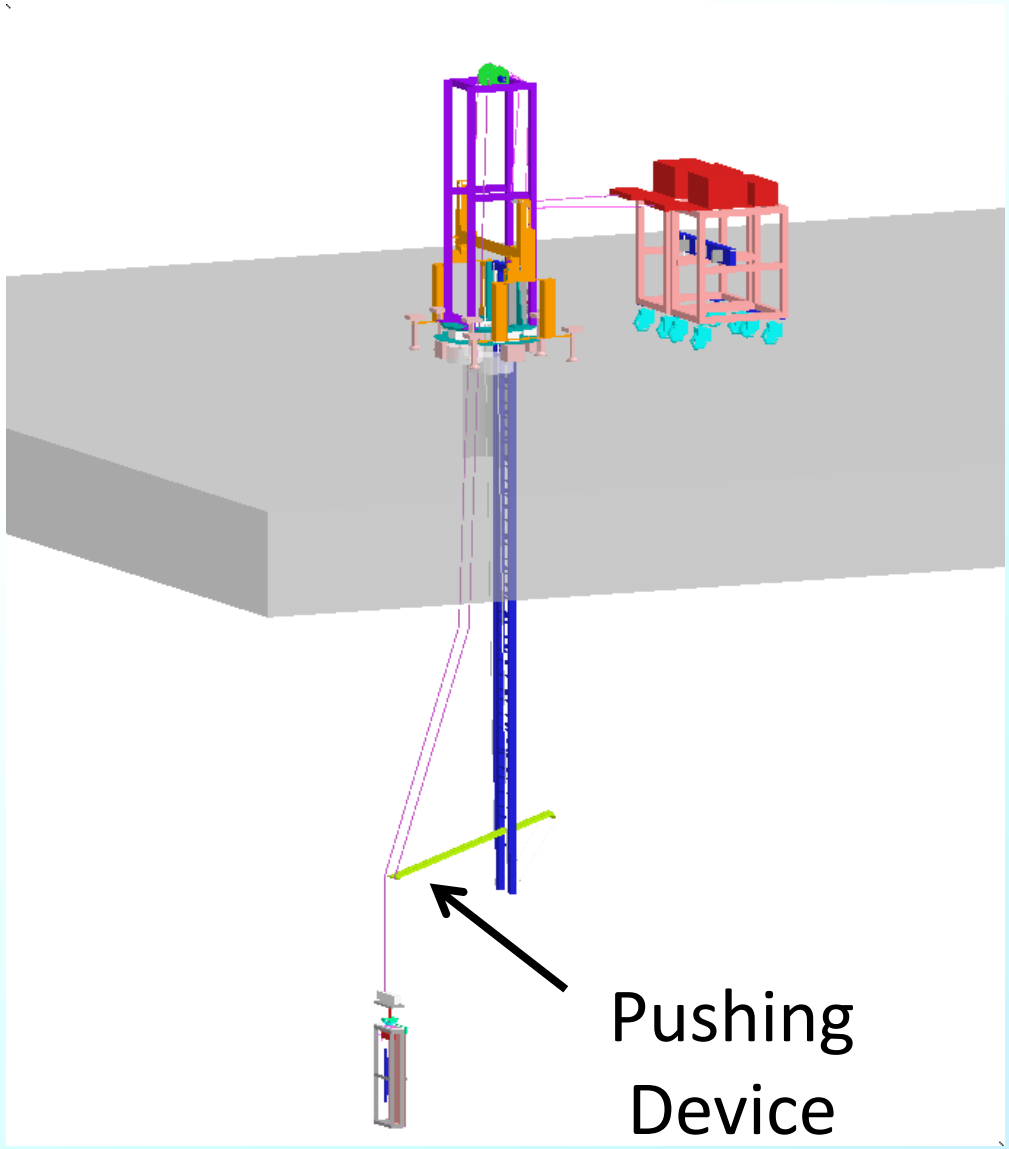
*Note: This project has been carried out under the research and development entrusted by METI

Schematical showing water level measurement system

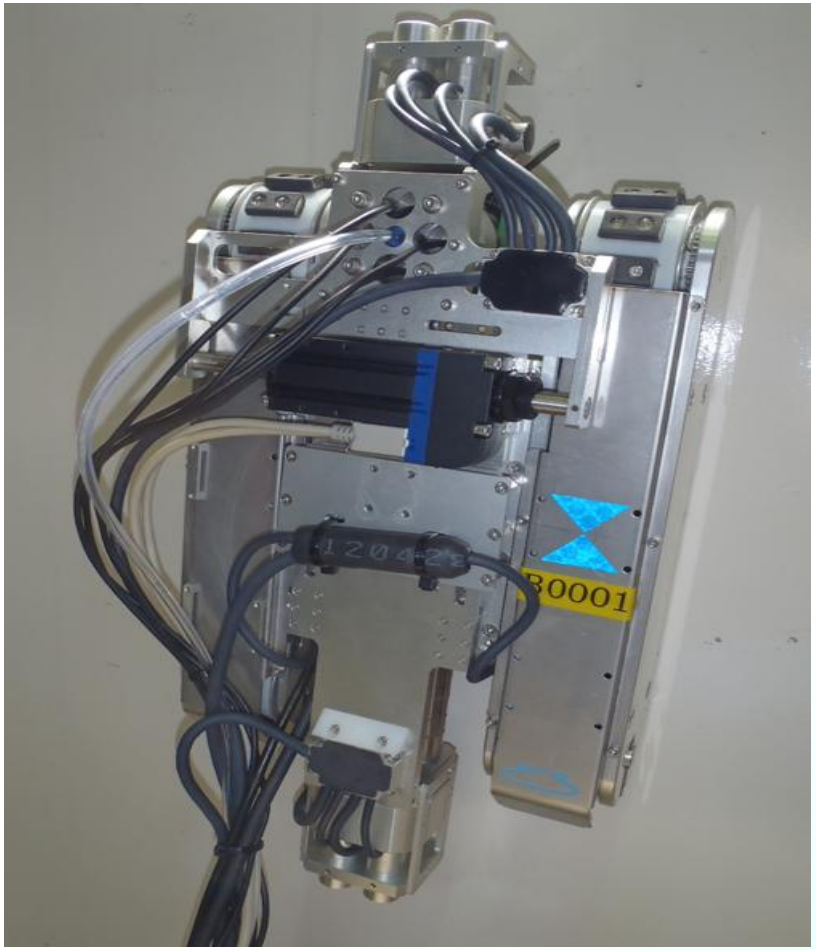


Remote Hanging Device

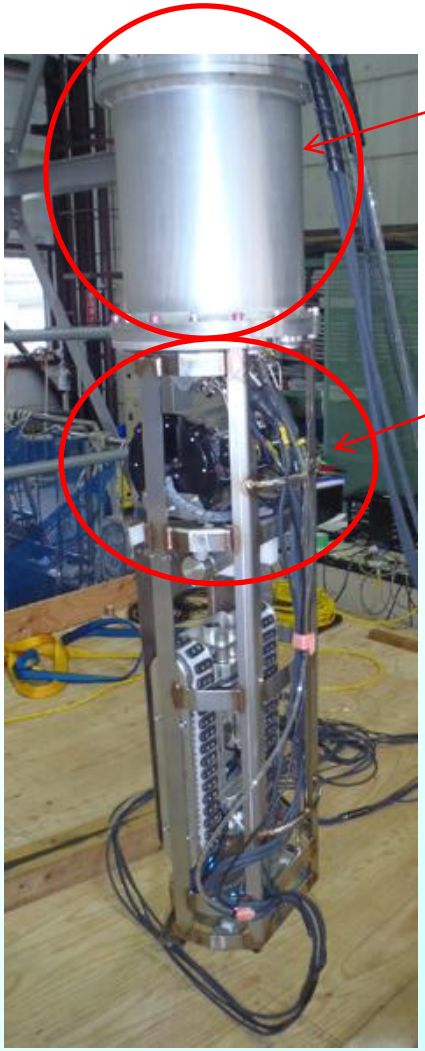


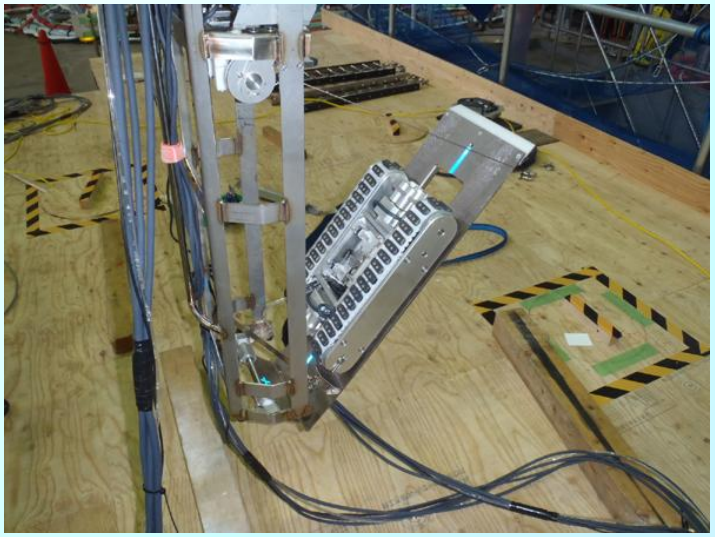


Carrier Device and Water Level Measurement Robot



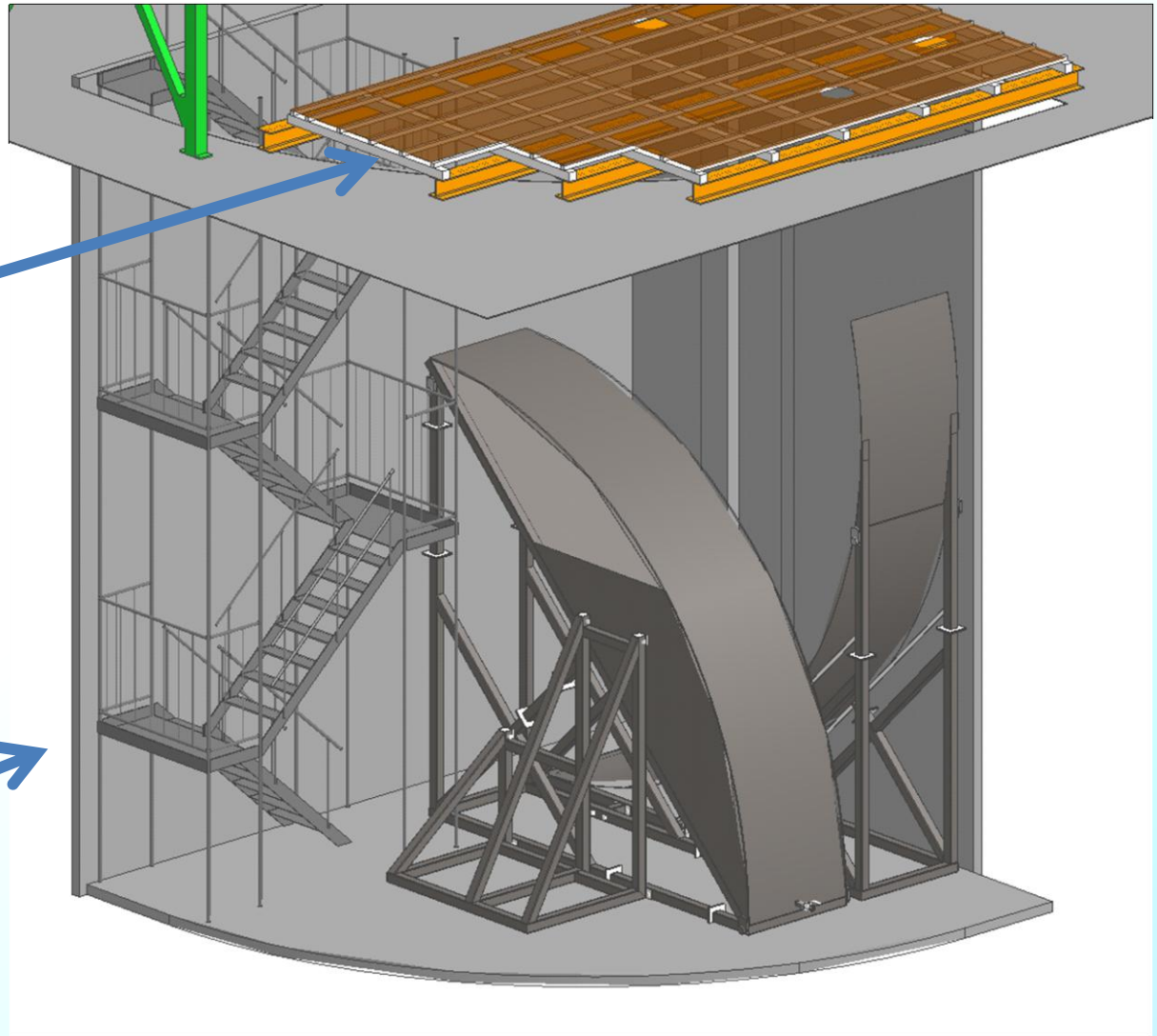
Scanning Type Water Level Measurement Robot





Rancher

Mock-up Test



Mock-up test was carried out at
TAOX Engineer Research and Development Center

Mock up Test and Field Test

Mock Up Test

Field Test at S/ C of Unit 2
at Fukushima Daiichi NPS

Result:
It was revealed that the water level inside the S/C is likely to be affected by changes of the water level in the torus.

5. Development of Aerial Radioactivity Survey System using Unmanned Helicopter

Background and Purpose

- Monitoring and analyzing radiation activity levels on the ground, identifying hotspot and objects in the environment are very important for planning of effective radioactivity reduction.

- Many places are prohibited to access the area because of highly accumulated radioactivity levels, the building structures and obstacles.

- Aerial radioactivity survey system using unmanned helicopter is very effective method for the survey.

Mini Surveyor
(Autonomy Control System Research Institute Co., Ltd in Japan)

Outline of Aerial Surveillance System

(1) Autonomy control helicopter: Mini Surveyor

Navigating by programmed course beforehand and corresponding to surrounding environment during the flight.

Video Camera
（SONY HDR-PJ800）

(2) Radiation measuring and evaluation method

- Light weighted GM survey meter and suitable for remote measurement processing method.

- Figure out of the contaminated density from the radiation rate actually obtained.

Radiation Measurement Device Polimaster BDG2
(0.1μSv/h～10Sv/h)

This Aerial Survey System is introduced in Fukushima Daiichi Nuclear Power Station.

6. Demonstration Project for Seawater Purification Technologies*

Project was implemented under the cooperation among ANADEC, AREVA and ATOX

Objectives and Goals

- To confirm validity of technology by verification test of decontamination(Sr and Cs) in seawater in harbor adjacent to Fukushima Daiichi NPS.
- Feasibility study on the plan to reduce the radioactivity concentration in contaminated seawater in harbor (160,000m^3) to environmental standards (DF10) or lower.

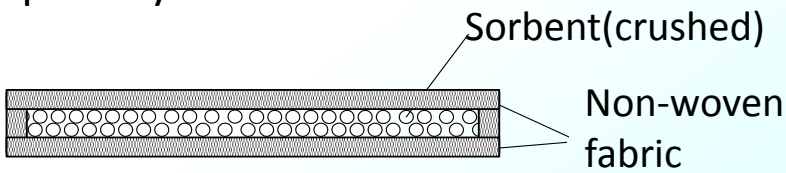
Project summary and feature

●The purification using NYMPHEA (AREVA, France; Fig.1).

- •Used as a pool water purification system approximately 20 years
- •Device maintenance and the replacement of the adsorption cartridge are easy and are available for various types of adsorbents.

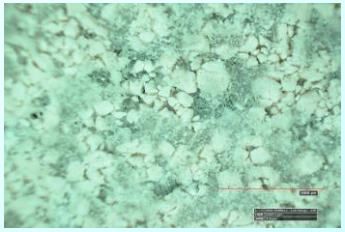
●Performance evaluation and sorbent selection of commercial sorbents and filter(Fig.2) under seawater environments.

●Optimum operation method, feasibility assessment, cost evaluation, and waste quantity evaluation.



Adsorption sheet structure （small size sorbent sandwiched between non-woven sheet）

Fig.2 Sr adsorption sheet



Sorbent adhered to the non-woven sheet

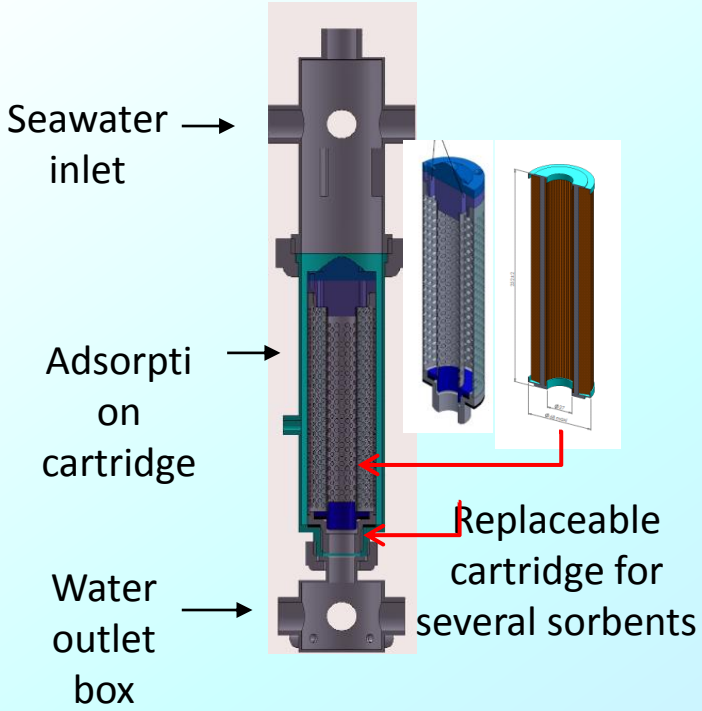


Fig.1 water purification equipment NYMPHEA

*Note: This project has been carried out as the subsidy project of METI

Result of the project

Development of adsorption cartridge

Sorbent end-point

- Evaluation of distribution coefficient (Kd) and adsorption capacity about Cs and Sr under seawater environment and selection.

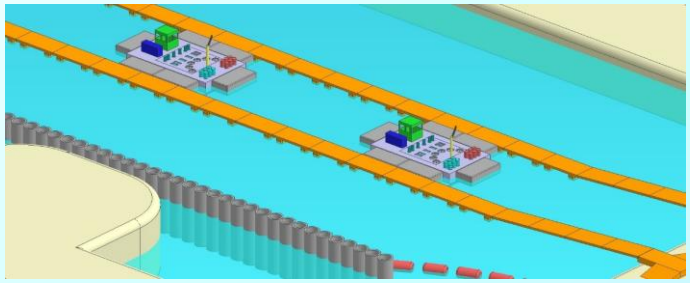
Development of filter sheet

- High performance of the adsorbent, low particle size sorbent sheet is developed.
- Adsorption sheet is flammable to reduce the secondary waste.

Adsorption filter

Project summary

- Verified adsorption performance using mini-NYMPHEA
- Confirmed volume and weight reduction by adsorption filter incineration test
- Evaluated the applicability to the contaminated seawater in the harbor adjacent to Fukushima Daiichi NPP
- Total operation cost and generated waste quantity were evaluated.



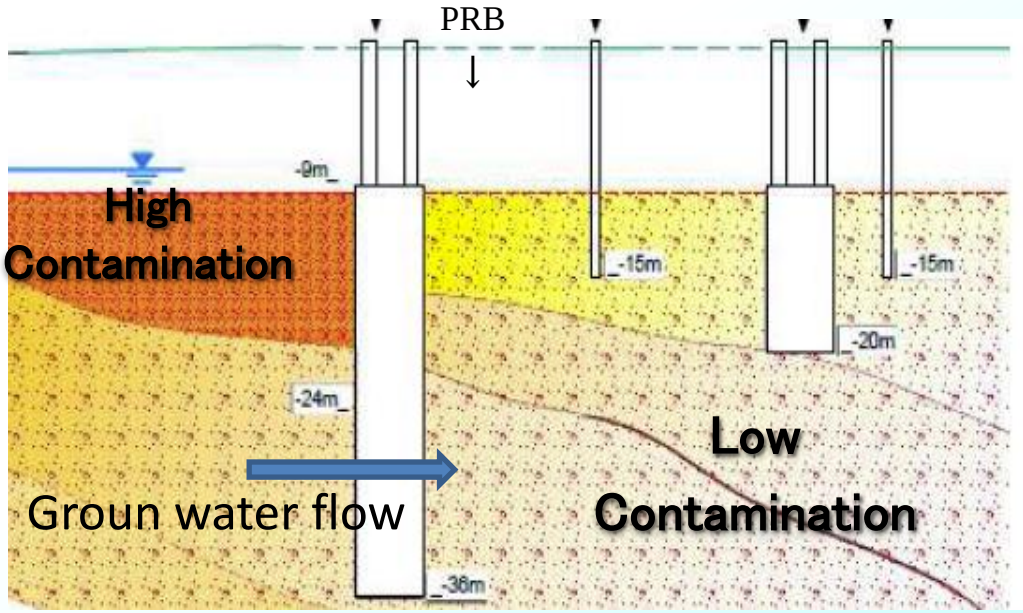
Setting image in harbor

7. Demonstration Project for Technologies for Capturing Radioactive Substance from Soil*

Project was implemented under the cooperation among ANADEC, AREVA and ATOX

Scope

PRB is verified for capture performance of radioactive strontium (Sr) by some capture tests, and applicability to the Fukushima Daiichi Nuclear Power Station (1F) were evaluated.



Principle of Permeable Reactive Barrier(PRB)

Overview and Features

Adsorption tests:

Capture performance of the radioactive Sr in soil has been verified by adsorption test using groundwater and soil purchased form Fukushima area.

Applicability evaluation

Based on the results of the capture tests described above, applicability to the Fukushima Daiichi nuclear power Station was evaluated.

*Note: This project has been carried out as subsidy project of METI

Obtained Results

1. Result for Adsorption test

① Inactive Tests

- Two zeolites are the most efficient reactants for Sr capture.
- Apatite don't show great selec

② Active Tests

- Two zeolites are the most efficient reactants for Sr-85.
- The double PRB test (Apatite and Zeolite) indicate a way for on-site optimization on the lifetime and the cost of the PRB.

2. Confirmation Tests

- Confirmation test using a similar soil and groundwater to 1F site was the equivalent results to test described above.

3. Applicability evaluation to Fukushima Daiichi NPS

- Stratum structure, soil property and groundwater flow was studied, applicability of the PRB was evaluated.

8. Conceptual Study of Innovative Approach for Fuel Debris Retrieval*

Project was implemented under the cooperation among ANADEC, AREVA and ATOX

1.Goal and Objectives

The object of this conceptual study is to remove the fuel debris by dry method in accordance with the situation of the Fukushima Daiichi NPS.

2. Obtained Results

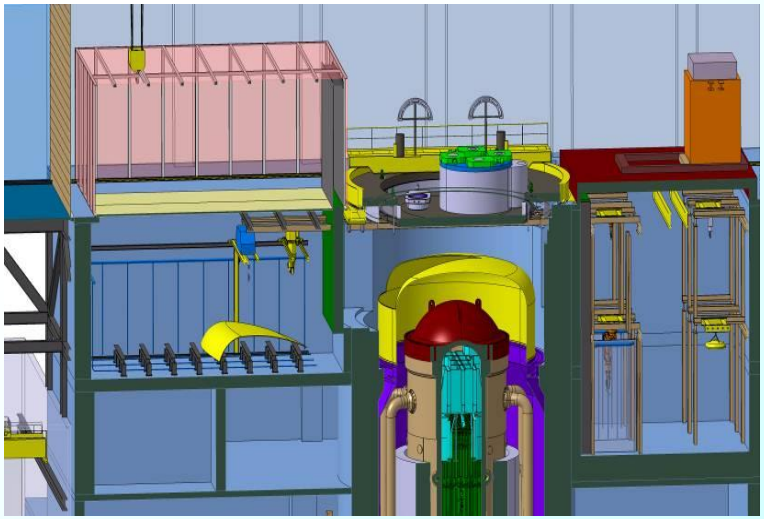
(1) Project overview and orientation

- Both accesses from RPV top and from PCV side
- Installation of external building
- Treatment of removal structures
- Two distinct phase for the structures and fuel debris retrieval
- Application of technologies based on A R E V A's decommissioning experience (TMI, BFR)

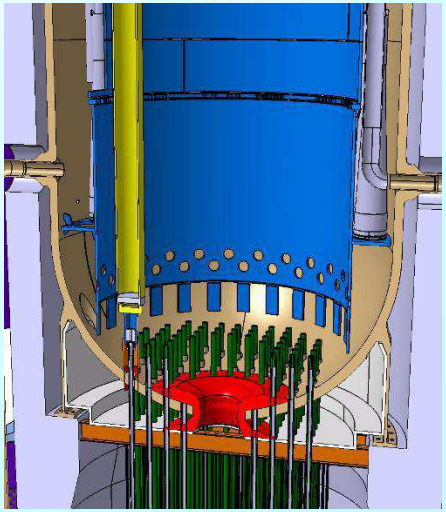
BFR: Breeder Fuel Removal project in Dounreay site

(2) Proposal of overall sequence

(3) Identification of issues in future



PCV head removal



Platform(Phase B)

*Note: This project has been carried out as the subsidy project of METI

Future initiatives

ATOX confirms our determination to tackle decommissioning at Fukushima Daiichi NPS and restoration for recovery in Fukushima and to develop technologies needed and collaboration/alliance with other organizations.

ATOX appreciate your continuous support.

Thank you for your attention