ISOE International Symposium

Investigation for contaminated materials at Genkai unit 1

October 25, 2018

Kyushu Electric Power Co., Inc.

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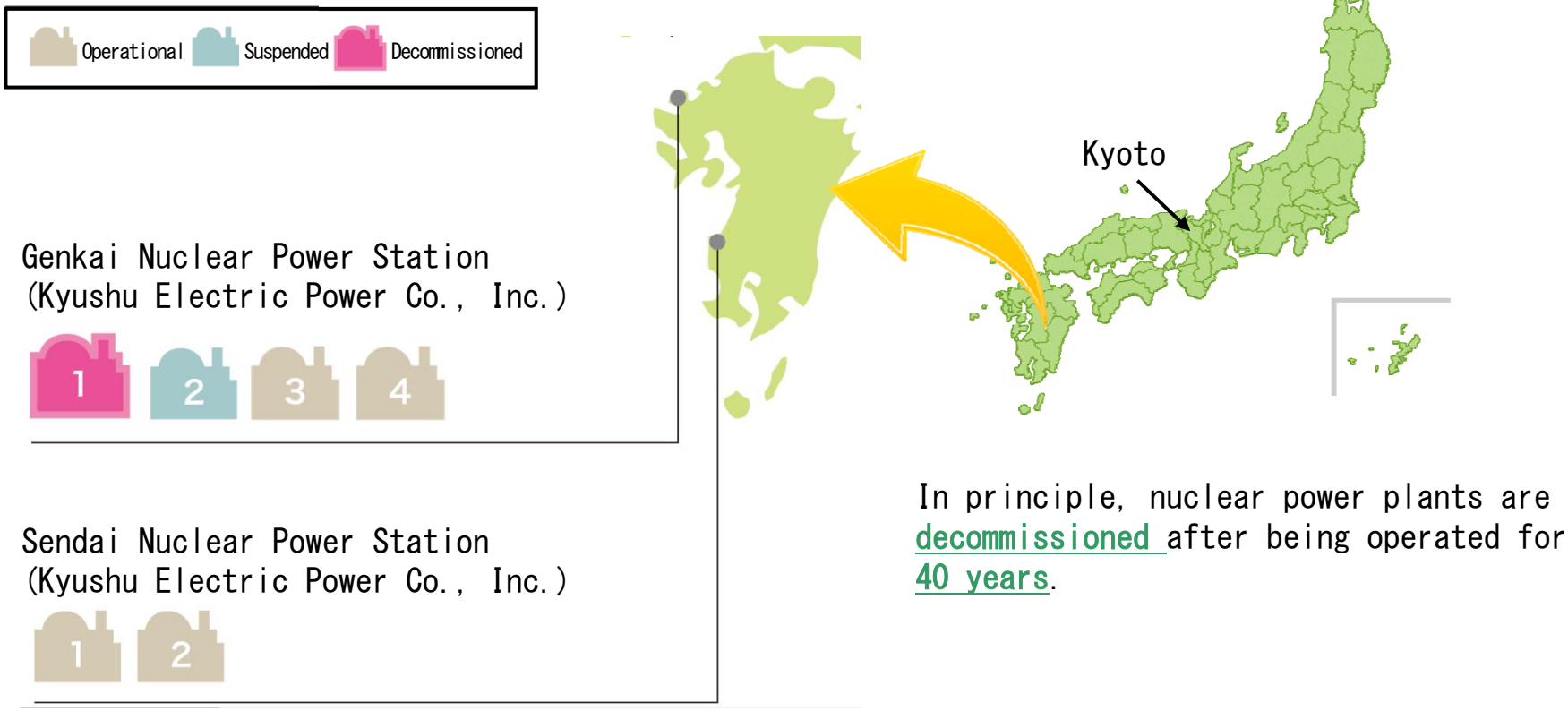
Background - Nuclear plants operated by Kyushu Electric Power Co., Inc.



In principle, nuclear power plants are decommissioned after being operated for 40 years.

Background - Genkai Nuclear Power Plant Unit 1

	Unit 1
Reactor type	Pressurized water reactor
Rated output	559,000 kW
Total power generation	Approx. 132.72 billion kWh
Equipment utilization rate	Approx. 68.5%

* Results until the operation stopped on April 27, 2015

Overall timeline	Unit 1
Application submitted for permission to install (change) a reactor	May 30, 1970
Permission received to install (change) a reactor	December 10, 1970
Initial criticality attained	January 28, 1975
Initial synchronization attained	February 14, 1975
Commercial operation commenced	October 15, 1975
Notification of changes of electric facilities submitted in accordance with the Electricity Business Act based on the decision to abolish Unit 1	March 18, 2015
Unit 1 abolished in accordance with the Electricity Business Act	April 27, 2015
Decommissioning plan approved	April 19, 2017
Periodic inspection of the facility finished (28th) (December 1, 2011)	April 19, 2017

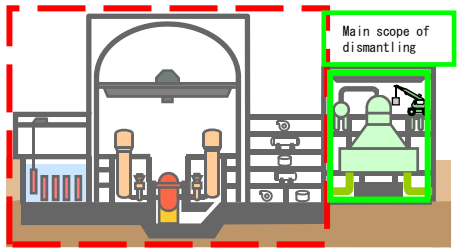
Overview of decommissioning

- Decommissioning refers to the process of dismantling a nuclear power plant that has stopped generating power and then removing its radioactive materials.
- The decommissioning process consists of four distinctive phases. The current phase is “I. Preparing for dismantling.”

【 Decommissioning process 】

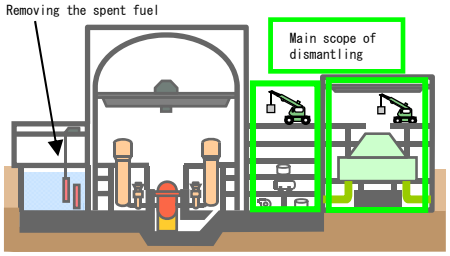
I. Preparing for dismantling (about 6 years)

Scope of survey of the contamination status



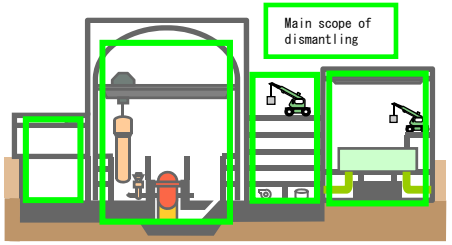
- The equipment's contamination status is surveyed.
- Radioactive materials adhering to piping, etc. are removed (washed) using chemicals.

II. Dismantling and removing the reactor's peripheral equipment, etc. (about 8 years)



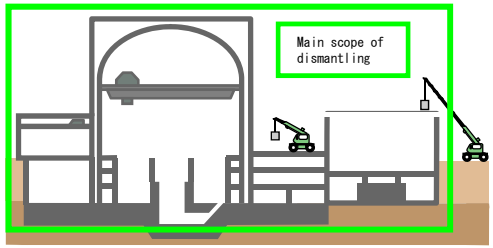
- Equipment whose radioactivity level is relatively low is dismantled and removed.
- Removal of the fuel is completed.

III. Dismantling and removing the reactor, etc. (about 7 years)



- The reactor vessel, steam generator, etc. are dismantled and removed after radioactivity decreases.

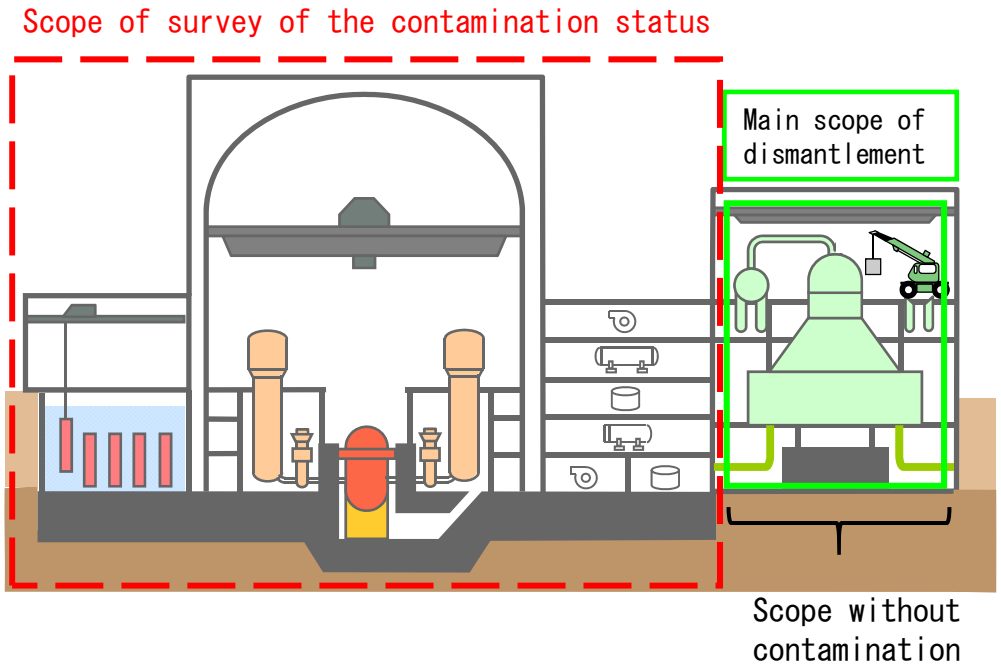
IV. Dismantling and removing the building, etc. (about 7 years)



- The contaminants in the building are removed. Finally, the building is dismantled and removed.

Decommissioning process
(Ⅰ. Preparing for dismantling)

I. Preparing for dismantling (about 6 years)

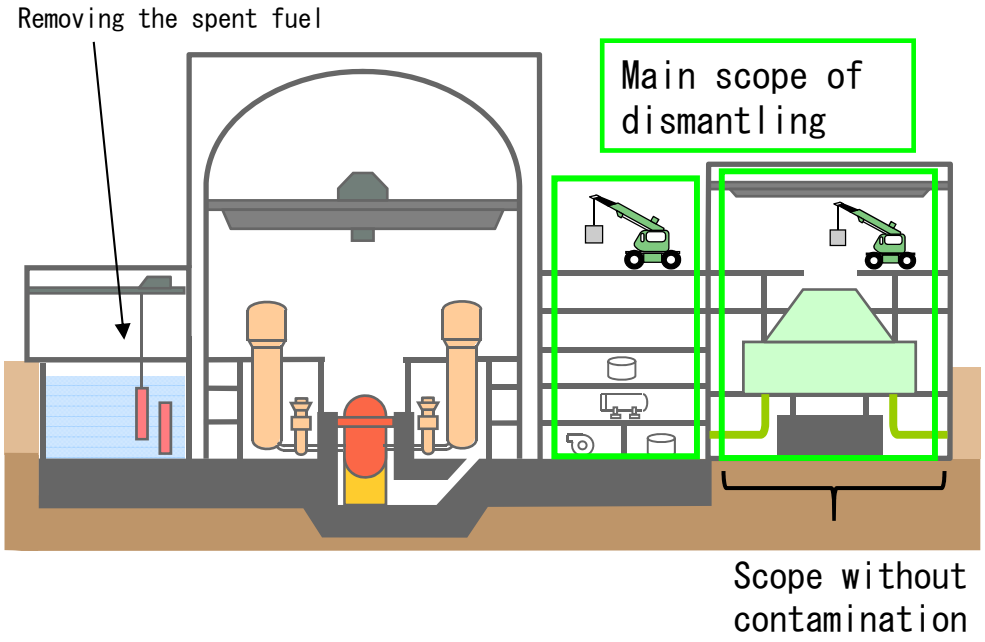


≪Preparing for dismantling≫

- Removing (washing) radioactive materials adhering to piping, etc.
- Conducting a contamination survey of the building and equipment
- Dismantling and removing non-contaminated equipment.
- Reducing the radioactivity level of the reactor, etc.
- Removing the spent fuel

Decommissioning process
(Ⅱ. Dismantling and removing the reactor's peripheral equipment, etc.)

II. Dismantling and removing the reactor's peripheral equipment, etc. (about 8 years)

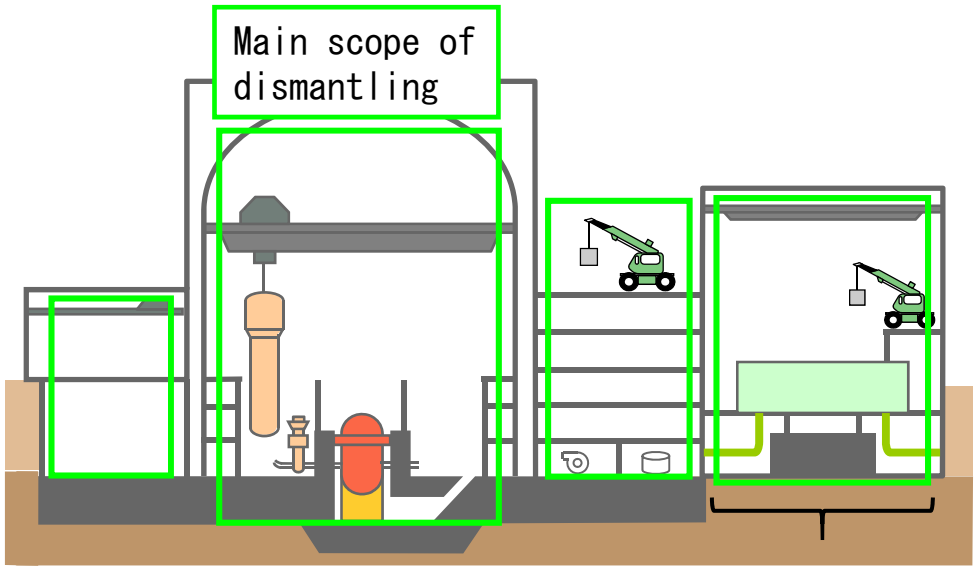


≪Dismantling and removing the reactor's peripheral equipment, etc.≫

- Dismantling and removing equipment whose radioactivity level is relatively low
- Removing the spent fuel
- Dismantling and removing non-contaminated equipment
- Reducing the radioactivity level of the reactor, etc.

Decommissioning process
(Ⅲ. Dismantling and removing the reactor, etc.)

III. Dismantling and removing the reactor, etc. (about 7 years)

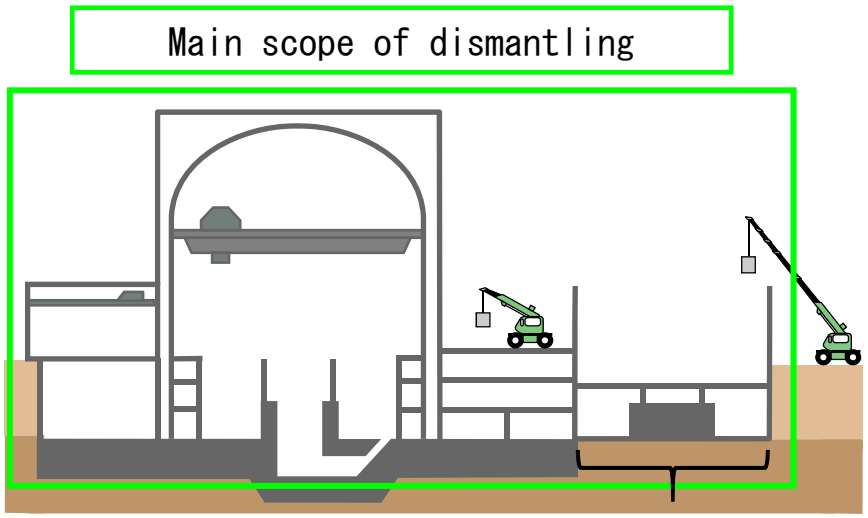


≪Dismantling and removing the reactor, etc.≫

- Dismantling and removing the reactor vessel, steam generator, etc.
- Dismantling and removing equipment whose radioactivity level is relatively low
- Dismantling and removing non-contaminated equipment

Decommissioning process
(Ⅳ. Dismantling and removing the building, etc.)

IV. Dismantling and removing the building, etc. (about 7 years)

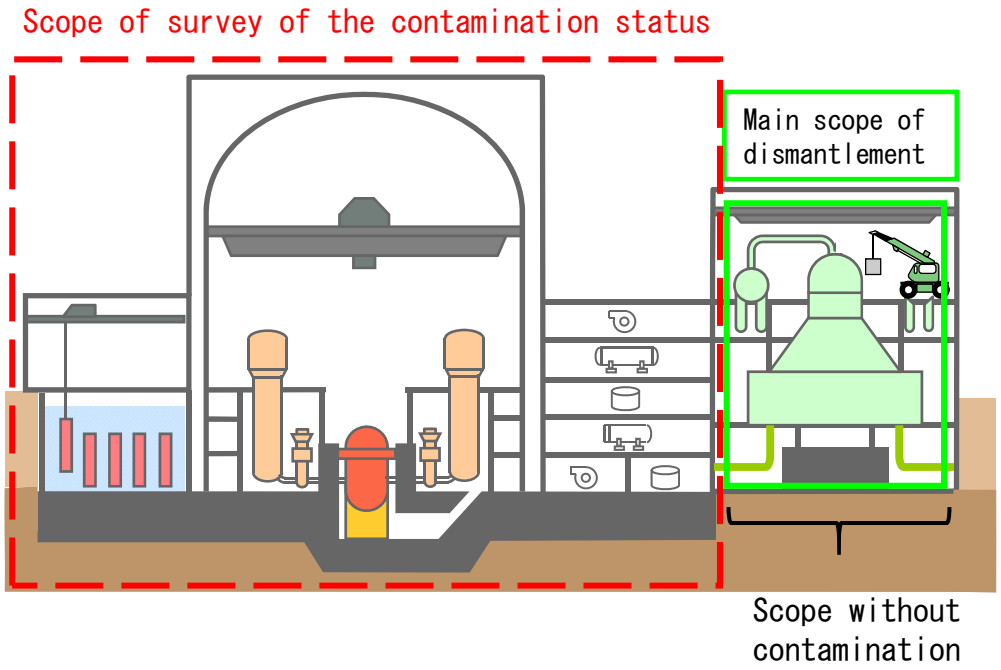


≪Dismantling and removing the building, etc.≫

- Dismantling and removing the building
- Dismantling and removing the non-contaminated building and equipment

Decommissioning process
(Ⅰ. Preparing for dismantling)

I. Preparing for dismantling (about 6 years)



≪Preparing for dismantling≫

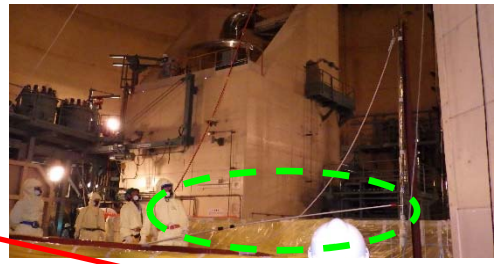
- Removing (washing) radioactive materials adhering to piping, etc.
- Conducting a contamination survey of the building and equipment
- Dismantling and removing non-contaminated equipment.
- Reducing the radioactivity level of the reactor, etc.
- Removing the spent fuel

Removal of radioactive materials (1/3)
(main preparation process before system decontamination)

Example of measures to reduce exposure in the main process before system decontamination (hoisting of the reactor vessel head and withdrawal of the control rod drive shaft)

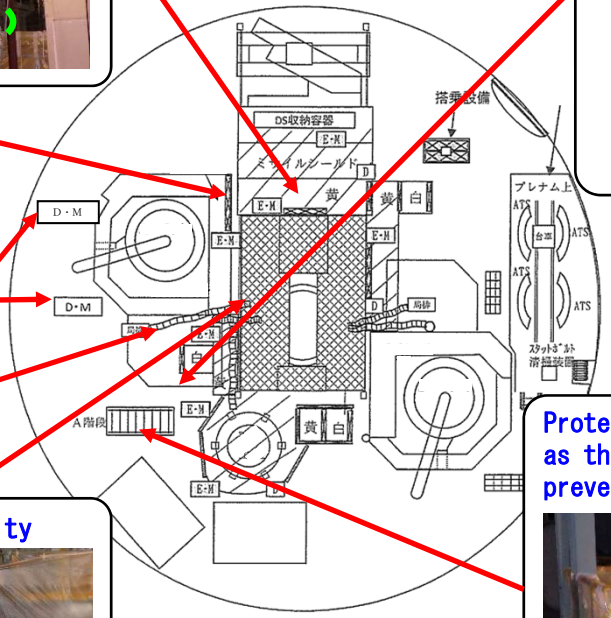
Lead shielding (for the operator of the winch for handling the control rod drive shaft horizontally)

Use of a long jig



Sampling of radioactive materials in the air using a high volume sampler

Installation of a portable dust monitor



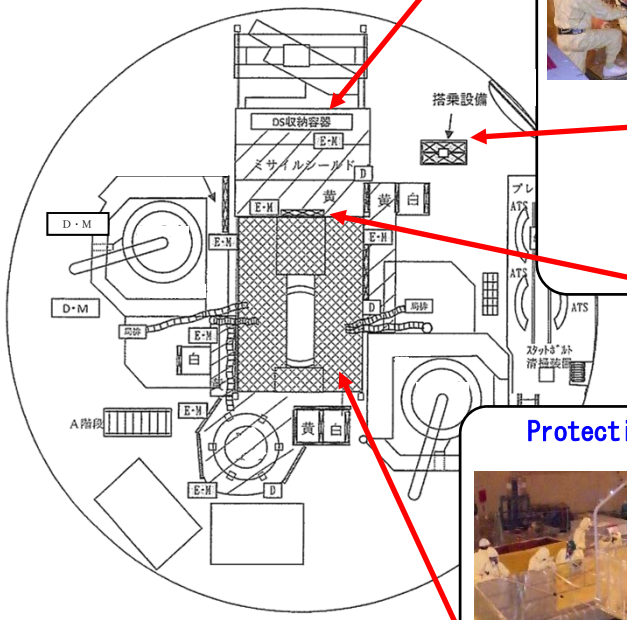
Continuous monitoring and recording of the dose equivalent rate in the cavity

Ventilation in the cavity

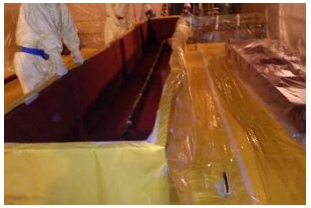
Protection of the openings such as the stairs (measures to prevent dust from scattering)

Removal of radioactive materials (2/3)
(main preparation process before system decontamination)

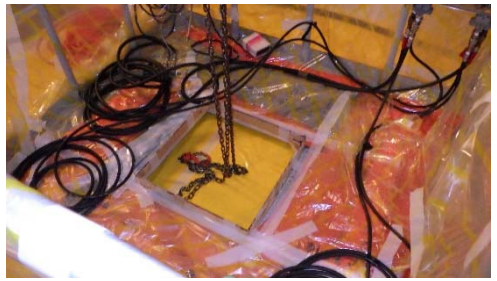
Example of measures to reduce exposure in the main process before system decontamination
(hoisting of the reactor vessel head and withdrawal of the control rod drive shaft)



Lead shielding of the area around the control rod drive shaft storage vessel in line with the increase in the dose of the vessel



Lead shielding of the cabin floor (for personnel inside)



Protection of the bottom side of the reactor vessel head when hoisting the reactor vessel head (measures to prevent dust from scattering)

Protection of the top side of the cavity when the control rod drive shaft is withdrawn (measures to prevent dust from scattering)

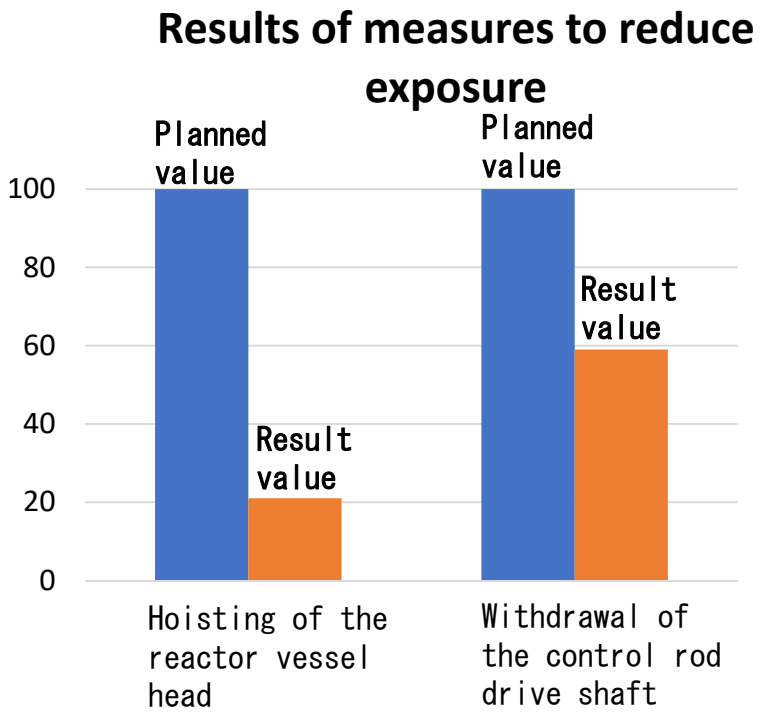
Protection of the control rod drive shaft and measurement of the dose equivalent rate

Removal of radioactive materials (3/3)
(main preparation process before system decontamination)

Results of measures implemented to reduce exposure
(results against the planned dose)

・Hoisting of the reactor vessel head: approx 20%
(plan：2.5 man・mSv、results：0.5 man・mSv)

・ Withdrawal of the control rod drive shaft ：
approx 60%
(plan： 11 man・mSv、results：6.5 man・mSv)



Removal of radioactive materials (system decontamination)

○To reduce exposure during dismantling, decontamination was performed to remove radioactive materials that adhered to the piping, etc. in the primary coolant system.

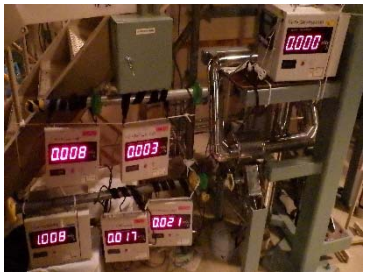
○ Results of decontamination using decontamination equipment (preliminary value)

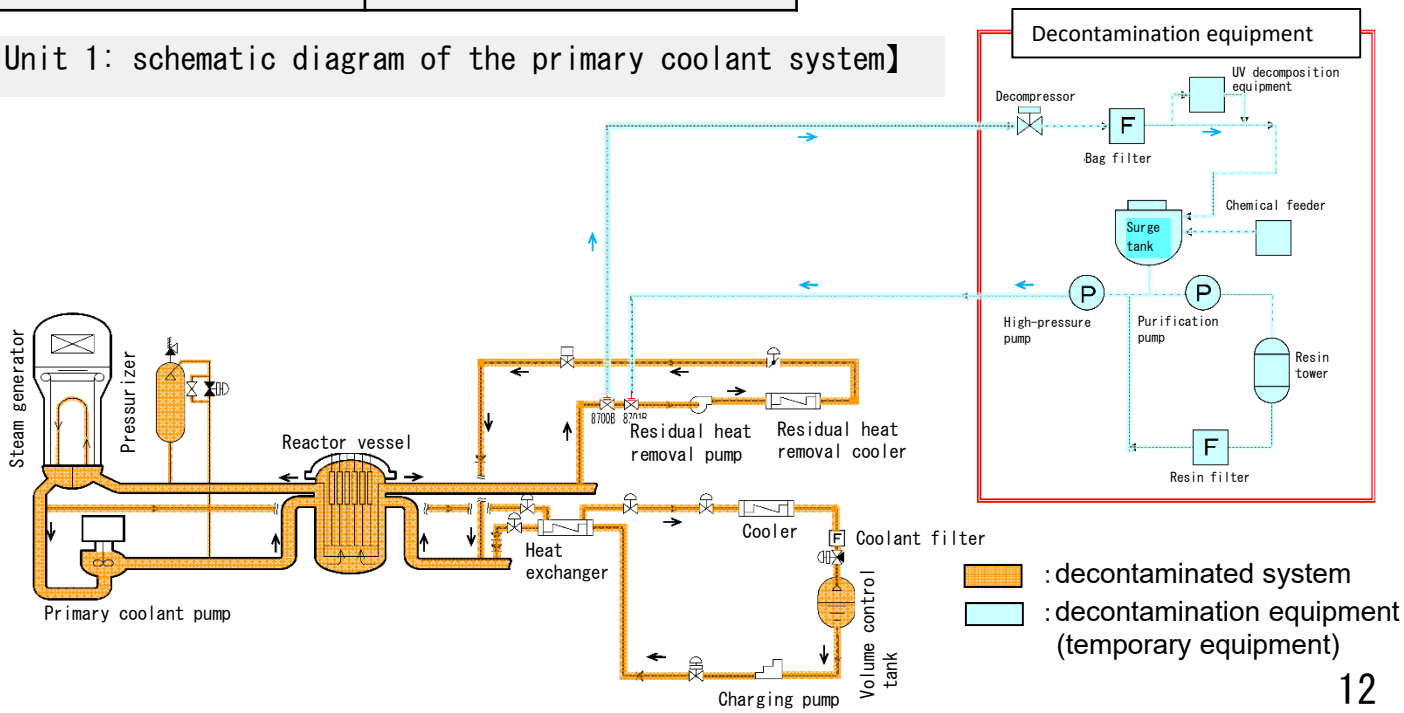
(unit : mSv/h)

	Dose equivalent rate (before decontamination)	Dose equivalent rate (after decontamination)
Steam generator heat transfer tube	8.7	0.095

【Genkai Unit 1: schematic diagram of the primary coolant system】

Visualization of dose during work





Need for a contamination survey

- A contamination survey is conducted to determine the distribution of radioactivity concentration and amount of radioactive materials remaining in the building and equipment. The dismantling and removal method and procedure are formulated based on the survey results with the aim of reducing exposure.
- The contamination survey helps formulate an appropriate treatment and disposal plan for handling wastes generated by the dismantling and removal process.

Types of contamination

- Radioactivation

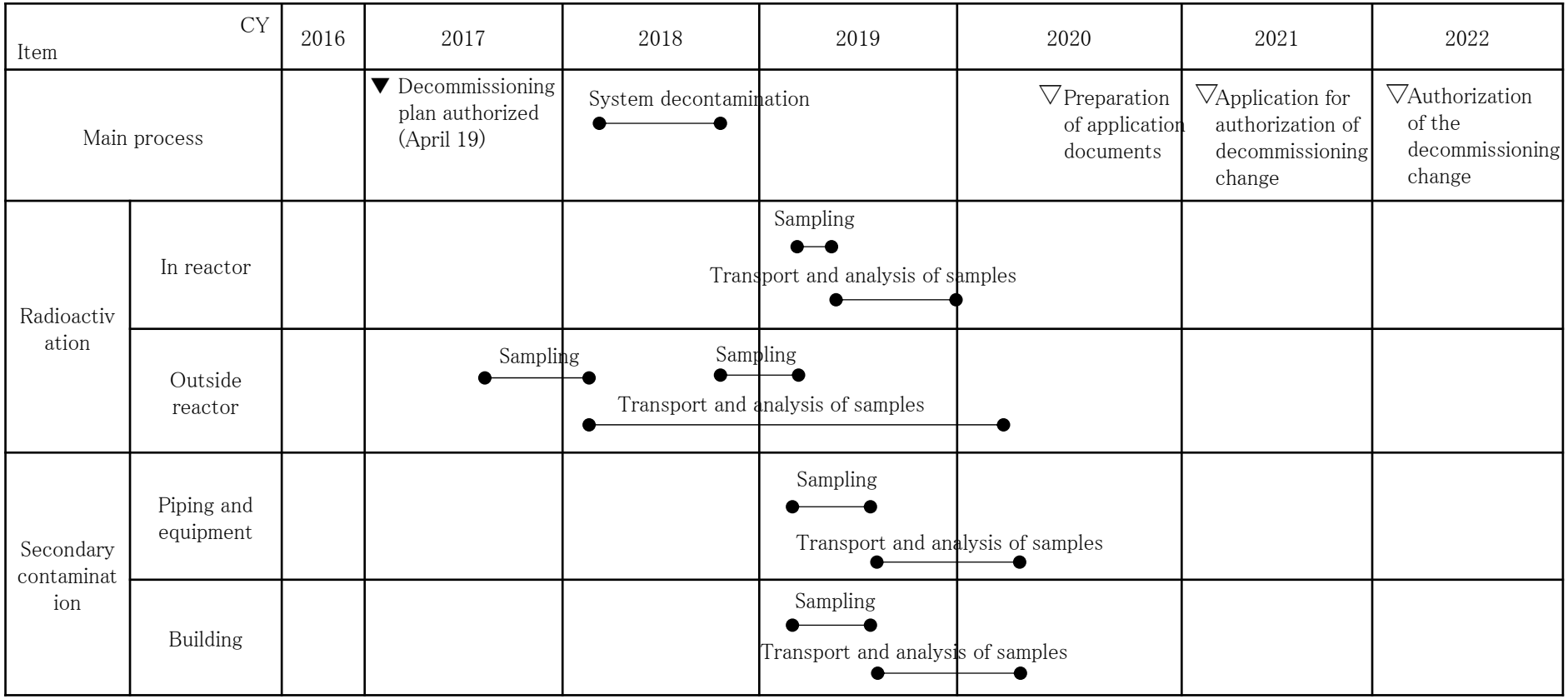
  Non-radioactive materials are exposed to radiation and turn into radioactive materials. This phenomenon is referred to as radioactivation.

  At nuclear power plants, radioactivation occurs mainly due to exposure to neutrons.

- Secondary contamination

  Radioactivated cooling water, etc. adheres to and remains in the piping, etc. This phenomenon is referred to as secondary contamination.

Schedule of the contamination survey (plan)



How to conduct a contamination survey (Radioactivation) (1/3)

≪Overview≫

- For radioactivated materials, nuclides produced are identified. The radioactivity concentration distribution of nuclides produced is surveyed by calculation and measurement.
- The calculation-based method aims to make evaluations using the neutron beam irradiation history and design information.
- The measurement-based method aims to analyze metals and concrete fragments collected from the building and equipment, identify the nuclides produced by radioactivation, and determine the radioactivity concentration of the nuclides produced.

How to conduct a contamination survey (Radioactivation) (2/3)

≪Calculation-based method≫

- A model is created based on the equipment design information.
- The neutron flux from the reactor core is evaluated.
- The radioactivation distribution is calculated based on the design information and neutron flux evaluation.

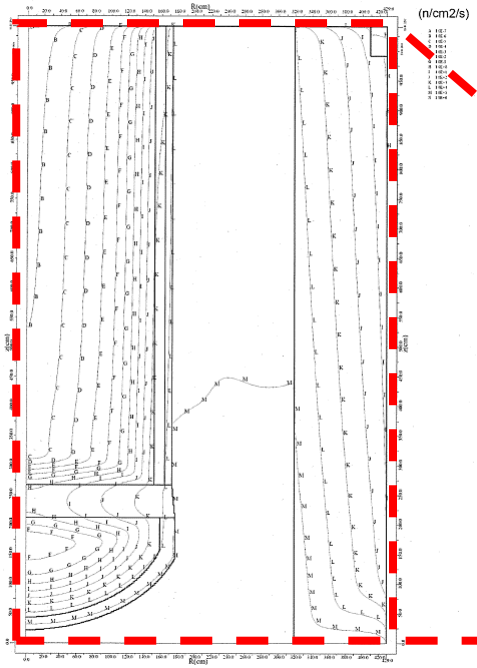


Fig. 1 Example of neutron flux evaluation

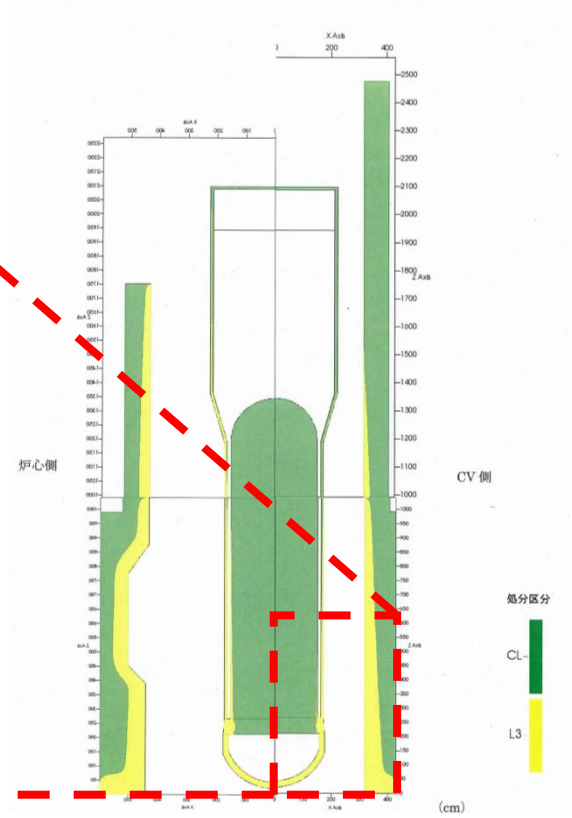


Fig. 2 Example of radioactivation distribution

How to conduct a contamination survey (Radioactivation) (3/3)

≪Measurement-based method≫

- Samples are collected from the building and equipment.
- Samples are analyzed.
- Results obtained from the calculation-based method are compared with those obtained from the measurement-based method to conduct a review.

How to conduct a contamination survey (Secondary contamination) (1/3)

≪Overview≫

- The radioactivity concentration of corroded products that adhere to the building and equipment is measured and evaluated.
- The measurement-based method has two variants. One is to measure the dose equivalent rate from outside the building and equipment and evaluate the radioactivity concentration based on the measurement results. The other is to evaluate the radioactivity concentration of corroded products that adhere to the building and equipment based on sample analysis.

How to conduct a contamination survey (secondary contamination) (2/3)

≪Calculation-based method (evaluation based on the dose equivalent rate) ≫

- The dose equivalent rate is measured from outside the building and equipment.
- The radioactivity concentration is calculated based on the obtained measurement results.

Measurement

※Measurement is conducted in-house as much as possible from the viewpoint of improving employees' engineering skills and passing on engineering capabilities.

How to conduct a contamination survey (measurement and analysis) (3/3))

≪Measurement-based method (analysis-based evaluation)≫

- Samples are collected from the building and equipment.
- Samples are analyzed.
- The evaluation results based on the dose equivalent rate are compared with those based on analysis to conduct a review.

Analysis

※ Analysis is conducted in-house as much as possible from the viewpoint of improving employees' engineering skills and passing on engineering capabilities.

Summary

The following measures will be implemented based on the contamination survey.

- **Reducing exposure**

  Appropriate dismantling and removal methods and procedures will be formulated.

- **Ensuring smooth decommissioning**

  A plan for treating and disposing of wastes generated by dismantling will be formulated.

- **Improving employees' engineering skills and passing on engineering capabilities**

  Measurement and analysis will be conducted.