Subsidy Project of Decommissioning and Contaminated Water Management Started From FY2021

Development of Support Technology for Integrated Management of Decommissioning the Fukushima Daiichi Nuclear Power Station (Development of Continuous Monitoring System in PCV)

Accomplish Report for FY2021

August 2022

International Research Institute for Nuclear Decommissioning (IRID)

(Contents)

(Note)
- In this document, fuel debris may be abbreviated as “debris,” mainly due to limited space for figures and tables on paper.

1. Background and purpose of the project

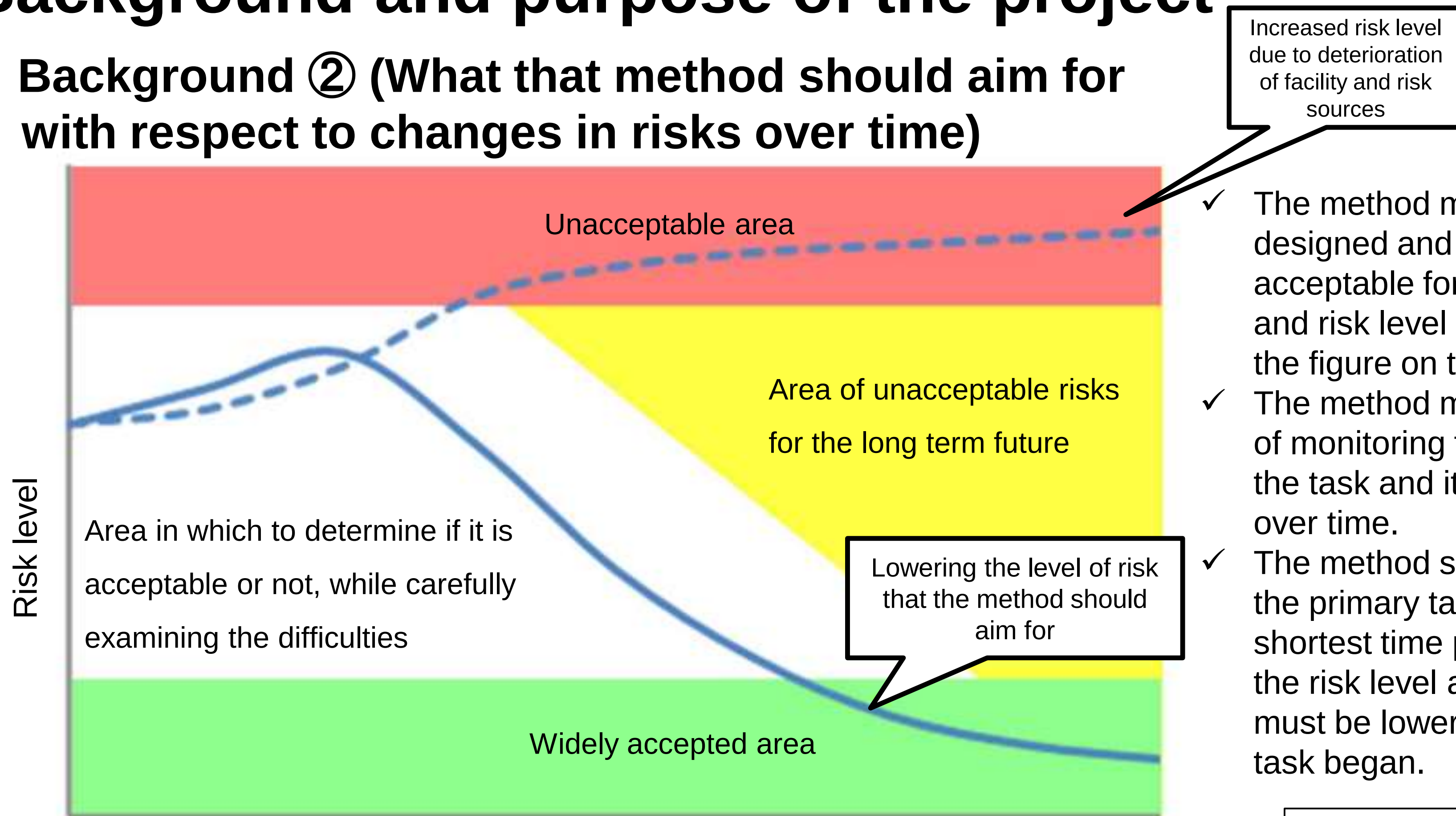
■ Background ① (Summary of Solicitation Application)

- Further increase in the retrieval scale of fuel debris will require more sophisticated monitoring systems to increase throughput and to support continuity of safe retrieval overview by providing a comprehensive and continuous identification of environmental changes inside the PCV where the retrieval operations are taking place.
- To secure throughput in remote operations under environmental conditions with uncertain elements, technology is needed to continuously monitor environmental changes inside the PCV over a long period of time during retrieval.
- In addition to the above, the development of technology (integrated management support technology (*1)) using the digital twin will be effective in enabling accurate and prompt on-site response by integrating and sharing the acquired monitoring data and operational data, which includes data on troubles, etc., obtained through actual operation of remote equipment.
  (*1) Integrated management support technology is defined as a technology to grasp, whether or not there is a deviation from the expected conditions which include the achievement of safety requirements, by processing data on the disturbing ensuring throughput. The digital twin is one of the unique technologies similar to this definition.

- **It is necessary to develop a continuous monitoring system inside the PCV as element technology for long-term support for safe, efficient, and continuous integrated management of the decommissioning of the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as the Fukushima Daiichi).**
- **The development of this technology will be based on the results of the “Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals.”**

1. Background and purpose of the project

■ Background ② (What that method should aim for with respect to changes in risks over time)



Source: Technical Strategic Plan 2021 for Decommissioning of the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc.

Appendix 5 Changes in risk over time Figure A5-1

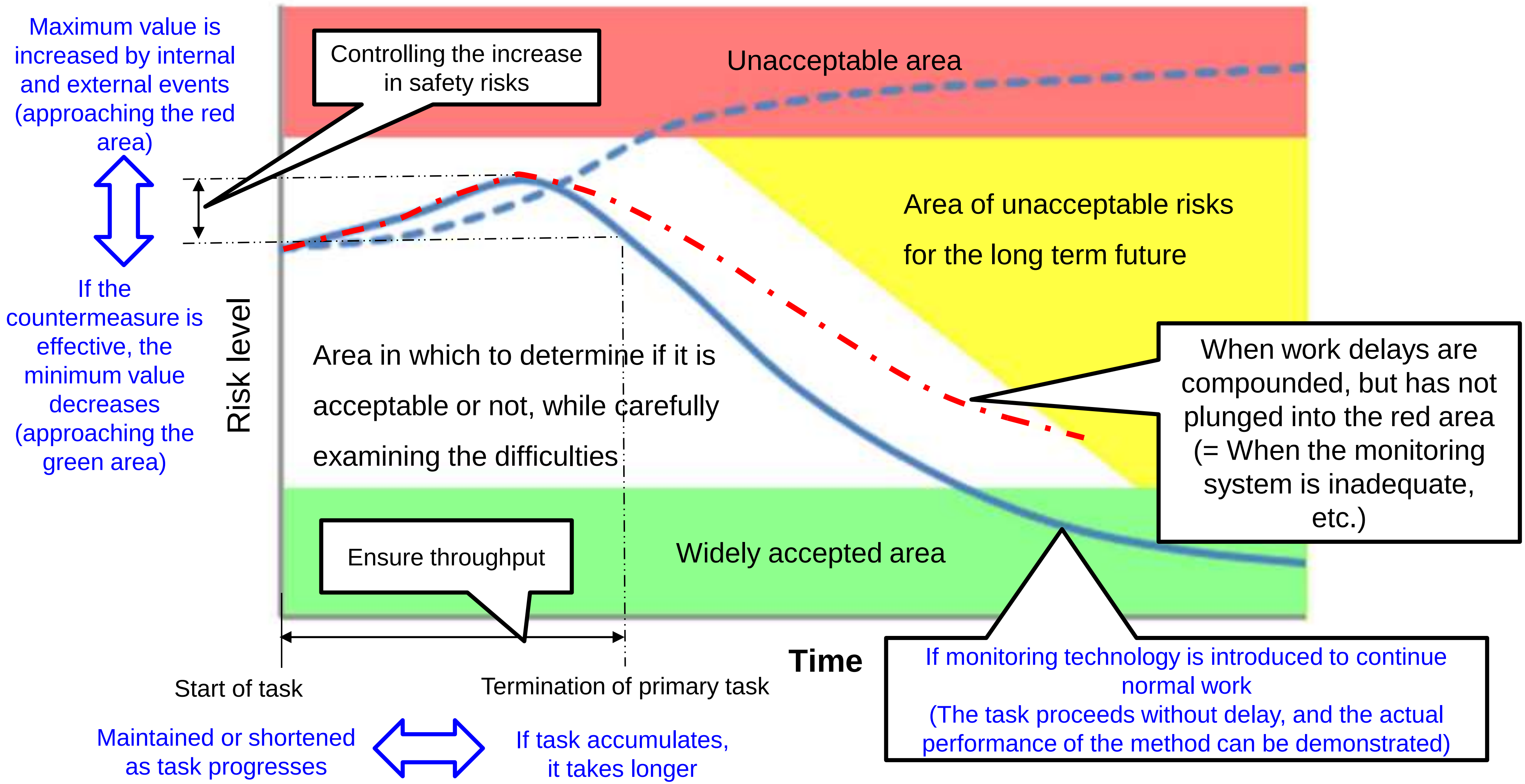
- ✓ The method must be designed and modeled to be acceptable for the time axis and risk level axis shown in the figure on the left.
- ✓ The method must be capable of monitoring the status of the task and its progress over time.
- ✓ The method should complete the primary task in the shortest time possible, and the risk level at that time must be lower than when the task began.

Note: This drawing represents a general concept and should be examined in accordance with the status of progress on-site.

Each method must advance to the green area by repeating the check items in the upper right corner before reaching the red/yellow area

1. Background and purpose of the project

■ Background ③ (Role of monitoring technology for changes in risk over time)



The monitoring technology will help ensure that the task should not be delayed and the method used can maintain its original performance (the solid blue line in the above figure). This contributes to ensuring safety against changes in risk over time

1. Background and purpose of the project

[Research Objectives (General Overview)]

- This project aims to support the development of technologies contributing to decommissioning and contaminated water management of the Fukushima Daiichi Nuclear Power Station (hereinafter referred to as "Fukushima Daiichi NPS") of the Tokyo Electric Power Company Holdings, Incorporated (hereinafter referred to as "TEPCO") based upon the "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi NPS" and "The Development Plan of Decommissioning Research in FY2021" (The 86th Secretariat Teem Meeting for Countermeasures for Decommissioning and Contaminated Water Treatment), so that the decommissioning and contaminated water management of the Fukushima Daiichi NPS can be implemented smoothly, and to raise the level of Japan's science and technology standard.
- The study of general theories unrelated to the method will proceed in FY2021 in order to continuously monitor the environmental changes in the Primary Containment Vessel due to further increasing the scale of fuel debris retrieval operations.
- Specifically, this project focuses on investigation, organization and setup of monitoring items considering safety requirements and task continuity, and conceptual studies of monitoring methods will be conducted and examined with consideration of on-site applicability.
- Moreover, these conceptual studies, etc, will be explained to the experts appointed by Nuclear Damage Compensation and Decommissioning Facilitation Corporation (hereinafter referred to as "NDF") and relevant parties (Ministry of Economy, Trade and Industry, TEPCO, NDF) and their opinions will be sought(*).
- In FY2022, the plan will be reviewed based on the opinions received and the status of progress in decommissioning, and candidates for measuring equipment and monitoring sites will be selected. In addition, the operational policies for the data obtained from monitoring will be studied.

*: In FY2021, NDF received opinions from the "Fuel Debris Retrieval Expert Committee (37th meeting, December 15, 2021)" established and convened by NDF.

The above objectives are detailed on the following pages

1. Background and purpose of the project

■ Details of research objectives (Considerations in conducting research)

- When fuel debris retrieval operations are conducted on-site, not only operational errors by equipment operators and equipment failures but events specific to the Fukushima Daiichi NPS are also assumed to occur. Research will be conducted based on the idea that these are disturbing ensuring throughput.
  - [Assumed Roles of the Operator]
    Operator: A person who operates equipment on a panel or terminal following the operation manual
    Leader: The team leader of operators. A person who understands the status of the site and gives instructions to the operators
  - The keyword “accurate and prompt on-site response” in No. 2, is carried out by equipment operators who work daily in uncertain elements.
- Maintaining nuclear safety and ensuring targeted throughput requires a decision-making process to determine a reliable response to the site conditions based on monitoring data (FACT data) obtained in the PCV. This will be taken into account in the research.

[Mission and definition of continuous monitoring system inside the PCV in this project]
A system (hereafter referred to as a monitoring system) that collects monitoring data for operators to respond accurately and promptly on-site and ensure throughput while maintaining safe conditions

[The role of this project]
Research results will be provided for the design of fuel debris retrieval methods to be studied for actual on-site response
(Specific recipients are shown in No. 15.)

2. Research goals

■ Goals

Research goals are to prepare development requirements and specifications for introducing the monitoring system in the design of fuel debris retrieval methods. The following two goals were established for this, and action items were established to achieve each of these goals.

Goal 1: The requirements and issues for monitoring inside the PCV will be organized under this project.

Implemented in FY2021

★ Investigation of important monitoring items inside the PCV

→ Replaced with action item (1) in No. 10 and TRL in No. 20

Implemented in FY2022

★ Study of monitoring methods to actualize monitoring

→ Replaced with action item (2) in No. 11 and TRL in No. 20

Goal 2: The concept of monitoring data operation (specific information processing and flow of its application) will be studied under this project.

Implemented in FY2022

★ It is assumed that three kinds of support are necessary: "operator support, analysis support, and work plan improvement support"

→ Replaced with action item (3) in No. 12 and TRL in No. 20

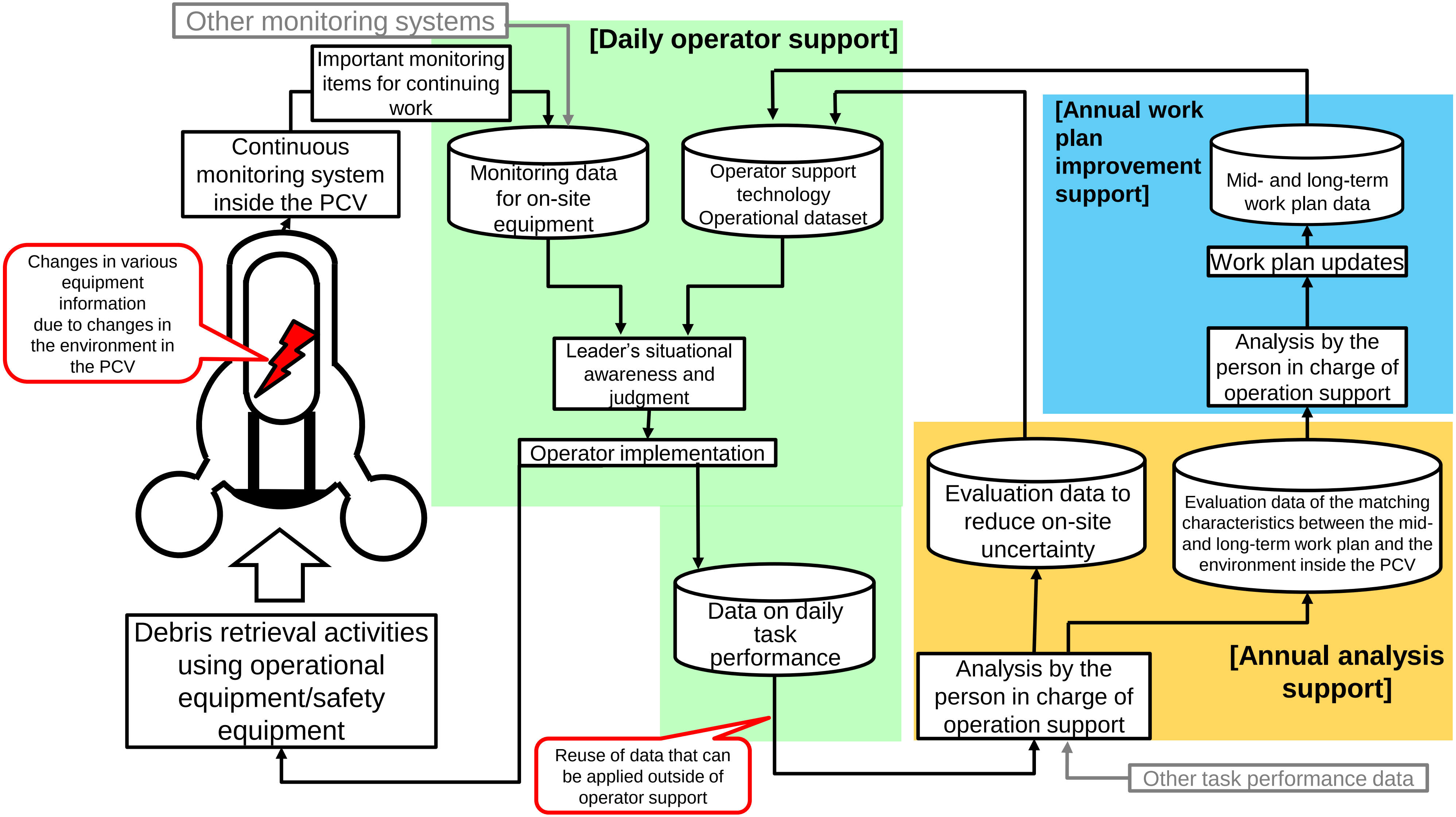
See the next page for how the monitoring system contributes on-site

2. Research goals

Detailed version: Appendix 2-1

■ **On-site data usage measures**

- Monitoring data obtained on-site can be used for the three supporting technologies shown in the figure below. Important monitoring items can be applied in "daily operator support" as monitoring data for on-site facilities to continue fuel debris retrieval and transfer work.
- The monitoring data may be reused in "work plan improvement support" and "analysis support."



2. Research goals

■ Definition of terminology

- The implementation details of this project pertains to risk management. Various technical terms in this project were set as follows as conditions for study by referring to ISO 31000 (Risk Management Guidelines).

Terminology/ Abbreviation	Description
Planned state of fuel debris retrieval	Defined as conditions of operation for fuel debris retrieval. . Conditions in which the safety requirements of the plant, such as the diffusion of radioactive materials are being met, and the fuel debris retrieval and transfer work are progressing according to plan. In addition, the fuel debris retrieval and transfer work in this project will be carried out for 200 days a year (*)(**) in which 300 kg of fuel debris will be transferred in10 hours a day. Maintenance and replacement of equipment performed outside of these work hours and working days are not included.
Throughput	Ability pertaining to the total amount of fuel debris retrieved during the period from the start to completion of fuel debris retrieval (Retrieval phase with further increase in scale).
Work delay factors (= throughput disturbing)	Factors that threaten planned state of fuel debris retrieval and worsen throughput. The two main points are as follows: Factor ①: Work is delayed due to deterioration of fuel debris retrieval and transfer functions. Factor ②: Work is delayed due to deterioration of safety function for radiation risks.
Risk	Risk is the effect of uncertainty on the objective of ensuring throughput where the effect is a deviation from the planned state of fuel debris retrieval.
Risk assessment	A means of determining if the risk is an important monitoring item in the PCV. The significance of the risk assessment is to substantiate the decision, and the risk assessment includes a comparison of the results of the risk analysis with the risk criteria to determine where further actions should be taken.

(*) This operating condition is an assumed `value (target value).

(**) Depending on the method, fuel debris may be temporarily stored during the day and transferred in batches at night (so-called batch treatment). In this table, the expression is for when there is continuous retrieval and transfer.

3. Implementation items, their co-relation, and relations with other projects

3.1 Implementation items for this project

■ Implementation item (1): Investigation of monitoring items inside the PCV

① Investigation of important monitoring items

- To enable operators to respond accurately and promptly on-site, the PCV monitoring items that lead to work delays are investigated and risk factors are extracted.
- As a method of extracting risk factors, a fuel debris retrieval and transfer process with added safety functions will be modeled (hereinafter referred to as a debris retrieval model).
- Extracted risk factors are weighted and evaluated in terms of the degree of deviation from the planned state of fuel debris retrieval (evaluation items: safety, operators, throughput).

② Organizing specifications for monitoring requirements

- Based on the results mentioned in ① above, methods of acquiring the required on-site data will be studied. This study will verify monitoring items that can be measured currently and in the future, and verify their excesses and deficiencies. The measurement source, range, and accuracy required for each measurement will also be studied. Here, if ① is found to be deficient in order, ① is reviewed.
- Based on ① and ② above, the important monitoring items inside the PCV , necessary for the operators to respond accurately and promptly on-site on a daily basis, are organized. This investigation will be coordinated with and reviewed in conjunction with the results of the subsequent implementation details (2) and (3).

Debris retrieval and transfer operations will be modeled, and the requirements for acquisition of monitoring data to achieve the objectives will be studied

3. Implementation items, their co-relation, and relations with other projects

3.1 Implementation items for this project

■ Implementation items (2): Study of the monitoring methods

① Study of diversification of monitoring measures

- When selecting monitoring sites, assume there will be cases where direct monitoring will be difficult, and include indirect monitoring methods that combine analysis, in the study.

② Study of installation methods for measuring equipment

- Installation methods of measuring equipment must be studied for on-site application of the methods considered in ① above.
- The penetration usage plans for monitoring equipment, will be studied, taking into account the constraints of the penetration and the structure of the reactor building.

③ Organization of technological issues

- Basic technological issues and development elements are studied, issues are identified for installation of each measuring equipment to be extracted, and a plan is developed to resolve the issues (e.g. avoid interfering with fuel debris retrieval related equipment).
- The requirements for the system to collect the measurement data will also be studied.

Specific monitoring methods will be studied and issues will be organized based on specifications of monitoring requirements

3.1 Implementation items for this project

■ Implementation items (3): Study of operational policies for integrated management support technology

① Study of on-site data usage measures

- Based on the results of implementation details (1) and (2), the usage measures for on-site data will be studied to enable operators to respond accurately and promptly on-site on a daily basis. In addition, in this study, the operator's point of view is taken into consideration.

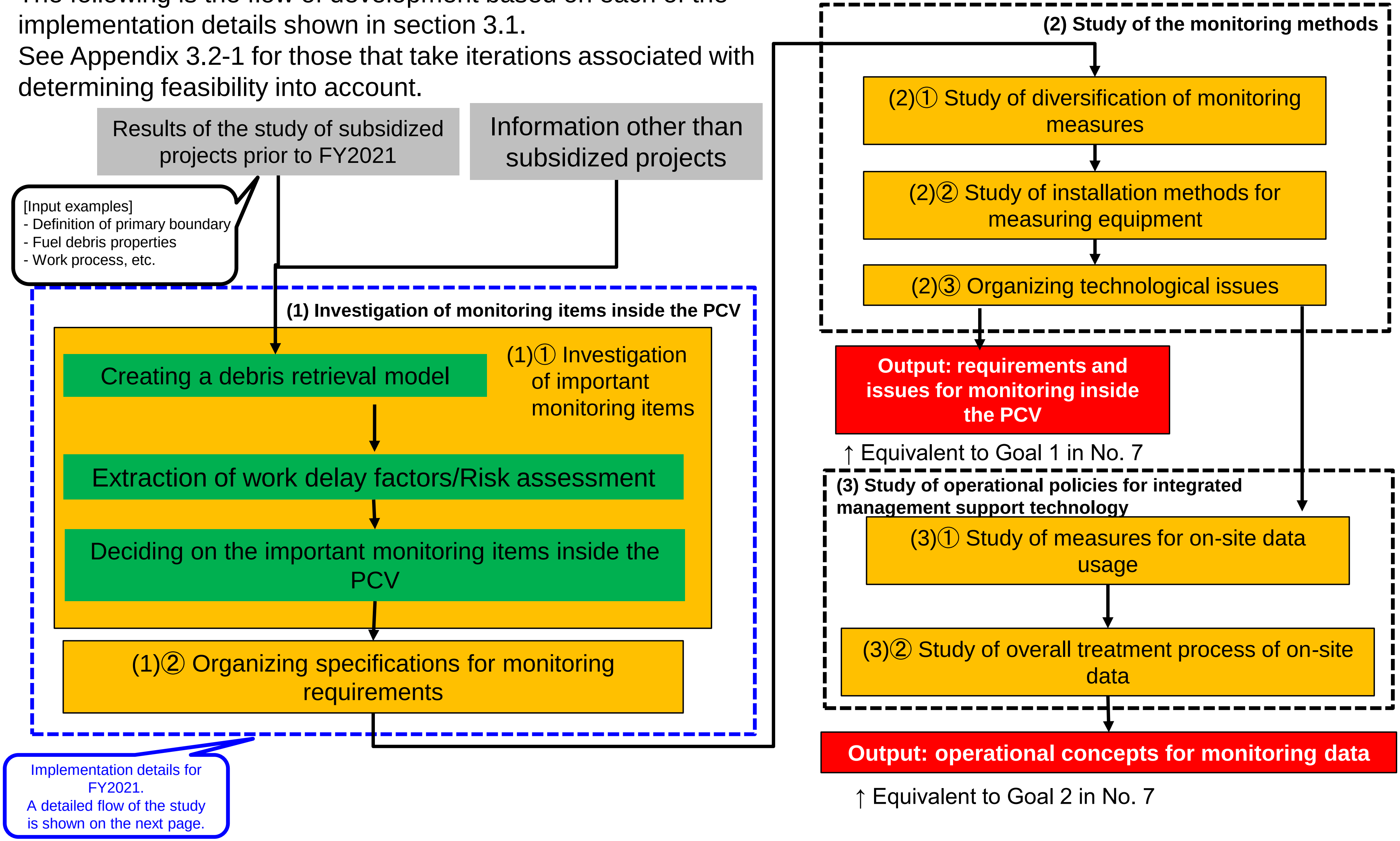
② Study of overall treatment process of on-site data *Collaborate with the study of IRID Head Office

- Utilizing the results of the study described in ① above, the on-site data treatment process that assumes on-site operation at the Fukushima Daiichi will be studied, and the data treatment process of the monitoring system, which is a part of the integrated management support technology, will be studied.

How the acquired monitoring data should be used on-site will be studied

■ Two-year flow of development

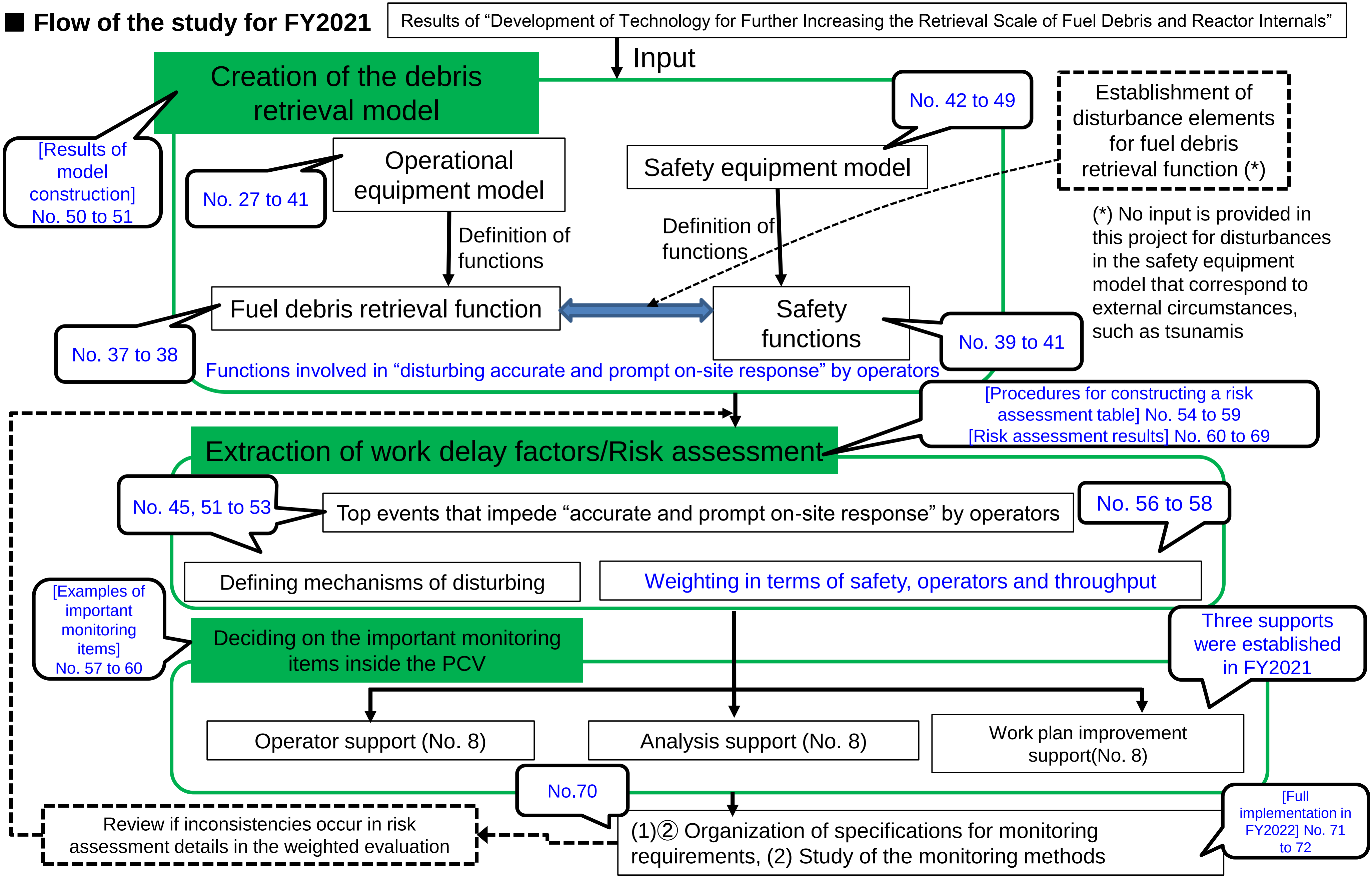
The following is the flow of development based on each of the implementation details shown in section 3.1.
See Appendix 3.2-1 for those that take iterations associated with determining feasibility into account.



3. Implementation items, their co-relation, and relations with other projects

3.2 Relevance between implementation items

■ Flow of the study for FY2021



3.3 Relation with other projects

■ Main collaborations with other projects

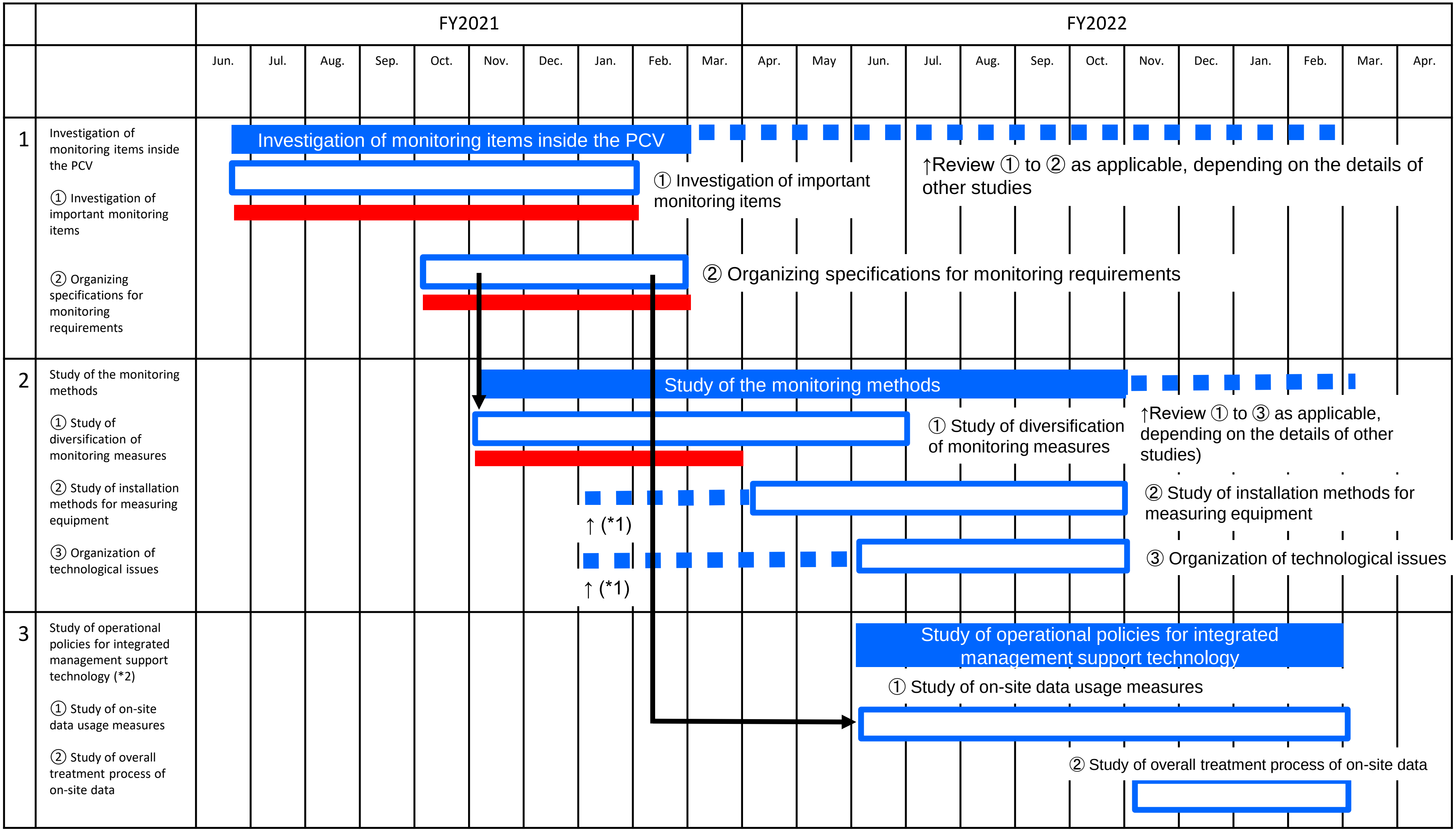
ID	Demand-side project	Provider-side project	Concrete actions	Information use
1	This project	Debris retrieval project/ Upgrading project/ Fundamental project/ Safety project/ Canister project	- Work plan for inside the PCV - Information on additional equipment installed inside the PCV and in the reactor building - Safety system operation plan - Work plan in the PCV atmosphere - Information on additional equipment installed inside the PCV and in the reactor building	- Conditions setting for studying important monitoring items within the investigation of monitoring items inside the PCV - Requirements setting for the study of diversification of monitoring measures within the study of the monitoring methods
2	Debris retrieval project Safety project Canister project	This project	- Important monitoring items and monitoring requirements - Operational policies for integrated management support technology (monitoring system)	- Capable of establishing and reviewing important monitoring items for each method. - Capable of specifying the monitoring technology necessary for each method. Details: See Appendix 3.3-1

Debris retrieval project : Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals
Upgrading project : Advancement of Retrieval Method and System for Fuel Debris and Reactor Internals
Fundamental project : Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals
Safety project : Development of Safety Systems
Canister project : Development of Technologies for Containing, Transfer and Storage of Fuel Debris

4. Implementation schedule

Implementation items / Planning schedule — Actual results (as of the end of FY2021)

No.16



*1: Conduct test preparation as needed

*2 Collaborate with the progress in the study IRID Head Office

5. Project organization

International Research Institute for Nuclear Decommissioning (IRID) (Head Office)

- •Coordination of general planning and overall technology management
- •Coordinate technological management, such as progress in technological development

Tokyo Electric Power Company Holdings, Inc.

- •Coordination for on-site applicability

Toshiba Energy Systems & Solutions (ESS) Corporation

(1) Investigation of monitoring items inside the PCV
(Coordinate, investigate monitoring items, and review the implementation details of other companies)
(2) Study of the monitoring methods
(Coordinate, study monitoring methods, and review the implementation details of other companies)
(3) Study of operational policies for integrated management support technology (Note 1)
(Coordinate, study operational policies for integrated management support technology, review the implementation details of other companies)

[Subcontracting details]
Design support for the study of monitoring methods (scheduled for FY2022): TBD
Design support for the study of operational policies for integrated management support technology (scheduled for FY2022): TBD

Hitachi-GE Nuclear Energy, Ltd.

(1) Investigation of monitoring items inside the PCV
(Investigate monitoring items, peer review of implementation details)
(2) Study of the monitoring methods
(Study monitoring methods, peer review of implementation details)
(3) Study of operational policies for integrated management support technology (Note 1)
(Study operational policies for integrated management support technology, peer review of implementation details)

[Subcontracting details]
Design support for the study of monitoring methods (scheduled for FY2022): TBD

Partner development project teams

- Development of safety systems
- Development of Technologies for Containing, Transfer and Storage of Fuel Debris
- Development of Fuel Debris Retrieval Method

Note 1: The IRID Head Office also organizes study policies concerning (3)

Manufacturers, Hitachi GE and Toshiba ESS, engage in this project.

6. Implementation details 6.1 Objectives and goals for each of implementation detail

6.1.1 Technology Readiness Level (TRL)

Implementation details	Targeted effects	(Supplemental) TRL definitions
(1) Investigation of monitoring items inside the PCV	The items that should be monitored inside the PCV will be investigated, extracted and organized to satisfy safety requirements, such as maintaining the confinement function of the PCV during fuel debris retrieval, and monitoring the sub-criticality condition.	(Technology Readiness Level (TRL) is not set because research and organization of issues for technological development are different from development items.)
(2) Study of the monitoring methods	Based on the organized results of implementation details (1), issues must be extracted for the installation of each measuring equipment for monitoring inside the PCV, and a plan must be developed to resolve the issues. (Target TRL upon termination: Level 2)	Development and engineering work is performed, and the required specifications are developed in areas where there is almost no applicable past experience.
(3) Study of operational policies for integrated management support technology	Support items that contribute to integrated management at the Fukushima Daiichi must be extracted, based on the results of implementation details (1) and (2), and on-site usage measures must be planned. (Targeted TRL upon termination: Level 1)	Basic requirements and necessary technologies are identified for the methods and systems to be developed and engineered.

The TRL indicates why the proposed monitoring items are necessary and how they can be useful on-site.

6. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.1 Prerequisites for the study

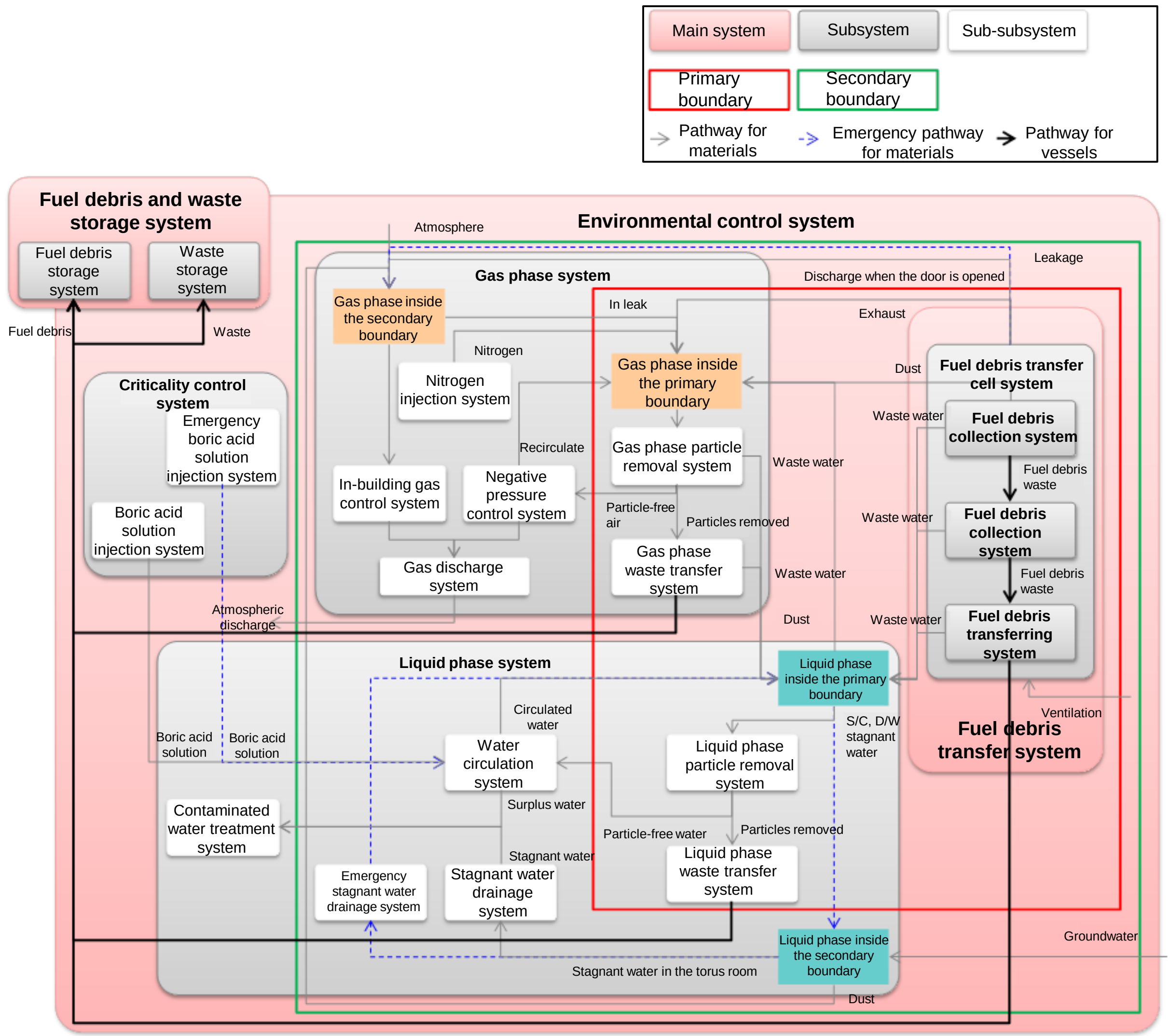
■ Scope of study on the system

- The figure on the right shows the correlation of the flow of materials such as gas, liquid, and fuel debris in the overall configuration of the fuel debris retrieval system (*).

  * Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals project

- The flow of information (data) during retrieving and transferring fuel debris, and their correlation (IN/OUT) are studied each of the systems shown in the figure on the right.

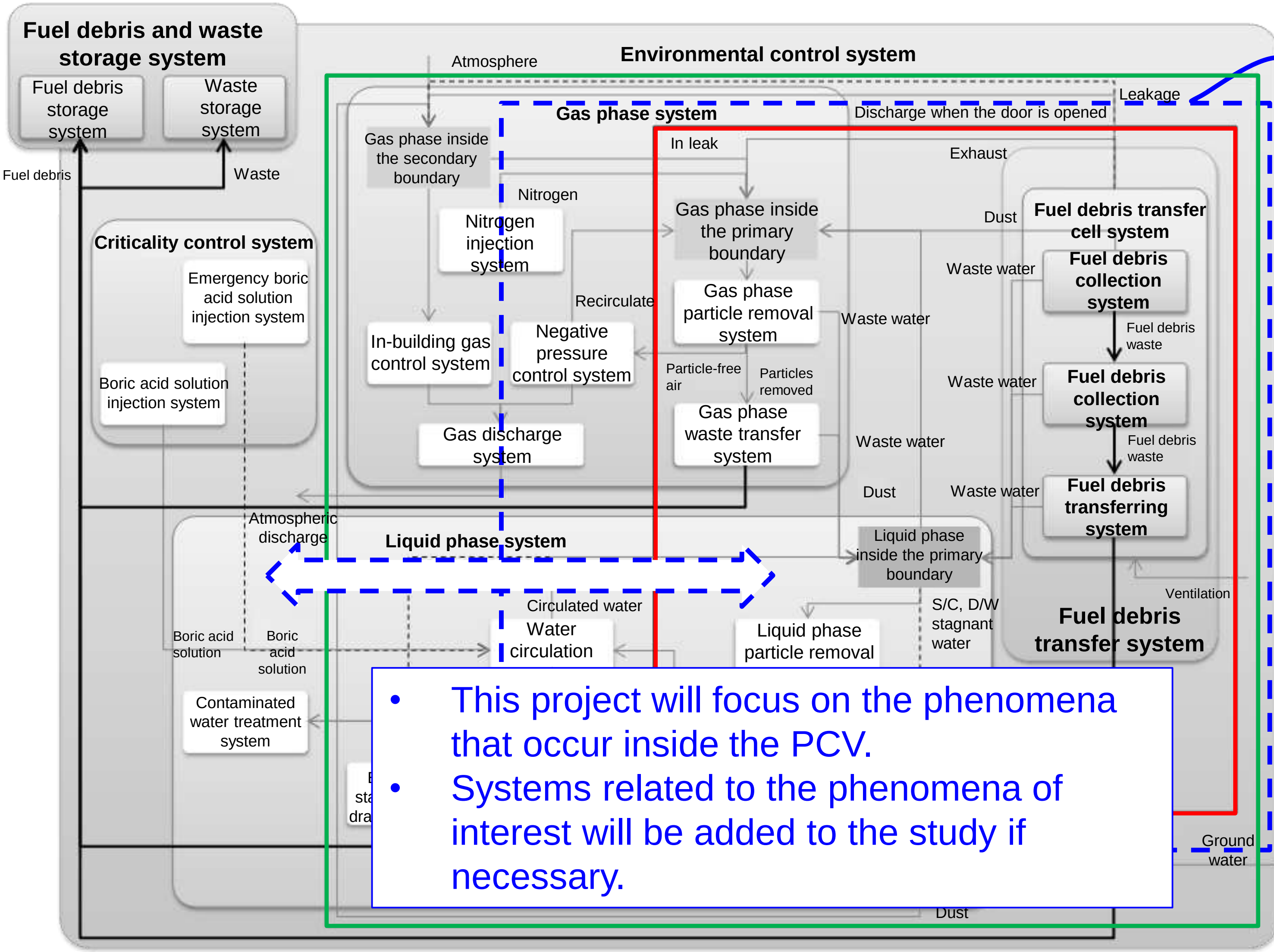
- Prior to the above, the approach to the scope of study for this project is shown on the next page.



6.2.1 Prerequisites for the study

■ Scope of study on the system

- The approximate scope of study for this project in terms of system configuration is shown in the blue dash box below.
- The work delay factors inside the PCV are extracted to study the monitoring requirements of systems and equipment associated with these factors.



- This project will focus on the phenomena that occur inside the PCV.
- Systems related to the phenomena of interest will be added to the study if necessary.

Focused systems (Add systems in stages as needed)

Fuel debris retrieval and transfer system (inside the PCV)

↑ Modify expressions using the figure on the left

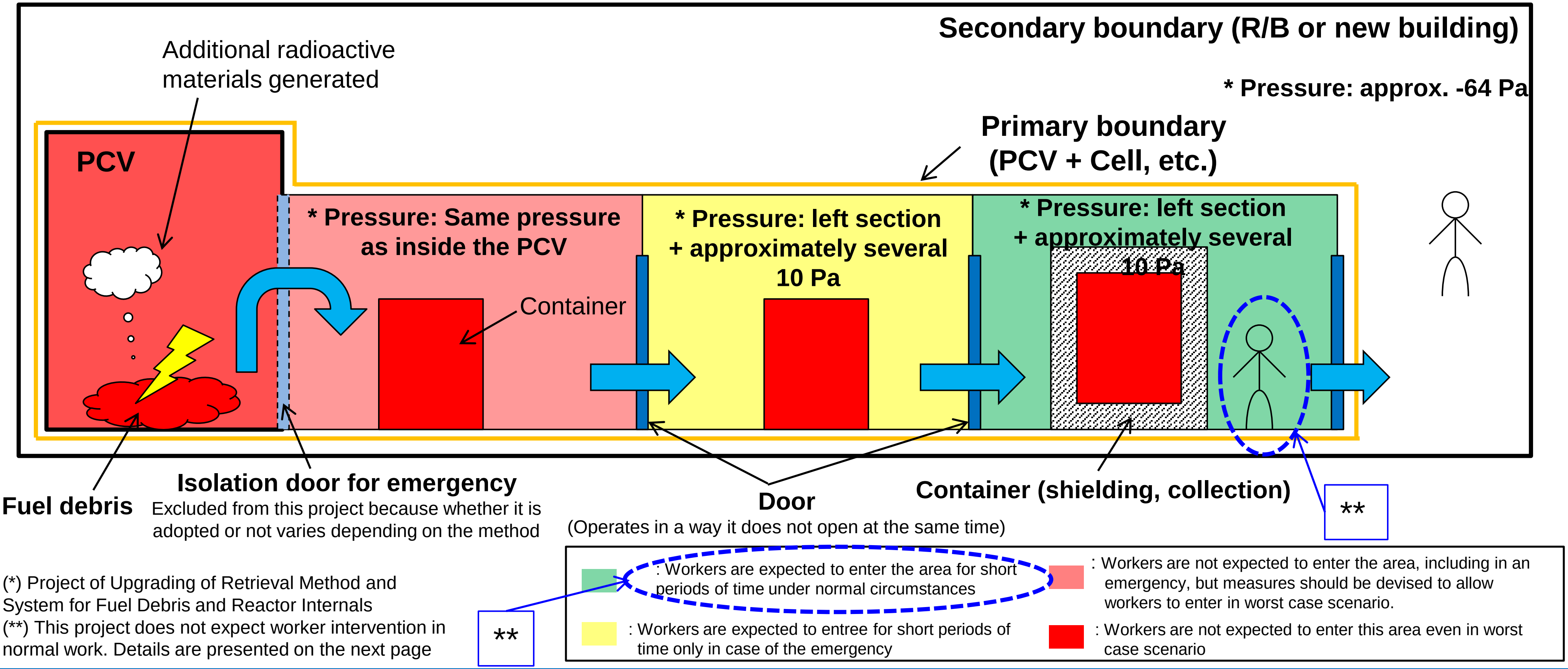
Gas phase system (inside the PCV)

Liquid phase system (inside the PCV)

The scope of study includes consideration of static boundary accompanying deterioration of the PCV structure

6.2.1 Prerequisites for the study ■ Scope of primary boundary

- The scope of the primary boundary that has a direct static confinement function for the risk source (fuel debris) utilizes the results of past projects in the figure below.
- Boundary definitions established through the project of upgrading of fundamental technology (*) are utilized, taking the unique environment at the Fukushima Daiichi and the fuel debris retrieval methods into consideration. In this definition, radiation dose area and contaminated area are setup separately based on the perspective of whether the workers are allowed to enter or not, and four types of areas (red (two types), yellow, and green) resulting from the combination of these two areas are defined.



(*) Project of Upgrading of Retrieval Method and System for Fuel Debris and Reactor Internals
(**) This project does not expect worker intervention in normal work. Details are presented on the next page

The definitions shown in this figure are considered in the operational equipment model (No. 26) and ultimately included in the debris retrieval model (No. 48).

6. Implementation details
6.2 Implementation details (1) :Investigation of Monitoring Items Inside the PCV
6.2.1 Prerequisites for the study ■ Prerequisites for each system (1/2)

- "Safety system" may be abbreviated as "safety equipment" due to space limitations. "Fuel debris retrieval and transfer system" may be abbreviated as operational equipment.

- Both operational equipment and safety equipment must be setup and secured with the defense in depth level 1 to 3 to ensure nuclear safety, according to past subsidized projects and preliminary engineering.

- All normal works (excluding maintenance) at work facilities must be remotely operated. The green area inside the primary boundary shown on the previous page is an environment that workers can enter at all times, but because the degree of worker intervention varies depending on the method, a versatile impact assessment has been deemed difficult.

Prerequisites were determined with the goal of presenting requirements to maintain the planned state of fuel debris retrieval.

[Scope of study for monitoring items inside the PCV]

- Throughput must be ensured by continuation of the planned state for fuel debris retrieval. Thus, in this project, the scope of monitoring inside the PCV will focus on those involved in sustaining normal work(excluding maintenance).
- See Appendix 6.2.1-1 for the contribution of monitoring in accordance with the risk levels of this project.

[Policies for generalization of each system]

- In this project, work procedures and equipment configurations for the fuel debris retrieval methods to be studied in the subsidized project will be investigated, and equipment and work procedures common to each method will be extracted and organized.

The results of this project will be made more versatile so that all methods can refer to the results of this project.

6.2.3 Study of the debris retrieval model

■ Requirements for the debris retrieval model

The following two points must be implemented after achieving versatility that does not depend on the type of method.

- Work delay factors inside the PCV (factors that threaten the planned state of fuel debris retrieval and worsen throughput) must be extracted.
- Along with the above extractions, the equipment related work delay factors must be identified.

■ Policy for representing the debris retrieval model

- The policy indicates only the minimum operational and safety equipment to control the fuel debris and the environment inside the PCV under normal conditions.
- The above equipment must be simplified to deal only with the minimum amount of information that shows how the equipment will physically act against the fuel debris and the environment inside the PCV. In other words, equipment specifications (output, model number, detailed configuration, etc.) are not set.

■ Policy for configuring the debris retrieval model

- In order to understand the movement of materials inside the PCV including fuel debris, the debris retrieval model must be equivalent to the schematic system drawing.

Debris retrieval model evaluates the impact of operational equipment activities on safety equipment and defines the correlation between both equipment

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

■ **Study policies**

- The versatile flow of retrieving and transferring fuel debris that does not depend on methods is developed based on the existing results.
- From the above flow, those with multiple work modes are organized based on the existing results.
- An equipment configuration block drawing is created to crystallize the above flow and to organize the information for integrating with the safety equipment model.

■ **Input from other projects**

- Fuel debris properties - Nuclear safety for the Fukushima Daiichi
- Fuel debris retrieval method (mainly processing method that is the basis for throughput evaluation)
- Fuel debris transfer method (mainly compositional elements of the primary boundary)

■ **Input from this project**

- Prerequisites specified in section 6.2.1

■ **Output from this project**

- Daily workflow
- Equipment configuration block
- Equipment operation mode
- Table of safety functions
- Table of operational functions

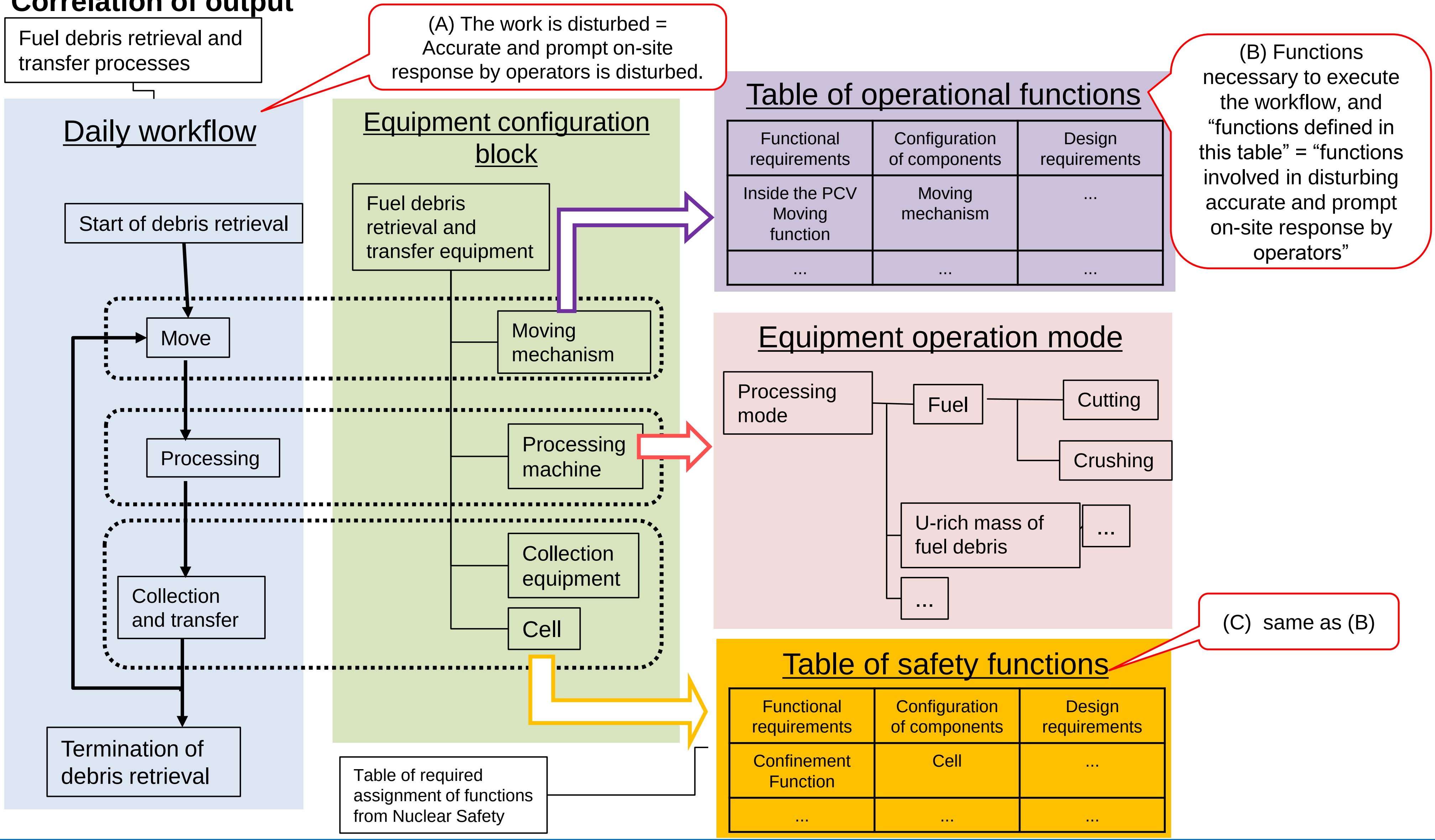
These correlations are explained on the next page

The operational equipment model will be created based on the results of other projects

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

■ Correlation of output



The above five outputs are described in the following pages

6. Implementation details 6.2 Implementation details (1) :Investigation of Monitoring Items Inside the PCV
6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model
(a) Daily workflow

- A generic workflow from the start to the termination of fuel debris retrieval is shown on the next page. This workflow describes the implementation details for the operators for the on-site equipment operators. If the operator's work is disturbed, the work will be delayed.

- In this project, in order to prevent work delays, items to be monitored are extracted for the debris retrieval model by the workflow described above. These monitoring items become important monitoring items inside the PCV.

- This workflow is a model case of continuous fuel debris retrieval and transfer.

A common operator workflow in each method is developed(see next page)

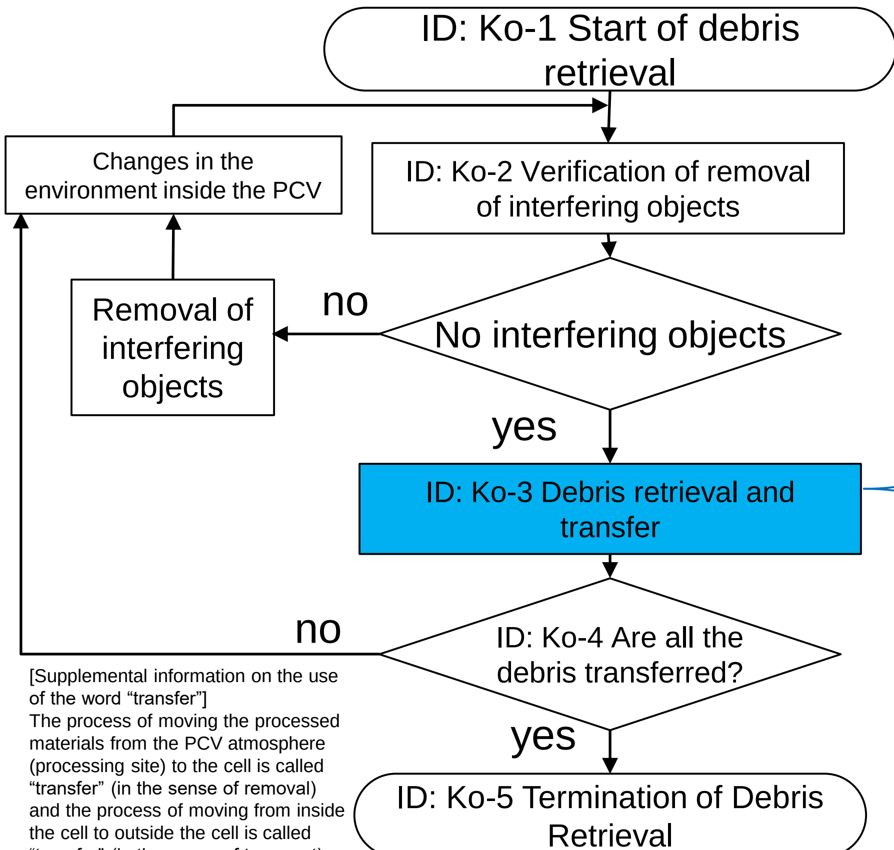
6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(a) Daily workflow

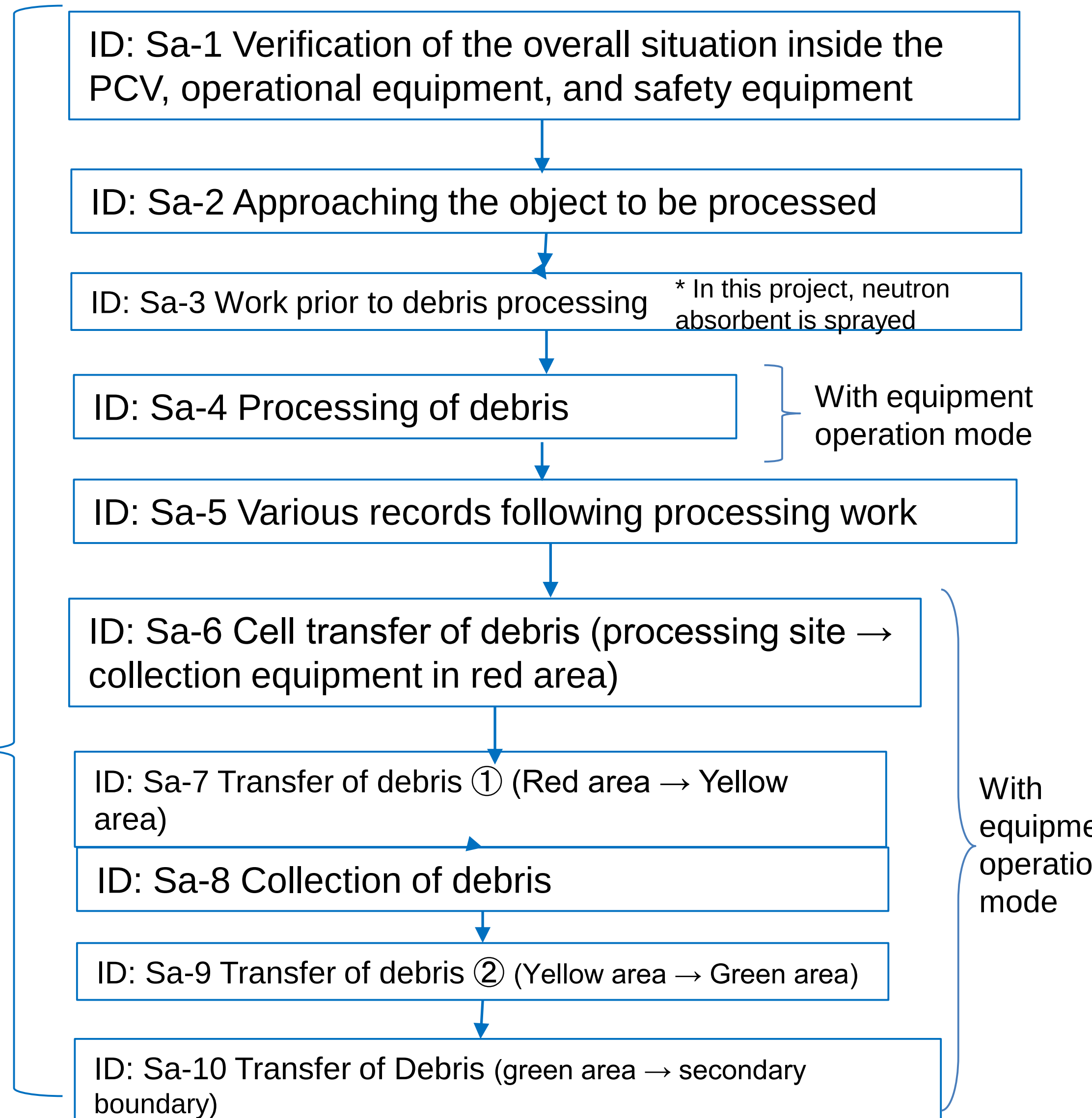
- Among the fuel debris retrieval and transfer processes, the fuel debris retrieval and transfer work were defined as within the scope of study for the continuous monitoring project.
- In this project, the important items inside the PCV are extracted in ID: Sa-1 to Sa-10.

Fuel debris retrieval and transfer processes



[Supplemental information on the use of the word "transfer"]
The process of moving the processed materials from the PCV atmosphere (processing site) to the cell is called "transfer" (in the sense of removal) and the process of moving from inside the cell to outside the cell is called "transfer" (in the sense of transport).

Daily workflow (target of study for continuous monitoring project)



6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(b) Equipment operation mode (fuel debris processing work)

■ Study policies

- As for “ID: Sa-4 Processing of debris” on the previous page, various processing methods have been studied in past the Fukushima Daiichi subsidized projects. Since the mechanism for work disturbing vary depending on the processing method, the settings for the operation mode will be adjusted accordingly.
- Specifically, when processing fuel debris, the operation mode is set from the perspectives of ① Where will the fuel debris be processed?, ② What properties does the fuel debris have?, ③ How is it processed?, and ④ What is used for collection?

[Fukushima Daiichi subsidized projects used to gather information]

- Advancement of Retrieval Method and System for Fuel Debris and Reactor Internals
→ Used to collect information for ① and ③ above
- Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals
→ Used to collect information for ① above
- Development of Technology for Fuel Debris Analysis and Characterization
→Used to collect information for ② above
- Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals
→ Used to collect information for ④ above

Aiming for versatile settings for the operation mode by collecting a wide range of information on other R&D projects

■ **Summary of study results / Equipment operation mode settings (1/2)**

- The results of the settings for ① to ④ on previous page are shown below. See Appendix 6.2.3.1-1 for the basis for these settings.
- Combine ① to ④ below for setting equipment operation modes. These combinations will refer to the details of the study regarding fuel debris processing procedures in the fuel debris retrieval project.

① Where is fuel debris processed?
(1) In air
(2) Underwater

② What properties does the fuel debris have?
(3) Nuclear fuel
(4) Existing structures (with surface contamination)
(5) U-rich mass of fuel debris
(6) Fe-rich mass of fuel debris
(7) MCCI formations
(8) Others

③ How is fuel debris processed?
(9) Crushing
(10) Cutting
(11) Chipping
(12) Picking up

④ What is used for collection?
(13) Inner containers and transfer casks

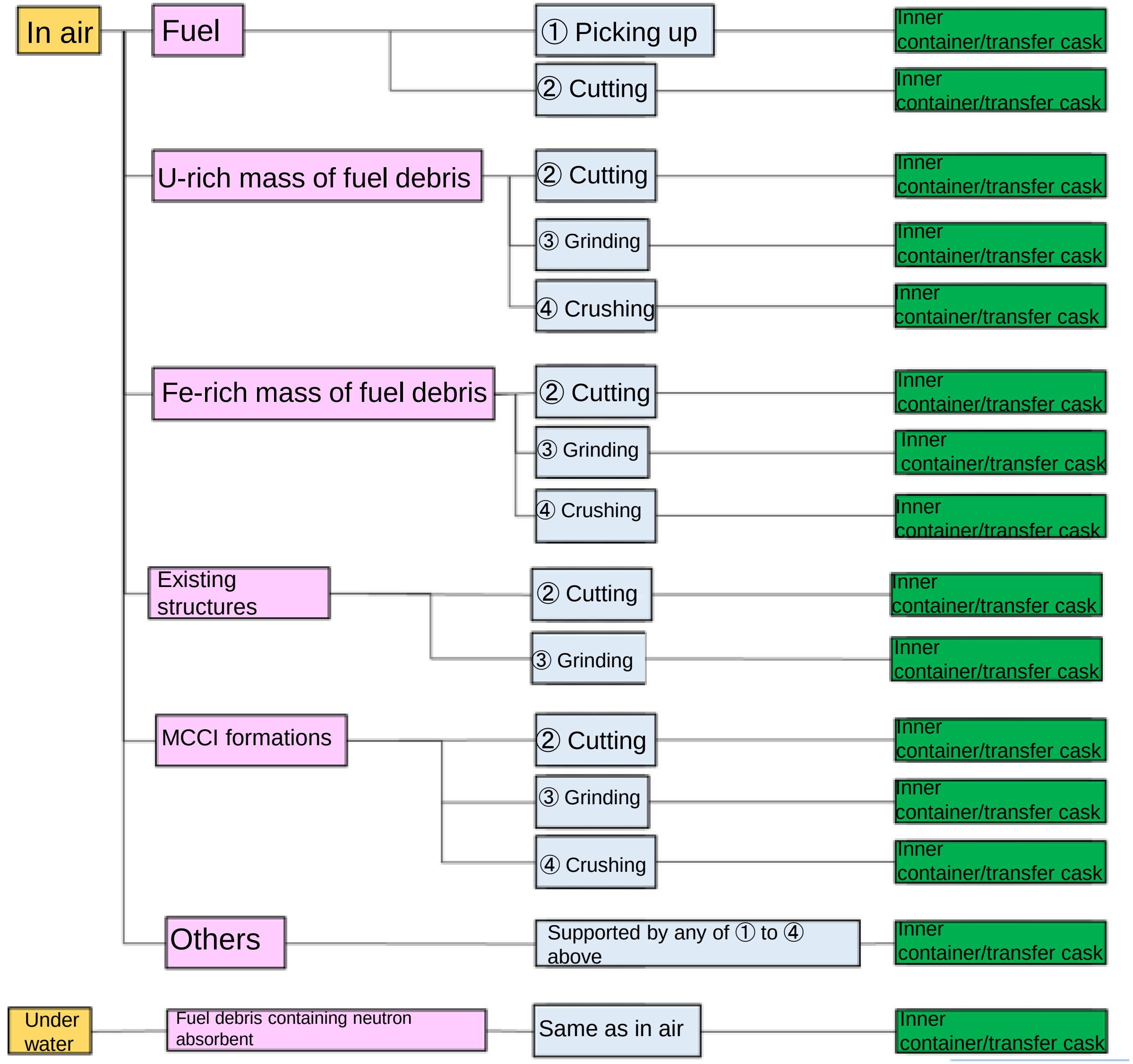
*Inner containers refer to unit cans and canisters

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(b) Equipment operation mode (fuel debris processing work)

■ **Summary of study results / Equipment operation mode settings (2/2)**

- A list of task modes during fuel debris processing is shown.
- There is a possibility that underwater processing work may be processed with the application of neutron absorbent as a prerequisite. Accordingly, since fuel debris change properties when it contains neutron absorbent, it was decided to take into account the figure on the right in the processing mode.
- Since the method of debris processing and the container in which the debris is collected underwater is no different from that in air, the description is omitted in this figure.



■ Study policies

- For “ID: Sa-6 to Sa-10” in No. 28, various fuel debris transfer methods have been studied in the past the Fukushima Daiichi subsidized projects. The operation mode is set by referencing this.
- Specifically, the equipment operation is set up to realize the procedure for transfer from the primary boundary shown in No. 21.

[Prerequisites for settings]

- Negative pressure maintenance equipment inside the PCV and cell is reflected in the safety equipment model.
- When transferring transfer casks outside the primary boundary, verify that they meet the on-site transfer criteria (surface contamination/surface dose rate) for the Fukushima Daiichi. If they do not meet the criteria, decontaminate or return the casks to cell (Y). In addition, the legally required verification inspection of on-site transfer criteria for the Fukushima Daiichi must be conducted at the secondary boundary.
- The decontamination site of the transfer casks is assumed to be cell (G) (*).

* Depending on the operational circumstances of the transfer casks in the cell, decontamination sites may be more reasonable in the cell (Y).

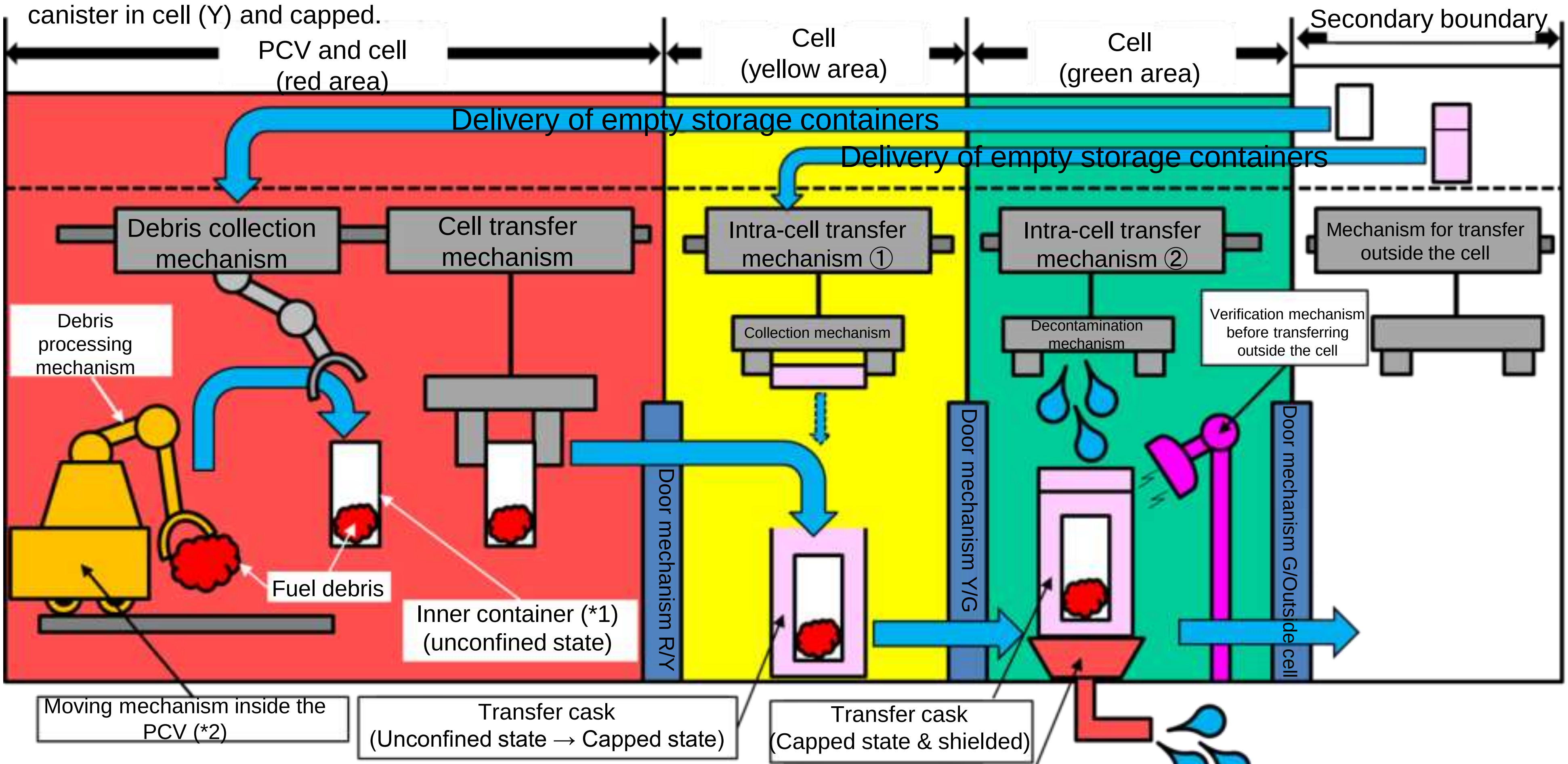
Information on the outcome of past subsidized projects for the Fukushima Daiichi will be gathered to setup the equipment operation modes

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(c) Equipment operation mode (fuel debris collection and transfer work)

- The compositional elements of the equipment that transfer fuel debris outside the primary boundary are organized as shown in the figure below. See Appendix 6.2.3.1-2 for environmental conditions in the cell.
- The inner container directly containing the fuel debris is used in the PCV and cell (R), and the fuel debris is collected into a sealed canister in cell (Y) and capped.



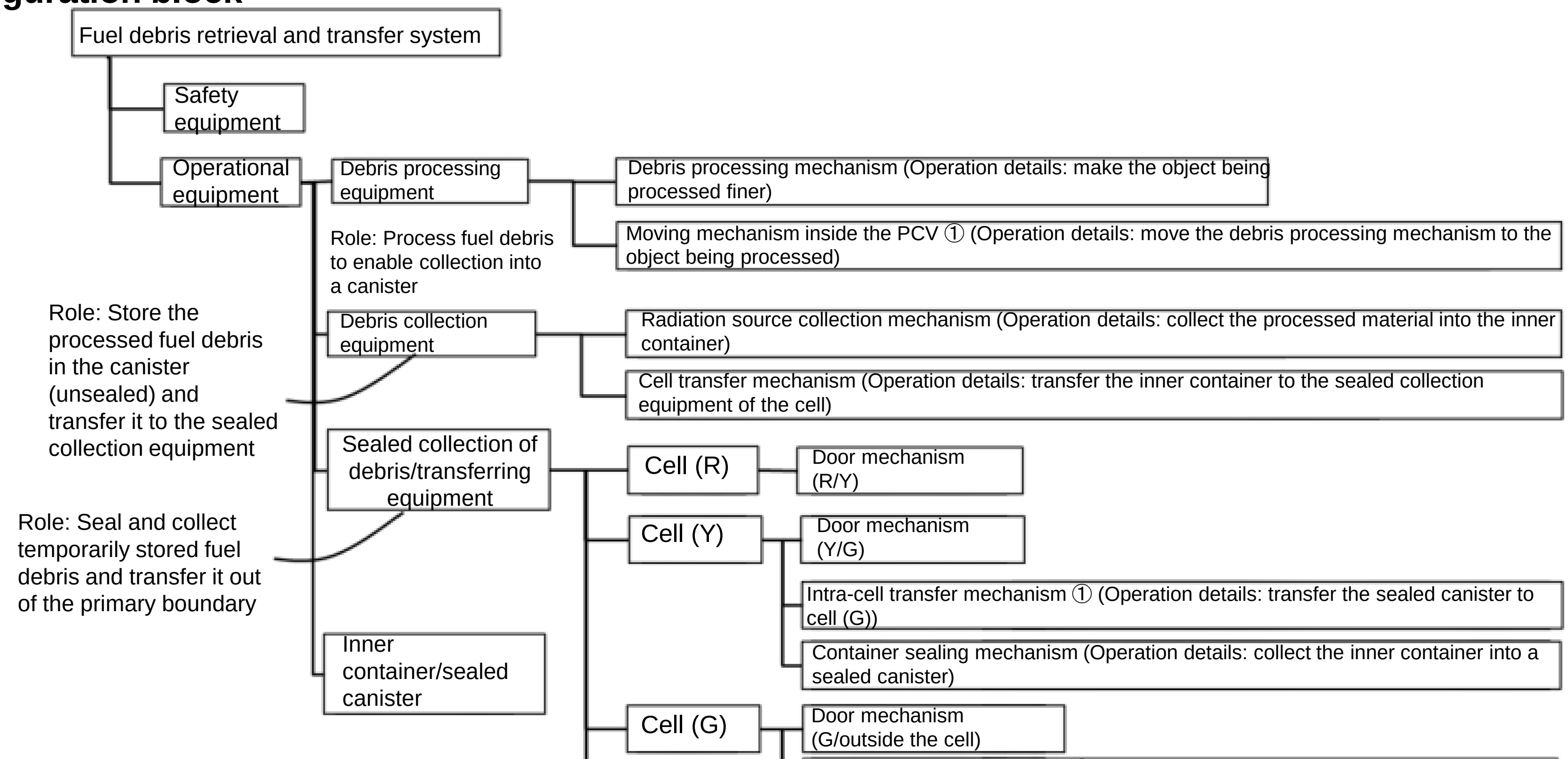
*1 Refers to unit cans and canisters

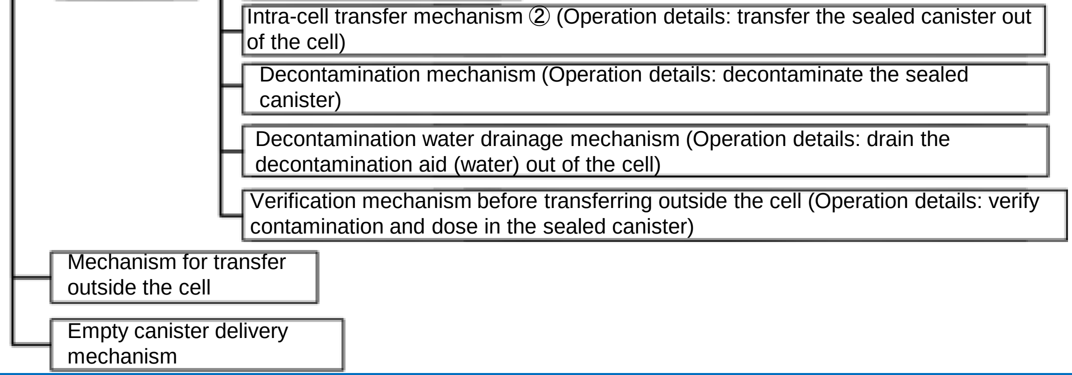
*2 Components involved other than fuel debris are transcribed as “Moving.”

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(d) Equipment configuration block





- A block diagram of the equipment configuration that executes each mode of operation and daily workflow is shown.
- Each equipment shown in this figure has one or both of the operational and safety functions.

This block diagram depicts the connection between equipment, but it is also necessary to connect the equipment to their functions (safety and operational). Defined on the next page and beyond

6. Implementation details

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model

(e) Table of operational functions

- Setup the operational functions of each equipment shown on the previous page. If operational functions are disturbed, it will cause work delays.
- As shown in the table below and on the next page, "moving function inside the PCV," "fuel debris processing function," "fuel debris collection function," "fuel debris packaging function," "fuel debris transfer function," and "empty container delivery function" are classified into six categories.

Table. Debris Retrieval Model Launch Equipment: Table of Operational Functions (1/2)

ID	Functional requirements	Configuration of components	Design requirements
1	Moving function inside the PCV	Moving mechanism inside the PCV	Equipment with fuel debris processing function must be moved in and out of the RPV and the pedestal.
2	Fuel debris processing function	Debris processing mechanism (cutting)	- Fuel debris must be processed so that it can be appropriately collected into the inner container and transfer cask. - Visual confirmation is needed during processing.
3		Debris processing mechanism (chipping)	Same as above
4		Debris processing mechanism (crushing)	Same as above
5		Debris processing mechanism (picking up)	Same as above
6	Fuel debris collection function	Inner container(*), transfer cask	Fuel debris must be collected and transferred out of the primary boundary. (*) Inner container is defined in this project as a general term for unit cans and canisters studied in the Fukushima Daiichi subsidized projects.
7		Radiation source collection mechanism	Fuel debris must be collected in the inner container.
8		Cell transfer mechanism	The inner container must be moved from the fuel debris processing site to cell (R).
9		Cell (R)	There must be a working environment to receive the inner container from the cell transfer mechanism.

6. Implementation details
6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV
6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model
(e) Table of operational functions

Table. Debris Retrieval Model Launch Equipment: Table of Operational Functions (2/2)

ID	Functional requirements	Configuration of components	Design requirements
10	Fuel debris packaging function	Cell (Y)	- There must be a place to receive the inner container from cell (R). - There must be a working environment for collecting the inner container into the transfer cask.
11		Door mechanism (R/Y)	The inner container must have passage from cell (R) to cell (Y).
12		Intra-cell transfer mechanism ①	The inner container must be transferred from cell (R) to cell (Y).
13		Collection mechanism	The inner container must be collected into the transfer cask (lid closing).
14	Fuel debris transfer function	Cell (G)	- There must be a working environment to receive the transfer cask closed by lid from cell (Y). - There must be a working environment for inspection and decontamination necessary for the transfer to the secondary boundary.
15		Door mechanism (Y/G)	The transfer cask must have passage from cell (Y) to cell (G).
16		Intra-cell transfer mechanism ②	The transfer cask must be transferred from cell (Y) to cell (G).
17		Mechanism for transfer outside the cell	The transfer cask must be transferred from cell (G) to the secondary boundary.
18	Empty container delivery function	Empty container delivery mechanism	Empty inner containers and transfer casks must be supplied into the cell or PCV atmosphere.

■ Reference for the Fukushima Daiichi nuclear safety and safety requirements

- In the Fukushima Daiichi subsidized project "Upgrading of Retrieval Method and System for Fuel Debris and Reactor Internals," nuclear safety and safety requirements were established based on the circumstances unique to the Fukushima Daiichi. Furthermore, in the Fukushima Daiichi subsidized project "Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals," safety requirements were established with a focus on fuel debris processing.

- The above knowledge will also be utilized in this continuous monitoring project. Safety requirements for retrieving and transferring fuel debris must be shared between operational equipment and safety equipment.

- The result of the sharing is shown on the next page.

■ Assignment of nuclear safety requirements (1/2)

Nuclear safety		General safety rules (What should be accomplished)		Basic safety requirements	Requirements as a safety function (What should be maintained): (When) At what timings do the requests occur?	Requirements as a safety function (What should be maintained): (How) What are the requirements involving specific measures?	(Who) Which systems will respond?
Protection of people and the environment from radiation risks	Protection of the public and the environment from radiation risks	Prevention of excessive discharge of radioactive materials	Confinement of radioactive substances	Confinement of radioactive materials using boundaries	[During environmental control inside the PCV] Gas phase confinement	Dust concentration reduction function	Gas phase system
						Static boundary function	Gas phase system
						Dynamic boundary function	Gas phase system
						Discharge control function	Gas phase system
					[During environmental control inside the PCV] Liquid phase confinement	Static boundary function	Gas phase system
						Dynamic boundary function	Liquid phase system
					[During Processing] Gas phase confinement	PCV/cell damage prevention function	Fuel debris retrieval system
						Dust dispersion prevention function	Fuel debris retrieval system
						Static boundary function	Fuel debris transfer system
					[During Transportation] Gas phase confinement inside the primary boundary (fuel debris collection/transfer area)	Static boundary function	Fuel debris transfer system
						Dynamic boundary function	Gas phase system
						PCV/cell damage prevention function	Fuel debris transfer system
					[During Transportation] Liquid phase confinement during transfer cask decontamination (water decontamination)	Contaminated water dispersion prevention function	Fuel debris transfer system
					[During transportation] Confinement of gas/liquid phase leakage during on-site transfer	Transfer cask confinement function	Fuel debris transfer system
				Prevention of additional nuclear fission reactions (Re-criticality due to abnormal deformation)	[During environmental control inside the PCV] Criticality prevention	Criticality prevention function	Liquid phase system
					[During processing] Criticality prevention	Fuel debris shape control function	Fuel debris retrieval system
					[During Transportation] Criticality prevention	Fuel debris shape maintenance function	Fuel debris transfer system
						Debris shape maintenance function of transfer cask	Fuel debris transfer system

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model (f) Table of safety functions

- Refer to Appendix 6.2.3.1-3 for the results of the allocation of components related to operational equipment responsible for safety functions

■ Assignment of nuclear safety requirements (2/2)

Nuclear safety		General safety rules (What should be accomplished)		Basic safety requirements	Requirements as a safety function (What should be maintained) (When) At what timings do the requests occur?	(How) What are the requirements involving specific measures?	(Who) Which systems will respond?
Protection of people and the environment from radiation risks	Protection of the public and the environment from radiation risks	Prevention of excessive discharge of radioactive materials	Confinement of radioactive substances	Prevention of abnormal heatup of fuel debris (Revolatilization of radioactive materials due to temperature rise)	[During environmental control inside the PCV] Prevention of abnormal heatup	Fuel debris cooling function	Liquid phase system/Re-circulating cooling system
					[During processing] Prevention of abnormal heatup	Function to prevent excessive heatup of fuel debris	Fuel debris retrieval system
					[During Transportation] Prevention of abnormal heatup	Heat removal function of transfer cask	Fuel debris retrieval system
			Prevention of excessive radiation exposure	Protection against external exposure	[During processing] External exposure prevention function	Shielding function of the cell	Fuel debris retrieval system/Fuel debris transfer system
		Protection against radiation from inside the reactor Protection against radiation from radioactive materials during transportation			[During Transportation] External exposure protection function	Shielding function of transfer cask	Fuel debris transfer system
	Protection of workers from radiation risks	Prevention of excessive radiation exposure and internal exposure of workers - Radiation exposure associated with fuel debris retrieval/transfer-related work - Exposure of on-site workers other than those related to fuel debris retrieval/transfer		Design for dose reduction of workers	[During Transportation] Appropriate shielding, contamination and dose classifications to reduce exposure with remote maintenance and fuel debris on-site transfer lines must be established	Transfer cask decontamination function	Fuel debris transfer system
				Operational control for dose reduction of workers	The operation method, maintenance plan, and task management must be designed for dose reduction.		Entire system
	Protection of people and the environment from the Fukushima Daiichi-specific risks	Prevention of fires and explosions [1] due to retained hydrogen [1] Hereafter abbreviated as fire and explosion.		Control of hydrogen concentration or oxygen concentration to maintain the lower limit of hydrogen explosion .	[During environmental control inside the PCV] Prevention of fire and explosion	Oxygen concentration reduction function	Gas phase system
					[During Transportation] Prevention of fire and explosion inside the primary boundary (fuel debris collection/transfer area)	Fire and explosion prevention function of the cell	Gas phase system
					[During Transportation] Prevention of fire and explosion during on-site transfer	Fire and explosion prevention function for transfer cask	Fuel debris transfer system

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(a) Overview of study policies and model

■ **Study policies**

- In this project, in order to evaluate the process leading to deviation from the expected safety conditions and the normal conditions of the fuel debris retrieval operations, deviation from the normal conditions are defined as conditions in which safety functions have been or may be adversely affected. A safety equipment model is established to identify disturbances that may lead to deviation from the normal conditions.

- In the above evaluation, out of the fuel debris retrieval/transfer operations (disturbances) assumed in the operational equipment model, the operations that affect the safety functions configured to achieve each safety requirement are determined to be risks, and the risks are extracted.

- Therefore, the basic configuration of the safety equipment model consists of each safety requirement and each safety function to achieve it.

The safety equipment model must be established to extract operational risks that affect the safety function.

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(a) Overview of study policies and model

■ Overview of the model (1/2)

- Since the safety function is defined as the role of each part in the system, fuel debris retrieval operations that affect each safety function are studied. To that end, the following environmental variables (physical quantities) inside the PCV and system design are both defined as elements that realize safety functions.

  ① Environmental variables (physical quantities) inside the PCV for the conditions to be achieved by the safety functions
  ② System design as a means to achieve the safety functions (countermeasures)

- The environmental variables (physical quantities) inside the PCV and the system design are the specific objects that affect the safety functions for the operations (disturbances) assumed in the operational equipment model. The system design referred to here refers to equipment and design conditions that constitute the safety functions.

- In addition, there is a correlation between the design values and design conditions of the equipment that constitutes the safety functions among the environmental variables (physical quantities) inside the PCV and the system design. This is modeled (physical model of the environment inside the PCV) and used to determine the transient effects of the disturbances from the operational equipment model.

The methods of realizing the safety functions are “environmental variables inside the PCV” and “system design”

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(a) Overview of study policies and model

■ Overview of the model (2/2)

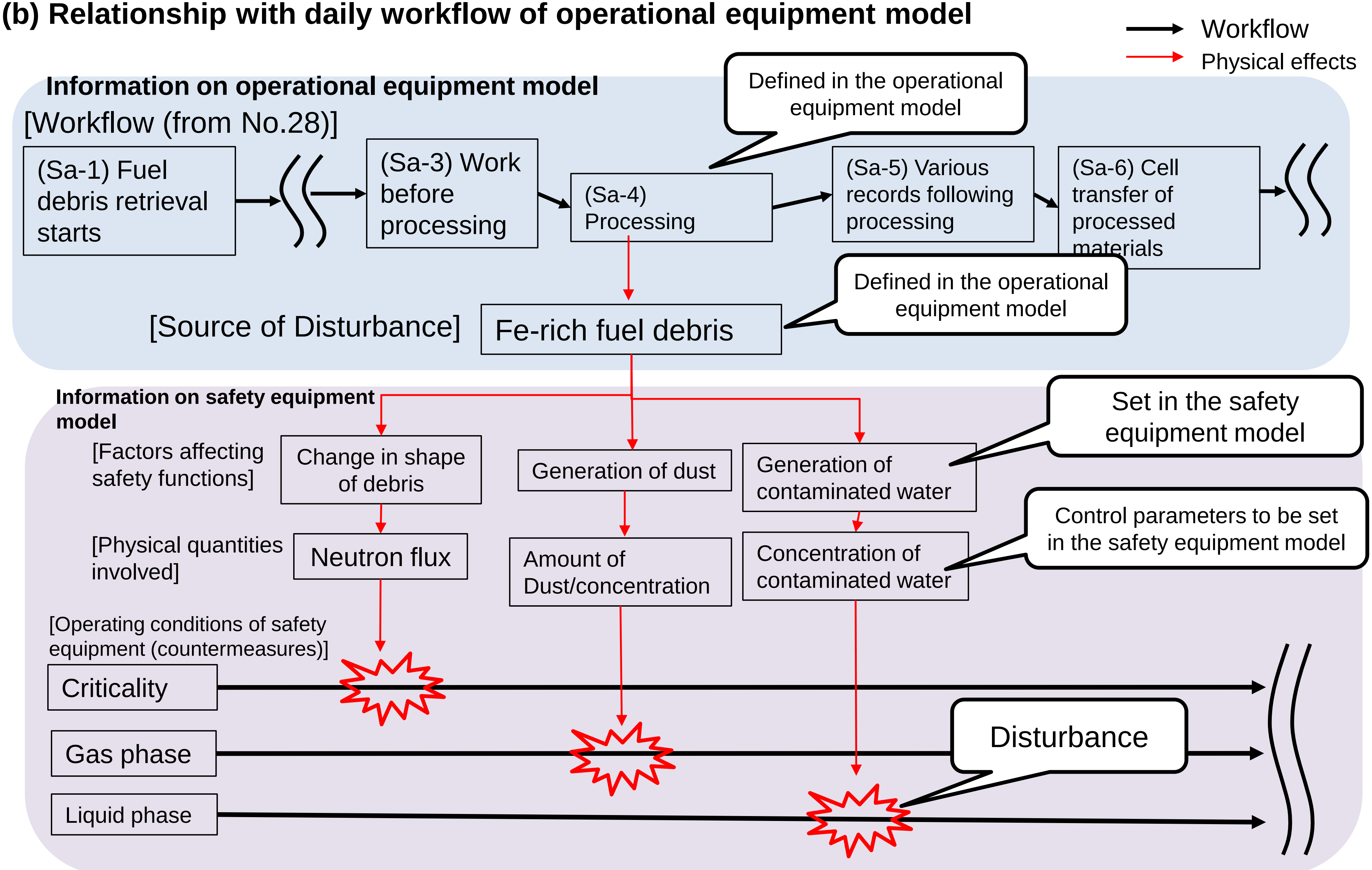
- It is assumed that the operating conditions of the safety equipment model assumed for each workflow (see next page) will be different.
- Therefore, in order to extract the disturbances by the operational equipment model, safety functions to achieve each safety requirement and the proposed countermeasures to achieve the safety functions are organized for each workflow.
- In this project, it is important to establish a process to extract disturbances that affect safety functions, and it is assumed that there may be multiple candidates for countermeasure proposals to achieve safety functions that take the method and the on-site environment between units into consideration. Based on the results of the subsidized projects up to the previous fiscal year, one countermeasure will be selected to conduct the study in this project.

The safety functions that constitute the safety equipment model for each workflow must be defined to set the operating conditions of the safety system.

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(b) Relationship with daily workflow of operational equipment model

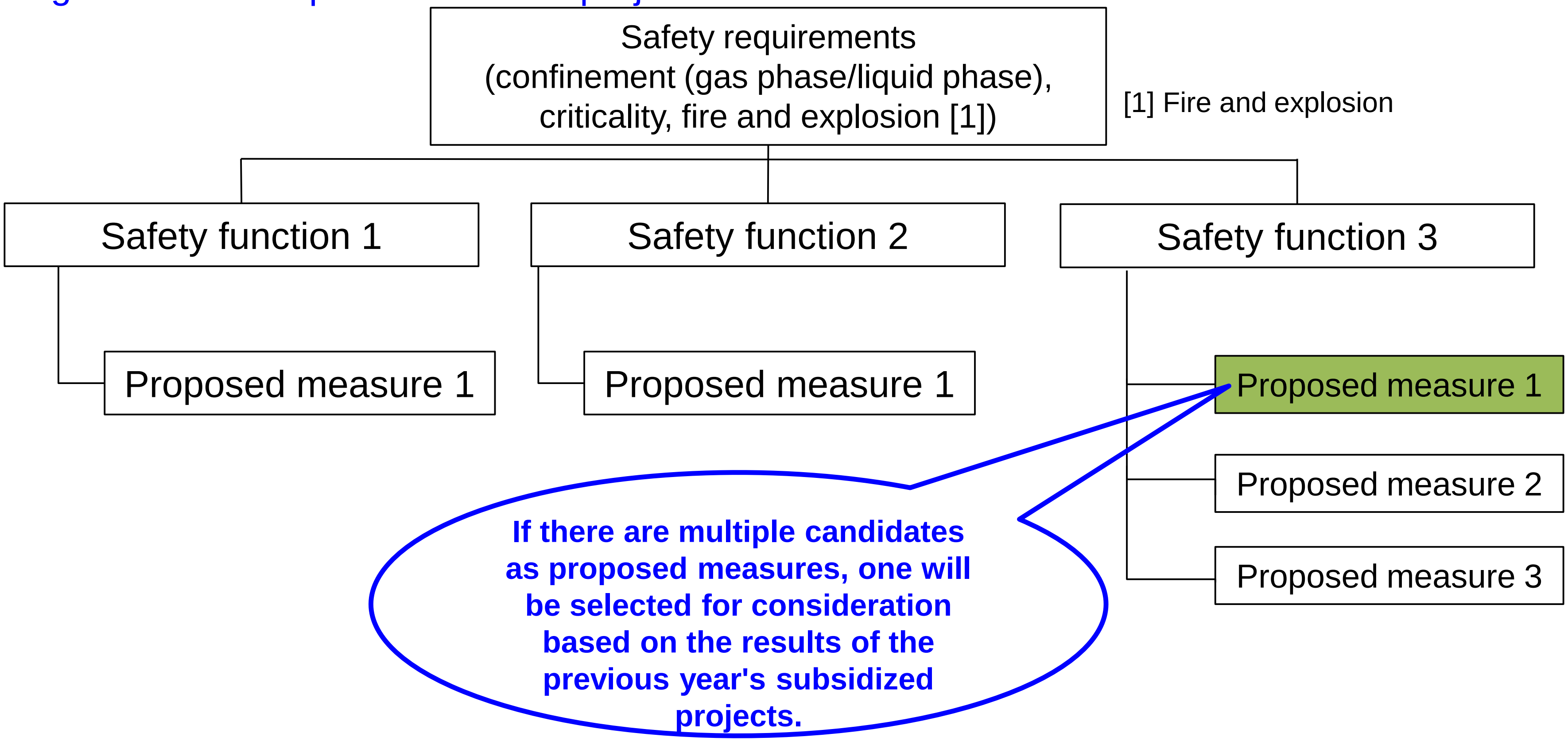


6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(c) Definition of safety functions for operational equipment activities;

- When extracting important monitoring items, the system configuration with safety requirements and safety functions are defined based on the safety requirements shown in No. 38 and 39.
- If multiple system configurations with a single safety function can be identified when considering the normal operational policies and the diversity of equipment that ensures the safety functions, not all of them will be included, but those most likely to become the main proposal in the future will be selected using the results of past subsidized projects as reference.

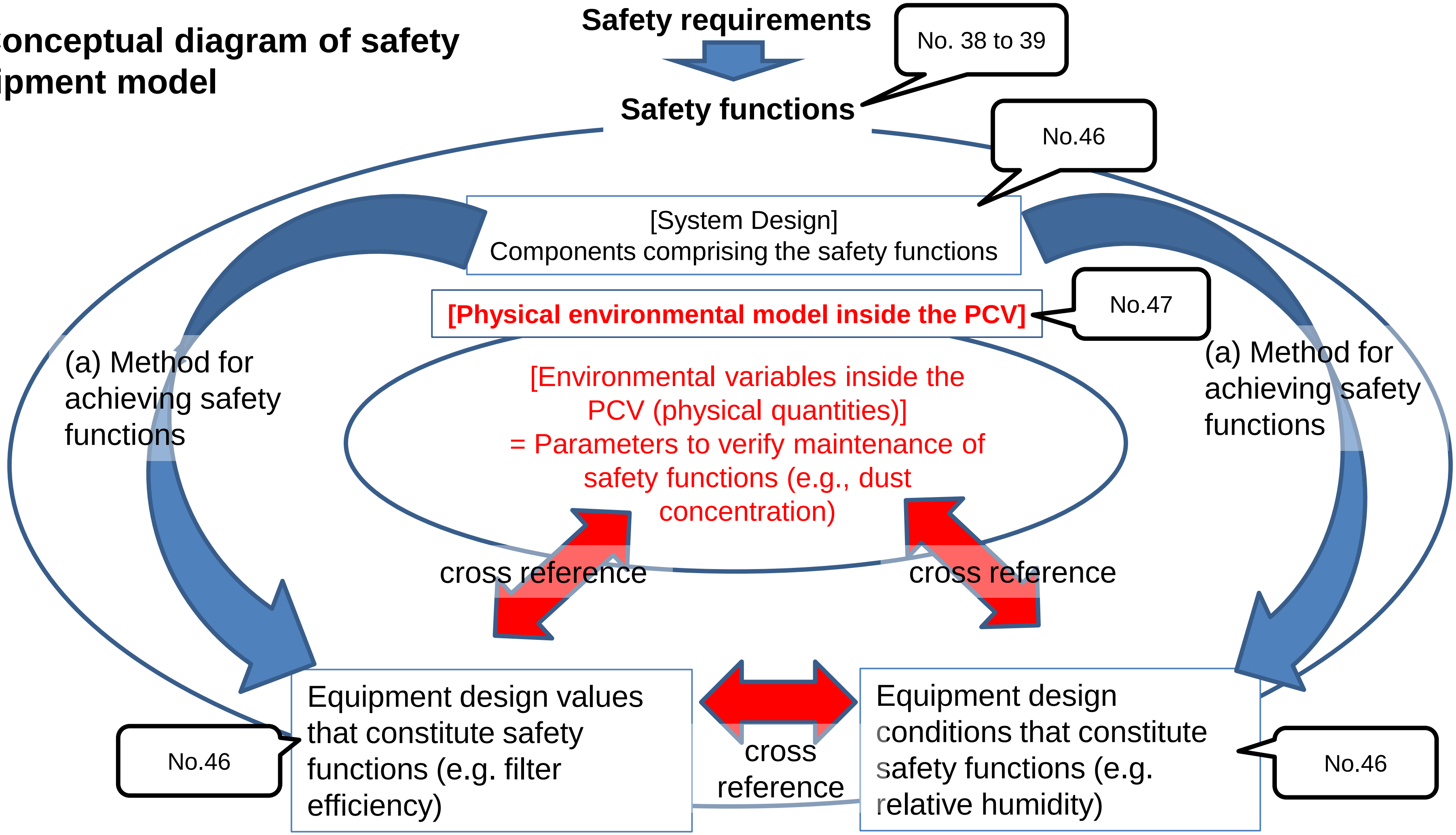


6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(d) Model Configuration

■ **Conceptual diagram of safety equipment model**



The physical environmental model inside the PCV is defined as the correlation between the environmental variables inside the PCV and the design conditions

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.2 Study of the safety equipment model

(d) Model Configuration

Note: The system configuration of the safety equipment was based on preliminary engineering information provided by Tokyo Electric Power Company Holdings, Inc. The information provided is tentative at this time and has not been finalized. In addition, there are multiple candidates for the system configuration of safety equipment, and one of them was selected as a representative case for this project.

■ System design

- A gas-phase system is shown as a typical example for design values and design conditions* for equipment and components comprising the safety functions required for the system design. The same settings were used for other liquid phase/liquid phase criticality/cooldown as well.

* Design conditions are conditions for maintaining design values

Functional requirements	Configuration of components	Design value	Design conditions(*)	Control parameters
Reduction of dust concentration	HEPA filter	Filter efficiency: 99.999%	HEPA filter inlet relative humidity: 99% or less	Dust concentration inside the PCV
	Exhauster	Airflow: 3000 m^3/h	In-leakage volume: 1000 m^3/h Nitrogen-charged amount: 1000 m^3/h Recirculation airflow: 1000 m^3 /h	
Static boundary	PCV (Primary Boundary)	Size of the opening with less than 1000 m^3/h in-leakage volume at differential pressure of 400 Pa	Primary boundary leakage volume: Opening with in-leakage volume of 1000 m^3/h or less at differential pressure of 400 Pa	Differential pressure between inside and outside of the PCV
Dynamic boundary	HEPA filter	Filter differential pressure: approximately several hundred Pa	HEPA filter inlet relative humidity: 99% or less	Differential pressure between inside and outside of the PCV
	Exhaust fan	Airflow: 3000 m^3/h	PCV negative pressure degree: 100 Pa	
Discharge control	HEPA filter	Filter efficiency: 99.999%	HEPA filter inlet relative humidity: 99% or less	Exhaust end dust concentration

(d) Model Configuration

■ Physical environmental model inside the PCV

The physical environmental model inside the PCV is broadly classified into the following two patterns.
See Appendix 6.2.3.2-1 for specific examples of expressions for each pattern

(Pattern A)
The PCV environmental model expresses the correlation between the design values and design conditions of the components that constitutes the safety functions and the PCV environment variables (physical quantities) (=control parameters) using mathematical formulas. Operations that affect this correlation are extracted as risks out of the disturbances in fuel debris retrieval operations.

(Pattern B)
Pattern A is the basic pattern, but if it is difficult to express by a mathematical formula, factors that have an adverse effect on environmental variables (physical quantities) (= control parameters) inside the PCV are organized, and operations that advance these factors are extracted as risks out of the disturbances in the fuel debris retrieval operations.

The environmental model inside the PCV is expressed by mathematical formulas. If it is difficult to do so, the factors that adversely affect the control parameters are listed by qualitative expressions

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.3 Study of the debris retrieval model 6.2.3.3 Creation of the debris retrieval model

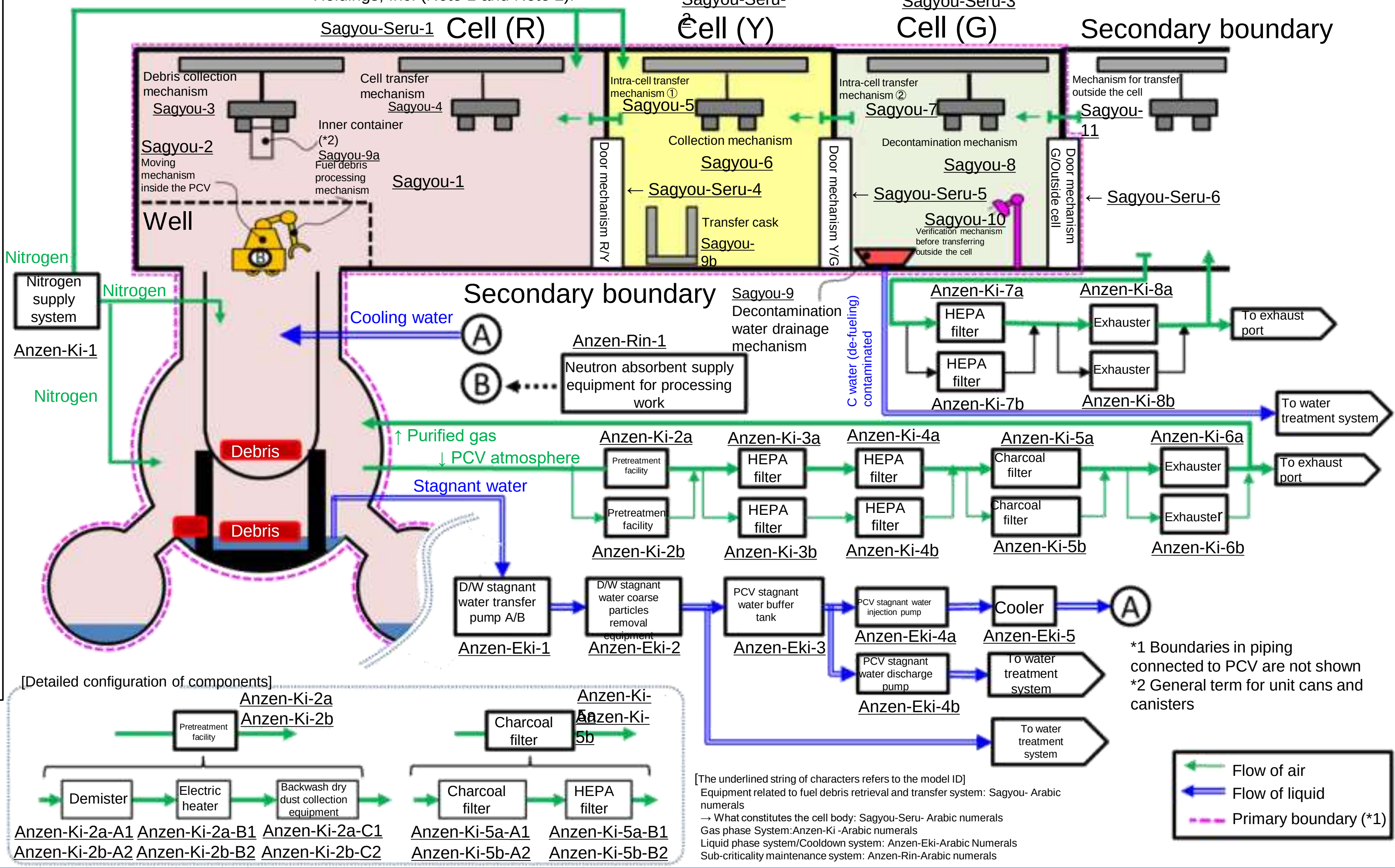
(a) Equipment layout diagram

- Equipment layout diagram was established based on the settings information of the operational equipment model and the safety equipment model.
- The system configuration for the safety equipment was established based on the design information provided by the TEPCO Holdings, Inc. (Note 1 and Note 2).

Note 1
- The design information provided is tentative at this time and not definitive information.
- There are multiple candidates for system configuration of the safety system, and one of them was selected out of these as the representative case in this project.

Note 2
This model is associated with the top-extraction method for convenience of expression, but the side-extraction method is also a target of study. The actual evaluation is based on the conditions common to both methods.

See Appendix 6.2.3.3-1 for the environmental conditions inside the PCV.

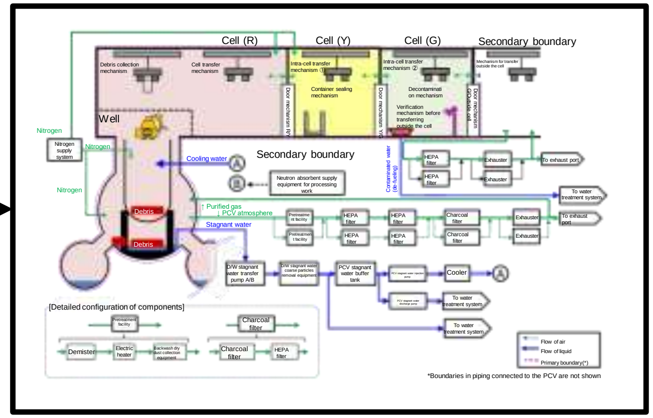


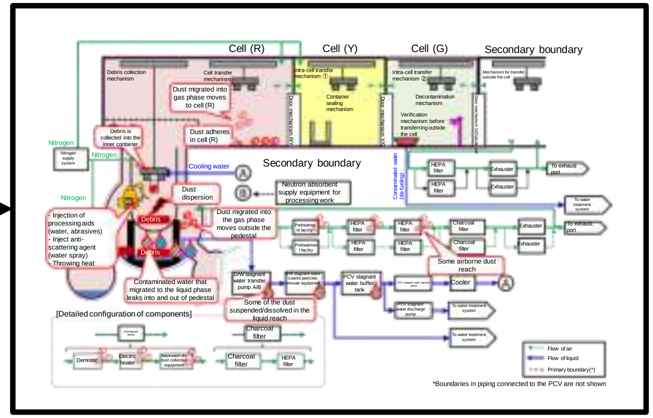
Important monitoring items are expressed as physical quantities and detection conditions for detecting work delay factors (=errors) that occur in any of the following components

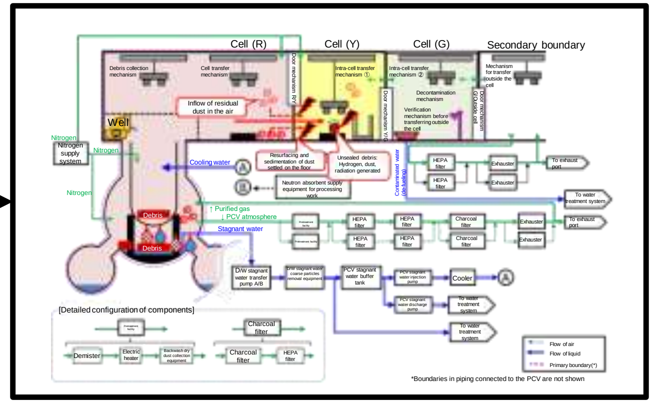
6.2.3 Study of the debris retrieval model 6.2.3.3 Creation of the debris retrieval model (b) Roadmap of environmental changes inside the PCV

The “daily workflow” is applied to the equipment layout diagram shown on the previous page to predict transitional changes in the environment inside the PCV due to the activities of the operational equipment by utilizing the roadmap method.

- ID: Sa-1 Verification of the overall situation inside the PCV, operational equipment, and safety equipment
- ID: Sa-2 Approaching the object to be processed
- ID: Sa-3 Work prior to debris processing (Spraying neutron absorbent on submerged debris)
- ID: Sa-4 Processing of debris
- ID: Sa-5 Various records following processing work
- ID: Sa-6 Cell transfer of debris (Processing site → collection equipment in the red area)
- ID: Sa-7 Transfer of debris ① (Red area → Yellow area)
- ID: Sa-8 Collection of debris
- ID: Sa-9 Transfer of debris ② (Yellow area → Green area)
- ID: Sa-10 Transfer of Debris (green area → secondary boundary)







*This page shows three transient changes as examples, but in the actual study, all task items are charted. See Appendix 6.2.3.3.-2 and 6.2.3.3-3.

A change in the environment inside the PCV becomes a disturbance to the safety equipment. Specific disturbance details are set on the next page

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.4 Risk assessment 6.2.4.1 Settings for environmental changes inside the PCV due to operational equipment

(a) Study policies

See Appendix 6.2.4.1-1 for detailed flow of the study

■ **Candidates for physical quantities that cause disturbances to safety equipment**

Investigation item ① : Dust properties during processing (particle size, mass balance)
Investigation item ② : Amount of processing aid, anti-scattering agent, and heat energy input during processing
Investigation item ③ : Amount of neutron absorbent injected during processing and properties of foreign matter (particle size) during processing
Investigation item ④ : Operational parameters of the jig during processing (e.g., cutter rotation speed, blade thickness, etc.)
Investigation item ⑤ : Dust properties during transfer (particle size, mass balance)
Investigation item ⑥ : Amount of hydrogen generated from fuel debris during transfer
Investigation item ⑦ : Amount of water used during decontamination

■ **Subject of investigation (IRID project)**

- FY2018 Subsidized Project “Development of Technology for Dust Collection System of Fuel Debris”
- FY2014, 2015, and 2017 Subsidized Project “Development of Technology for Investigation inside the Reactor Pressure Vessel (RPV)”
- FY2014 Subsidized Project “Development of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals”
- FY2016 Subsidized Project “Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals”
- FY2018 Subsidized Project “Development of Technology for Retrieval of Fuel Debris and Reactor Internals”

■ **Subject of investigation (supplementing lack of data in the IRID project)**

- FY2006 Ministry of Economy, Trade and Industry commissioned investigation “Technical Investigation on Impact Assessment of Decommissioning Works for Nuclear Power Reactors (Study on Environmental Impact Assessment Parameters),” Appendix: Handbook on Environmental Impact Assessment for Decommissioning Work (third edition), Central Research Institute of Electric Power Industry, March 2007
- METI, Decontamination Technology Catalogue https://www.meti.go.jp/earthquake/nuclear/pdf/120626/120626_01j.pdf (URL validity verification date: 2022.8.3)

Investigation of physical quantities that can possibly cause disturbances to safety equipment

6.2.4 Risk assessment 6.2.4.1 Settings for environmental changes inside the PCV due to operational equipment

- See Appendix 6.2.4.1-2 for the method used to estimate total amount of dust generated and a table of other changes
- See Appendix 6.2.4.1-3 for impact assessment results of static environmental changes for the PCV

(b) Settings for environmental changes inside the PCV

■ Table of environmental changes inside the PCV (typical example)

Fuel debris type	Assumed properties			Assumed processing methods				Particle size of dust			
	Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing	
	$[g/cm^3]$	[MPa]						---	[μm]	---	[μm]
Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than above mentioned: 230	[U Rich] (U, Zr)O2-C, (Zr, U)O2-T, [Fe Rich] UO2, Fe, Zry-2, α-Zr(O), SUS/Fe, Fe2(Zr, U), ZrB2, Fe2B, Zr(O), Fe2Zr	Pedestal inside the PCV (floor/inside/outside) drywell	Cutting	Disc cutter	Blade diameter: 200 mm Blade thickness: 1 mm Number of revolutions: 1000 rpm	Airborne	All in range of peak particle size 2 to 3 (mass concentration distribution) 0.1 to 0.3 (number concentration distribution)	Airborne	Unknown
								Sedimentation	All in median diameter 0.3 (number distribution) 7.9 (sediment distribution)	Sedimentation	Above 50
								Peripheral dispersion	Either airborne/sedimentation	Floating in water	50 or less

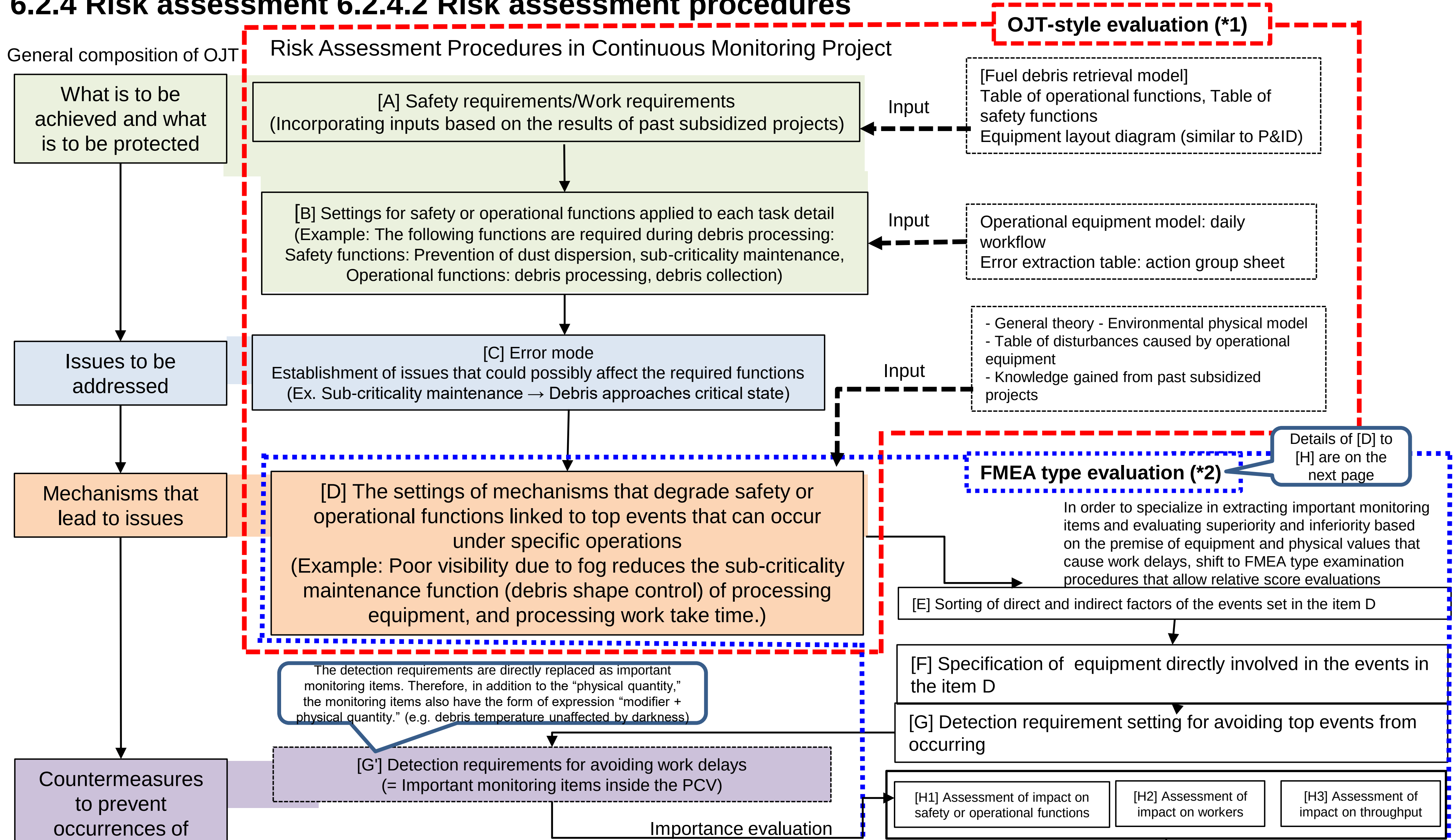
Total amount of dust generated		Mass balance and amount of dust migration						Amount of processing aid injected		Amount of anti-scattering agent injected (Only for aerial processing)	
		Aerial processing			Underwater processing						
Aerial processing	Underwater processing	Mass balance		Amount of dust migration	Mass balance		Amount of dust migration				
[g]	[g]	---	[%]	[g]	---	[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input
1242.1	1242	Airborne	4	49.7	Airborne	2E-05	0.0	[Aerial processing] Water: 1 L/min	198 L ↑ (*)	Mist: 0.05 L/min	9.9 L ↑ (*)
		Sedimentation	37	459.6	Sedimentation	99.5	1235.9				
		Peripheral dispersion	59	732.9	Floating in water	0.5	6.2				

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

This information is used as a candidate for disturbance to safety equipment (especially the area indicated by the red dashed line) in the risk assessment

6. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV
6.2.4 Risk assessment 6.2.4.2 Risk assessment procedures

- Important monitoring items were extracted from OJT-style methods (top-down) and FEMA-style methods (bottom-up).



*1: OJT is conventionally a safety assessment method for nuclear safety measures developed for each defense in depth level 1 to 3, but in this project, it will be utilized irregularly in order to focus on normal work.
*2: Although FMEA is a design method for predicting failures of compositional elements (equipment) and evaluating their causes and effects, in this project, it is utilized irregularly to identify detection requirements based on the component of interest /cause and effect of the error.

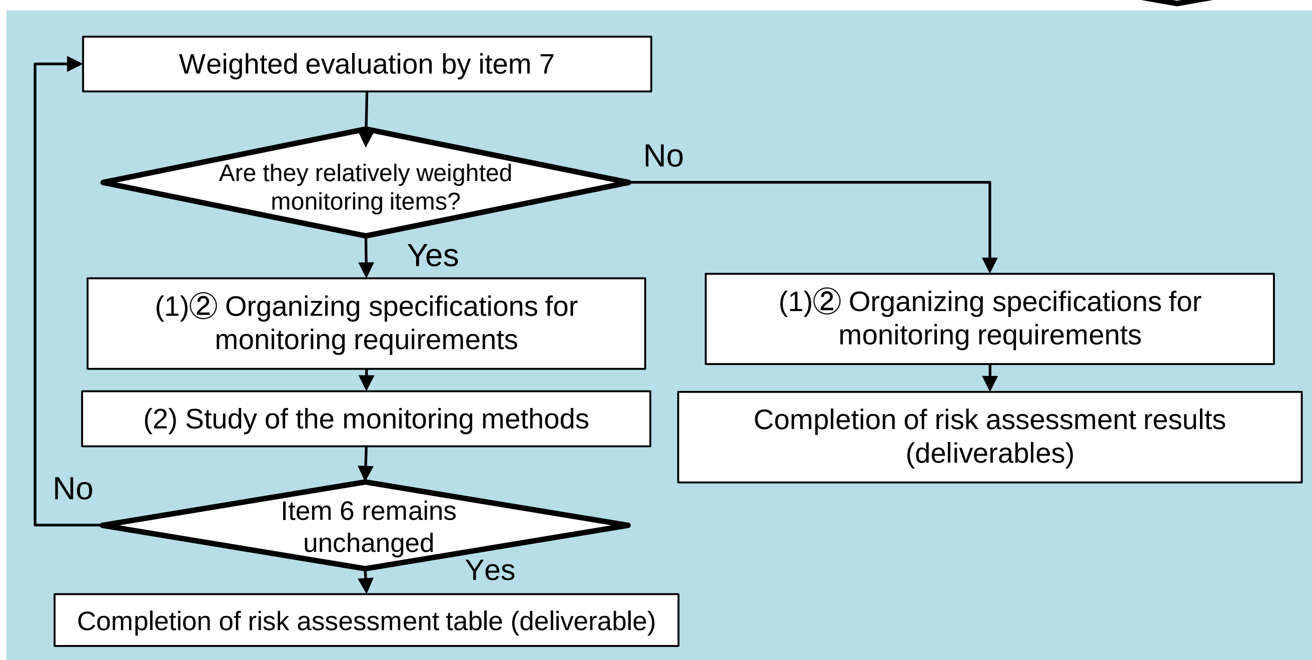
6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.4 Risk assessment 6.2.4.2 Risk assessment procedures

■ Input of weightings in the risk assessment table (1/4)

- The FMEA type evaluation shown on the previous page is presented as a risk assessment table shown on the right.
- Item [H] (weighted evaluation) on the previous page is entered in item 7 in the table. Details are shown on the next page.
- Weighting is decided after verifying the validity as shown in the flow in the lower right figure.

Item [F] on the previous page		Item [D] on the previous page	Item [E] on the previous page	Item [E] on the previous page	Item [G] on the previous page	Item [H] on the previous page
Item 1	Item 2	Item3	Item 4	Item 5	Item 6	Item 7
Target equipment	Safety functions or operational functions the target function is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Evaluation perspectives in continuous monitoring project
HEPA filter	Reduction of dust concentration	Acceleration of the deterioration of dust concentration reduction function inside the PCV	The effective flow path area of the HEPA filter is reduced and the filter performance cannot be maintained	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	Filter differential pressure	Details of the evaluation are explained on the next page



Validation of the weighted evaluation is performed in action items (1)② and (2)

■ Input of weightings in the risk assessment table (2/4)

The detection requirements (=important monitoring items) shown in item 6 in the table below are weighted in terms of safety/operators/throughput as shown in item 7 series.

Item [H1] on the previous two pages

Item [H2] on the previous two pages

Item [H3] on the previous two pages

Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7-1	Item 7-2	Item 7-3	Item 7-4
Target equipment	Safety functions or operational functions the target function is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Presence or absence of countermeasures for disturbing safety or operational functions	Impact on accurate and prompt on-site response by workers	Impact on throughput by countermeasures in item 7-1	Estimation results
HEPA filter	Reduction of dust concentration	Acceleration of the deterioration of dust concentration reduction function inside the PCV	The effective flow path area of the HEPA filter is reduced and the filter performance cannot be maintained	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	Filter differential pressure	Scored from 1 to 4 points (See table below)	Scored from 1 to 4 points (See table below)	Scored from 1 to 4 points (See table below)	Product of items 7-1 to 7-3

*The entry details for items 1 to 6 are the same as those on the previous page

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for Item 7-2 (for safety systems)
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-2 (for fuel debris retrieval and transfer system)
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly and there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

- Item 7-2 differs in details between the fuel debris retrieval and transfer system and the safety system. See next page for the reasons
- The meaning and handling of the output scores in the evaluation results (Item 7-4) are explained on the following pages

■ Input of weightings in the risk assessment table (3/4)

~ Concept of weighting ① (Conditions that result in lower scores) ~

(Item 7-1) … If countermeasures have already been considered or technologies have been developed for countermeasures, assign lower scores

(Item 7-2) … If the data (mainly digital values) obtained on-site can be easily determined without the need for workers to be proficient, assign lower scores

(Item 7-3) … Assign lower scores if there is no impact on throughput.

~ Concept of weighting ② (Reason why item 7-2 is divided between operational equipment and safety equipment) ~

- The fuel debris retrieval and transfer system (operational system) must continue to operate in an unclear environment inside the PCV. Therefore, the focus was placed on the feasibility of monitoring countermeasures to overcome environmental changes inside the PCV (= Are there any issues with introduction?)
- The safety system must cope with transient environmental changes inside the PCV caused by the operational system and their impact on the safety functions. Therefore, the focus was placed on whether the cause of deterioration of safety functions (= whether the predictability is good) is easy to identify.
- On the other hand, regarding the definition “there are issues with introduction/can expect introduction to be feasible” for the scores that were introduced for the operational equipment, the cases of evaluation were defined as follows to avoid discrepancies in interpretation among evaluators.

There is a possibility of introduction:
Assuming an instrument to be applied to a detection request, direct determination can be made from the instrument’s output (e.g., digital values). In addition, there are no development issues in utilizing the instrument. (Example: When the detection requirement is the ambient temperature in the PCV: Assuming that a sheathed thermocouple is used, if the threshold value is set, the digital value output from thermocouple can directly determine if an event disturbing work is occurring even if the operator is not proficient. In addition, sheathed thermocouples have a track record of application at the Fukushima Daiichi and there are no development issues.)

There are issues with introduction:
Assuming an instrument to be applied to a detection request, no direct determination can be made from the instrument's output (e.g., digital values). There are also development issues in utilizing the instrument.
(Example: When the detection requirement is the dimension of debris inside the RPV: Assuming that camera images are used, the operator cannot directly determine the dimension from the image output from the camera alone. Mechanical treatment support through image processing will be required. In addition, cameras generally have low radiation resistance, and there are development issues for use in high-dose radiation environment.)

* This project presents indicators from the perspective of ensuring throughput, but there is a need to take into account the frequency of disturbing work in the future.

■ Input of weightings in the risk assessment table (4/4)

~ Characteristics of the output of scores in items 7-4 ~

(Characteristics as a design indicator)

- Low scores do not mean that monitoring is unnecessary. The high or low score is one indicator for determining the degree of focus for each important monitoring item among limited resources (*).

(Characteristics as monitoring system development)

- Those with relatively low scores are those where “ Countermeasures are being developed for disturbing work,” “Study of countermeasures has already begun in conceptual design,” and “There is a track record of past application at the Fukushima Daiichi. or is expected to be applied.”
- In other words, those with relatively high scores are likely to be those that have not been fully studied in the current subsidized projects for the Fukushima Daiichi, etc., and are highly likely to require the development of monitoring technology.

~ Treatment of items with high scores in items 7-4 ~

(Treatment in this project)

- The first thing to note as a candidate for important monitoring items to be focused on in the FY2022 research.
- It is possible that those with high scores may drop in scores depending on the hearings for each method (whether or not there are countermeasures to prevent disturbing work), so their acceptance or rejection will be determined in FY2022, including corrections to the scores.

(Treatment in each method)

- Each method will be the first input to be focused on for studying the introduction of monitoring systems.
- This project proposes a generic risk assessment method that does not depend on specific methods. Therefore, each method should reevaluate Item 7-4 after reviewing the debris retrieval model with consideration of the

Monitoring items with low scores: Monitoring is necessary, but various countermeasures are being studied when this project is implemented

Monitoring items with high scores: There is a possibility that countermeasures, including monitoring, are inadequate when this project is implemented

6.2.4 Risk assessment 6.2.4.3 Assessment results (a) Important monitoring items

■ Actual details described (gas phase system)

■ Score table for Item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but have not been applied at the Fukushima Daiichi
[1 point] Countermeasures exist and have been applied to the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-9	: Transfer of debris ②

*1

See Appendix 6.2.4.3-2 for details on this item

*2

*3

The analysis number is defined by the combination of these two character strings

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target …	The function that the …t is …nsibl… r	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring /Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (indirect causes)	Individual	Point of representation
An-Ki-1	HEPA filter	Reduction of dust concentration	Acceleration of deterioration of dust concentration reduction function inside the PCV	The effective flow path area of the HEPA filter is reduced and the filter performance cannot be maintained	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (Item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure, and this tendency is affected by the amount and particle size distribution of the dust flowing in.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion of filter elements by dust migrating from processing point to HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (Item 4)	Deterioration of the filter elements due to accumulation of dust in the HEPA filter causes partial damage of the filter elements, resulting in a decrease in the dust concentration ratio between the upstream and downstream sides. Selected because this tendency is affected by the amount and chemistry (pH, chloride ion concentration, and chemical composition) of the dust flowing in the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of dust and chemical properties at the HEPA filter inlet (pH, chloride ion concentration, chemical composition)	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

[The numbering rules for analysis numbering]
Gas phase equipment: Anzen-Ki-Arabic numerals
Liquid phase equipment: An-Eki-Arabic numerals
Cooling equipment: An-Rei-Arabic numerals
Liquid phase sub-criticality maintenance equipment: An-Rin-Arabic numerals

(*1) The name of item 2 is omitted for layout reasons. Formal name: Safety functions or operational functions the target equipment is responsible for
(*2) The name of item 7-1 is omitted for layout reasons. Formal name: presence or absence of countermeasures for disturbing safety or operational functions
(*3) The name of item 7-3 is omitted for layout reasons. Formal name: Impact on throughput by countermeasures in item 7-1

■ Actual details described (debris retrieval system)

■ Score table for Item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but have not been applied at the Fukushima Daiichi
[1 point] Countermeasures exist and have been applied to the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly and there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-9	: Transfer of debris ②

See *1 on the previous page

See *2 on the previous page

See *3 on the previous page

Analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	1	Debris processing mechanism	Fuel debris processing function	The properties of the debris are incompatible with the processing method selected, and time is required to determine the processing method.	Delay in determining the optimum processing method	Fuel debris with various properties	[Items 4/5] (a) Fuel debris properties (compressive strength) in the processing area	3	Work	Debris retrieval project is studying debris processing methods according to the properties of debris (mainly compressive strength), and is also studying work procedures in which multiple processing methods are sequentially tried on a single piece of debris.	4	There is a problem in that the property data necessary for determining the optimum processing method for debris is not specified except for the compressive strength.	2	The workload is limited during sequential testing of the processing methods in item 7-1.	24	24
Saku-A-	1	Debris processing mechanism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris in the dark (poor visibility) and volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to darkness (poor visibility)	[Item 4] (a) Dust concentration at the processing site unaffected by darkness	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology to measure dust concentration at the debris processing site in a dark and high-dose radiation environment is required.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by darkness	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there is a problem with radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

[The numbering rules for analysis]
Safety function related: Saku-A-Arabic numerals
Operational function related: Saku-B-Arabic numerals

■ Important monitoring items of high interest in safety equipment (1/2)

- Based on the risk assessment results, the high-profile important monitoring items that have an impact on throughput (= 2 or more points for item 7-3) and furthermore are items for which countermeasures for operational (safety) functions are still being developed or have not been sufficiently established (= 3 or more evaluation points for item 7-1) are shown below.
- In the evaluation of the importance of important monitoring items, among the equipment that make up the safety functions, the PCV, which is an existing equipment and constitutes a static boundary, was extracted as having a high degree of importance.
- See Appendix 6.2.4.3-1 for a quick reference table of all important monitoring items, and Appendix 6.2.4.3-2 for a detailed version.

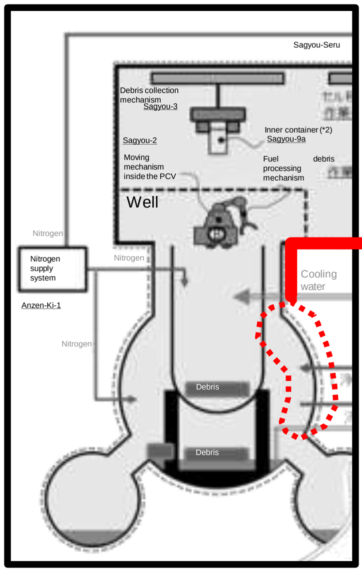


Table. Important monitoring items for the gas phase confinement system during debris processing work (excerpt)

Equipment name	Work delay factors from which monitoring items are set	Important monitoring items for detecting work delays	Weighted evaluation of risk assessment table	
			Item 7-1	Item 7-3
[Gas phase confinement system] PCV	[Analysis number: Sa- 4 An-Ki-14, 15] As the PCV deteriorates and the size of the PCV opening increases, leaks occur inside, and the differential pressure between inside and outside of the PCV decreases	Differential pressure between inside and outside of the PCV	4	3
		Amount and chemical properties (pH, chloride ion concentration) of mist flying to the PCV wall near the D/W water surface	4	3

Other monitoring items, including those not listed above, that should be focused on in FY2022 will be selected.

■ Important monitoring items of high interest in safety equipment (2/2)

- Based on the risk assessment results, the typical examples of high-profile important monitoring items that have an impact on throughput (= 2 or more points for item 7-3) and furthermore are items for which countermeasures for operational (safety) functions are still being developed or have not been sufficiently established (= 3 or more evaluation points for item 7-1) are shown below. These will be candidates for important monitoring items to be focused on in next year's research.
- See Appendix 6.2.4.3-1 for a quick reference table of all important monitoring items, and Appendix 6.2.4.3-3 for a detailed version.

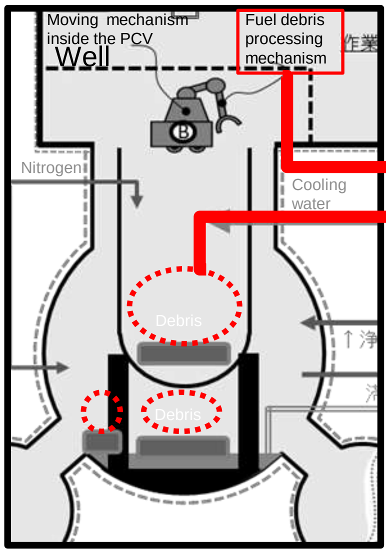


Table. Important monitoring items for operational system during fuel debris processing (excerpt)

Equipment name	Work delay factors from which monitoring items are set	Important monitoring items for detecting work delays	Weighted evaluation of risk assessment table	
			Item 7-1	Item 7-3
[Debris retrieval system] Debris processing mechanism	[Analysis number: Sa-4 Saku-B-3] Processing jigs wear out quickly, and frequent replacement make processing time-consuming	Degree of wear and tear of processing jigs	3	2
		Compressive strength of debris to be processed	3	2
	[Analysis number: Sa-4 Saku-B-7] Processing results (whether it was processed to the specified size) cannot be determined due to fog, and it is time consuming due to having to redo the process	Dimensions of processed debris unaffected by fog	4	4

[Explanation of “Degree of wear and tear of processing jigs”]
- If the technology for immediate replacement of jigs by a tool changer, which is being developed as a separate subsidized project, is applied on-site, the impact on throughput can be expected to be minimized. The degree of expectations vary depending on the method.

[Explanation of “Dimensions of processed debris unaffected by fog”]
- It is possible that alternative countermeasures may be necessary depending on site conditions that impede visual inspection.
- It is necessary to interview other subsidized projects that are considering each method to see if there are any countermeasures, and to consider how to handle them in FY2022.

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.4 Risk assessment 6.2.4.3 Assessment results (b) Overall trends

■ (Reference) Overall results including safety equipment/operational equipment (1/2)

- The details of the factors that disturb work (= number of errors) and important monitoring items extracted from the results of the risk assessment are shown below.
- See Appendix 6.2.4.3-4 for the correlation between the debris retrieval model and the risk assessment table.

Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
			Extraction evaluation of important monitoring items		
Target equipment	Safety functions or operational functions the target function is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays
HEPA Filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) Filter differential pressure (b) Dust amount and particle size distribution at the HEPA filter inlet

Number of item 3 = number of errors
In the case of this table, 1 case

Total number of factors that impede work (errors) extracted
(The number in the graph is the number of errors)

Number of item 6 = Number of important monitoring items
In the case of this table, 2 items

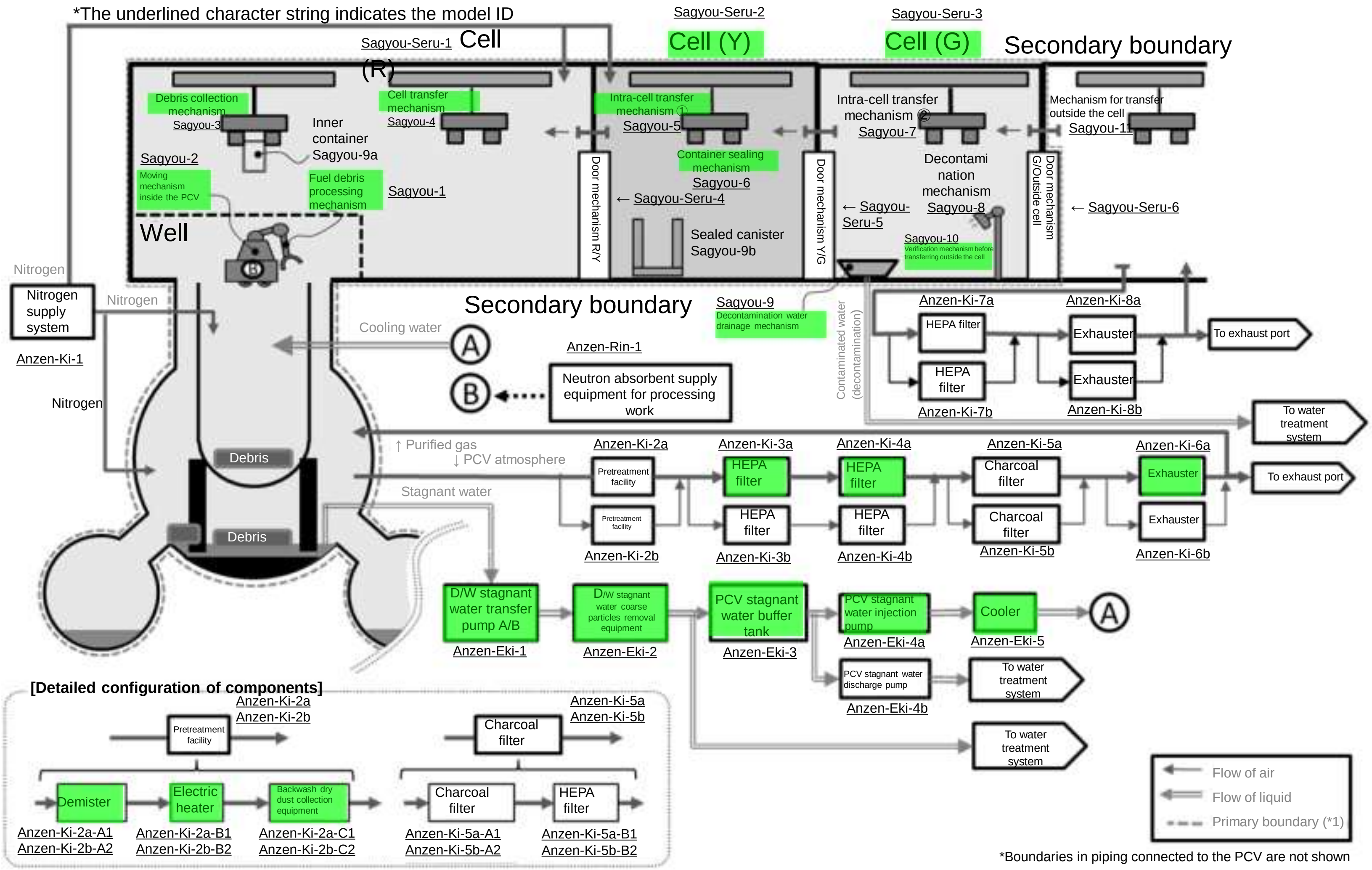
Total number of important monitoring items extracted (*)
(The number in the graph is the number of monitoring items)

*Exclude duplicate monitoring items

Total number of errors extracted: 193; total number of important monitoring items extracted: 201

■ (Reference) Overall results including safety equipment/operational equipment (2/2)

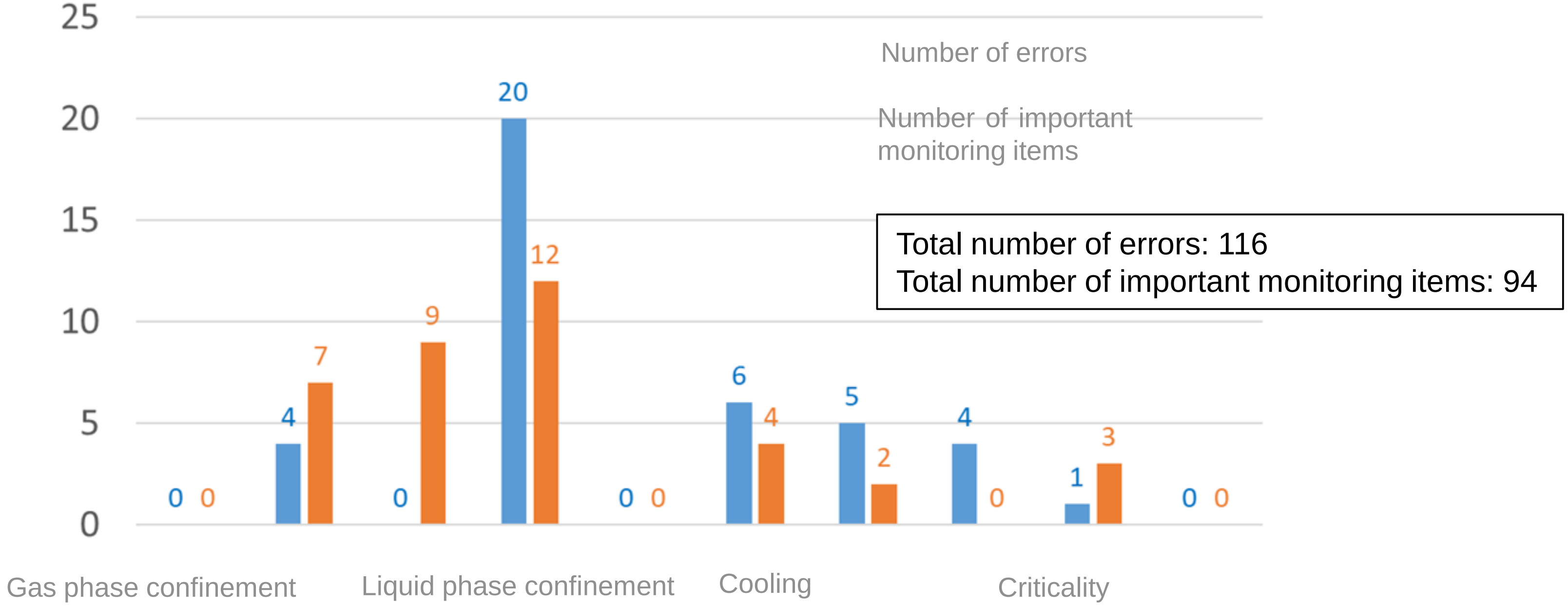
- The green hatching in the diagram on the right (equipment layout) indicates the main components affected by factors that impede work.



Detailed descriptions of safety equipment and operational equipment are shown on the following pages

■ (Reference) Overall trends in safety equipment (1/2)

- The figure below shows the number of work delay factors (= errors) and important monitoring items extracted for each system. The number of errors is highly dependent on the number of equipment that comprise the safety functions.
- The number of important monitoring items including direct monitoring items (process changes due to safety equipment) and indirect monitoring items (environmental changes due to fuel debris retrieval operations) were organized so as not to overlap.



Gas phase confinement has the largest number of work delay factors and important monitoring items

■ (Reference) Overall trends in safety equipment (2/2)

- The results of the weighted evaluation of work delay factors (= errors) extracted in the risk assessment table are shown.
- Even though it is detected that the risk to the safety function has become actualized, if the feasibility of procedures to maintain the safety function is low, the impact on the safety function will be large, and similarly the impact on the throughput will be large as well, resulting in a higher score in the error weighting.
- From the above point of view, the score of gas phase confinement was high.

Safety requirements	Weighted evaluation results of errors	
	Highest score	Lowest score
Gas phase confinement	48	1
Liquid phase confinement	4	3
Cooling	4	3
Criticality prevention	4	3

Monitoring items shown in No.59

The highest score in the weighted evaluation results were given to the work delay factors for the gas phase confinement equipment

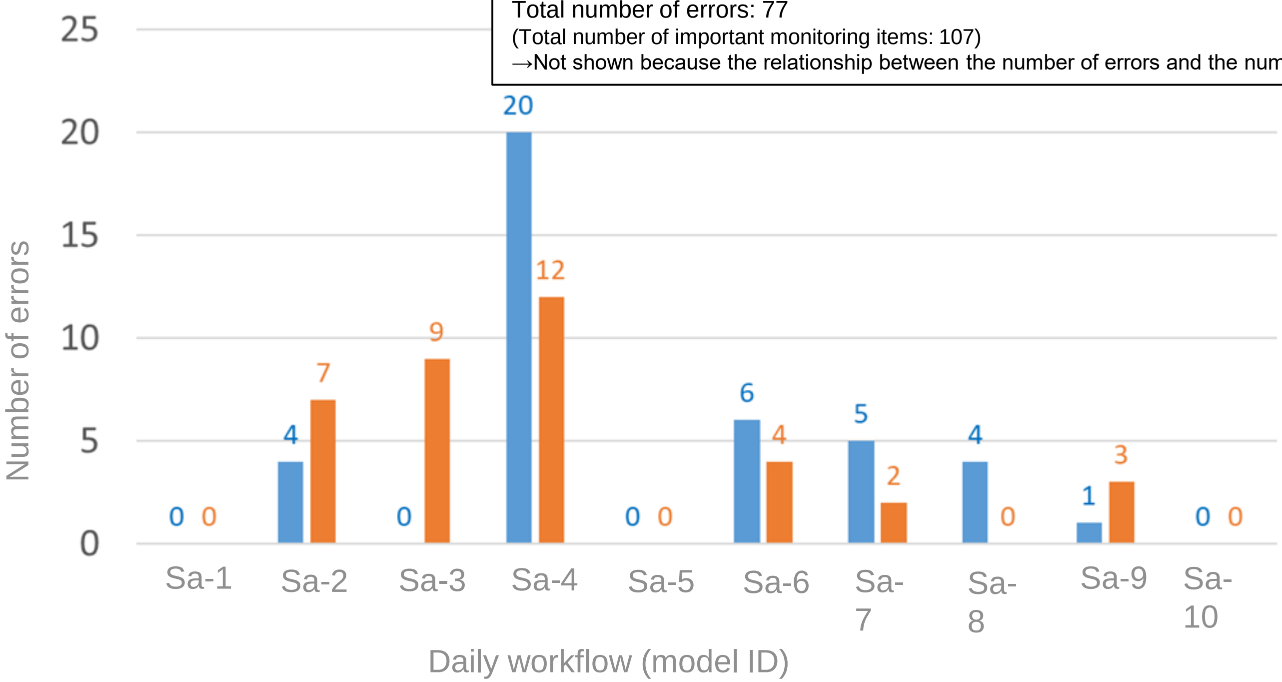
■ (Reference) Overall trends in operational equipment (1/2)

The following figure shows the trends in the extraction of work delay factors (errors) in the fuel debris retrieval and transfer system (Figure below).

[Pattern verified in the overall trends]

- Direct operation on fuel debris (model ID Sa-4) has the largest number of errors extracted.
  → Reason: Dynamic changes in the environment inside the PCV, such as dust dispersion, are conspicuous. This is because the results (database) of existing subsidized projects are also substantial.
- The number of errors extracted in the task of collecting fuel debris in a container and transferring it out (Model ID Sa-6 to 9) has decreased compared to Sa-4.
  → Reason: Separation from the atmosphere inside the PCV due to the cell. Reducing the impact of fuel debris packaging.

Total number of errors: 77
(Total number of important monitoring items: 107)
→Not shown because the relationship between the number of errors and the number of



Model ID	Name of work
Sa-1	Verification of the overall situation inside the PCV, operational equipment, and safety equipment
Sa-2	Approaching the object to be processed
Sa-3	Work prior to debris processing (spraying neutron absorbent on submerged debris)
Sa-4	Processing of debris
Sa-5	Various records following processing work
Sa-6	Cell transfer of debris (Processing site → collection equipment in the red area)
Sa-7	Transfer of debris ① (Red area → Yellow area)
Sa-8	Collection of debris
Sa-9	Transfer of debris ② (Yellow area → Green area)
Sa-10	Transfer of debris (green area → secondary boundary)

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.4 Risk assessment 6.2.4.3 Assessment results (d) Trends in operational equipment

■ (Reference) Overall trends in operational equipment (2/2)

- The results of the weighted evaluation of work delay factors (= errors) extracted in the risk assessment table are shown.
- The highest score was for the error “It takes time to confirm the fuel debris processing result (fuel debris shredding completion)” in “Model ID Sa-4: Processing of debris.”

Model ID	Work Name	Evaluation results of error weighting (*1)	
		Highest score	Lowest score
Sa-1	Verification of the overall situation inside the PCV, operational equipment, and safety equipment		
Sa-2	Approaching the object to be processed	9	1
Sa-3	Work prior to debris processing	18	12
Sa-4	Processing of debris	64	9
Sa-5	Various records following processing work		
Sa-6	Cell transfer of debris (Processing site → collection equipment in the red area)	9	3
Sa-7	Transfer of debris ① (Red area → Yellow area)	6	2
Sa-8	Collection of debris	12	4
Sa-9	Transfer of debris ② (Yellow area → Green area)	4	1
Sa-10	Transfer of debris (Green area → Secondary boundary)		
*1 Quoted scores for item 7-4 in the risk assessment table			

No.60 table “Dimensions of processed fuel debris unaffected by fog,” etc.

The highest score in the weighted evaluation results were given to the work delays during fuel debris processing.

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV

6.2.5 Organizing specifications for monitoring requirements

- An example setting of monitoring requirement specifications for important monitoring items is shown in the table below.
- The following items, which are generally considered important in terms of instrument selection, were individually set for the activities in item (2) “Study of the monitoring methods.”

[Monitoring requirement specifications]
Detection location, number of detection points, physical quantity measured, corrosion resistant environment for measurement instruments, measurement range (approximate), measurement environmental conditions (air dose rate, temperature, pressure, humidity), detection accuracy requirements

	Important monitoring items	Detection location	Number of detection points	Unit of measurement	Corrosion resistance required by instruments	Approximate measurement range	Environmental conditions for the measurement	Required detection accuracy
Debris retrieval system	Debris dimensions (during debris processing)	Debris during processing (RPV, inside and outside of the pedestal)	Attached to debris retrieval equipment	cm	Corrosion due to the following components should be considered - Chlorine derived from seawater - Boric acid solution derived from neutron absorbent - Condensation	In the criticality project, the processing range per occasion is limited to 16 cm × 16 cm × 16 cm cube, so the following will be used. - 1 cm to 30 cm	RPV: Maximum 5000 Gy/h Temperature: Maximum 50°C Pressure (gauge pressure): -2000 to 500 Pa Humidity: 100% (with condensation)	±1 cm
Gas phase confinement system	Differential pressure between inside and outside of the PCV	Inside and outside of the PCV	Two locations (1 inside the PCV / 1 outside the PCV) Whether or not to measure multiple locations instead of just the representative points is to be determined in the future design stage	Pa	Corrosion due to condensation should be considered	-2000 to +500Pa	[Process conditions] Dose: high radiation Temperature: 100°C or less Pressure: Atmospheric pressure ±2000 Pa Humidity: 100% (with condensation) [Ambient environmental conditions] Dose: high radiation Temperature: 100°C or less Humidity: 100% (with condensation)	±10 Pa

6.3.1 Study of diversification of monitoring methods

- It is necessary to consider some of the detection requirement items ,assuming countermeasures on the operational equipment side for the purpose of avoiding work delays, and to consider replacement and refinement of detection requirements that can support them. An example of operational equipment is shown below. An example of safety equipment is shown on the next page.

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	11	Debris processing mechanism	[Criticality] Debris processing shape control function	The dust dispersed by processing approaches the allowable dust concentration inside the PCV	Debris approaching to criticality due to shape change	Fall of structure	[Item 5] (b) Structural strength of structure leading to fall mode	3	Safety	- A technology to prevent re-criticality by spraying neutron absorbent (temporary suspension of work) is under development in the debris retrieval project. - In the debris retrieval project, concepts such as a support arm that supports the processed materials and a tray that catches falling objects are being considered to prevent the processing area from becoming brittle and falling by gravity.	4	- The structural strength of structures must be evaluated based on various parameters such as defects, strain, stress, and cracks, making direct determination difficult. - In general industry, there are non-destructive inspection equipment (ultrasonic wave counter, etc.) for evaluating the structural strength of bridges and concrete tunnels, but there are technological issues such as radiation resistance in high-dose radiation environment and methods of application to complex shapes.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	24	24

[For operational equipment Model ID "Sa-4: Processing of debris" detection requirement "Structural strength of structure leading to fall mode" (above table)]

- The purpose of avoiding this work delay is to "ascertain whether or not the surrounding structures are likely to fall." In the above risk assessment table, "Structural strength of structure leading to fall mode" was established as a detection requirement.
- In general, to evaluate the strength of structures, it is necessary to assume the stress applied on-site against the allowable stress and determine whether various failure modes such as fracture and fatigue failures occur. Therefore, the data required to satisfy this detection requirement covers a wide range of data such as materials, damage conditions, and dimensions, etc. of the structure on-site.
- On the other hand, in the actual fuel debris retrieval operations, measures to avoid work delays can be considered through hardware design for operational equipment, such as, "install dedicated arms to support the structure in order to prevent it from falling," "provide receiving pans and buffer materials to catch falling structures," and "spray neutron absorbent around in places where falls are predicted in advance."
- Therefore, it is necessary to evaluate in FY2022 whether the detection requirement "Structural strength of structure leading to fall mode" is essential as countermeasures for hardware design as in the above example, and whether it needs to be more detailed, or whether the objective can be achieved even if another alternative detection requirement is established.

The important monitoring items established in FY2021 include those that need to be modified to support countermeasures against work delays executed by operational equipment

6.3.1 Study of diversification of monitoring methods

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

① Particle size and amount of dispersion of dust generated during processing

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-1	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure, and this tendency is affected by the amount and particle size distribution of the dust flowing in.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

[For safety equipment model ID “Sa-4: Processing of debris” detection requirement “Dust concentration downstream side of HEPA filter”]

- This work delay is based on the assumption that the filter element is partially damaged due to deterioration of the filter element caused by dust accumulation in the HEPA filter. This work delay can be detected by a decrease in the dust concentration ratio upstream and downstream.
- This detection is not aimed at predicting failure (i.e., the goal is to detect consequences of damage).
- The reason why this detection goal can be established is that even if the HEPA filter is damaged, backup measures are being considered for switching filters through 2 series of filters.
- Due to the above, depending on the method, there is a possibility that it may not be necessary to study algorithms for prediction.
  There is a need to evaluate the treatment of important monitoring items with such characteristics in the next fiscal year.

Some of those that have backup measures currently in place against disturbing work do not require resource-intensive predictive detections

■ Summary of the implementation details for FY2021

[Implementation Details (1): Investigation of monitoring items inside the PCV]

① Investigation of important monitoring items

- Monitoring items inside the PCV that lead to work delays were investigated, risk factors (= work delay factors) were extracted, and important monitoring items inside the PCV were established to detect these factors with the objective of enabling operators to respond accurately and promptly on-site on a daily basis.
- As a method for extracting risk factors, a fuel debris retrieval and transfer process with the added safety functions were modeled.
- The extracted risk factors were weighted and evaluated in terms of the degree of deviation from the planned state of fuel debris retrieval (evaluation items: safety, operators, throughput).

② Organizing specifications for monitoring requirements

- Required on-site data (= physical quantities to be detected) were established for the important monitoring items inside the PCV extracted in ① above.
- In addition, the necessary parameters, range, and accuracy for measurements were studied for each physical quantity.

[Implementation Details (2): Study of the Monitoring Methods]

① Study of diversification of monitoring measures

- Looking to the next year's study, an initial analysis of important monitoring items was conducted. The hardware response on the operational equipment side was assumed, and verified the need to consider replacing or refining detection requirements capable of support.

6. Implementation details

6.5 Contributions to the recipients of the results

- The planned input destination of the final deliverable is as shown in No.15, but the results of FY2021 will be contributed as follows.

To whom	What	In what form
To operational equipment to be studied for each method,	Important monitoring items to continue normal work in response to the risks caused by environmental changes inside the PCV due to fuel debris retrieval operations	are entered in the report.
To safety equipment to be studied for each method,	Same as above	Same as above

6. Implementation details
6.6 Issues

- As shown in Section 6.2.4.3, it is necessary to select items that should be focused on in FY2022 in response to the important monitoring items extracted. This issue will be studied in the Implementation Details (2) : Study of the Monitoring Methods.

- As shown in Section 6.3.1, among the extracted important monitoring items, it is necessary to flexibly review them depending on the content of countermeasures taken by equipment for each method against work delays. This issue will be studied in the Implementation Details (2) :Study of the Monitoring Methods.

6. Implementation details

6.7 Level of achievement relative to the goals

■ TRL (reposted from No.18)

Implementation details	Targeted effects	(Supplemental) TRL definitions
(1) Investigation of monitoring items inside the PCV	Monitoring items that should be monitored inside the PCV must be investigated, extracted and organized to satisfy safety requirements including maintaining confinement function of the PCV during fuel debris retrieval, and monitoring the sub-criticality condition.	(Technology Readiness Level (TRL) is not set because research and organization of issues for technological development are different from development items.)
(2) Study of the monitoring methods	Based on the organized results of implementation details (1), issues must be extracted for the installation of each measuring equipment for monitoring inside the PCV, and a plan must be developed to resolve the issues. (Target TRL upon termination: Level 2)	Development and engineering work is performed, and the required specifications are developed in areas where there is almost no applicable past experience.
(3) Study of operational policies for integrated management support technology	Support items that contribute to integrated management at the Fukushima Daiichi must be extracted, based on the results of implementation details (1) and (2), and on-site usage measures must be planned. (Targeted TRL upon termination: Level 1)	Basic requirements and necessary technologies are identified for the methods and systems to be developed and engineered.

In 2021, important monitoring items inside the PCV were extracted
Of the above TRLs, Implementation Details (1) were accomplished on schedule

6.8 Future plans

■ Response for FY2022

- Based on the input from the results of the risk assessment conducted in FY2021, “Implementation Details (2) Study of the Monitoring Methods” and “Implementation Details (3) Study of Operation Policies for Integrated Management Support Technology” will be undertaken according to the initial schedule.

Subsidy Project of R&D Program on Decommissioning and Contaminated Water Management started in FY2021 Development of Support Technology for Integrated Management of Decommissioning Fukushima Daiichi Nuclear Power Station (Development of Continuous Monitoring System in Primary Containment Vessel)

Accomplishment Report for FY2021
~ Appendix ~

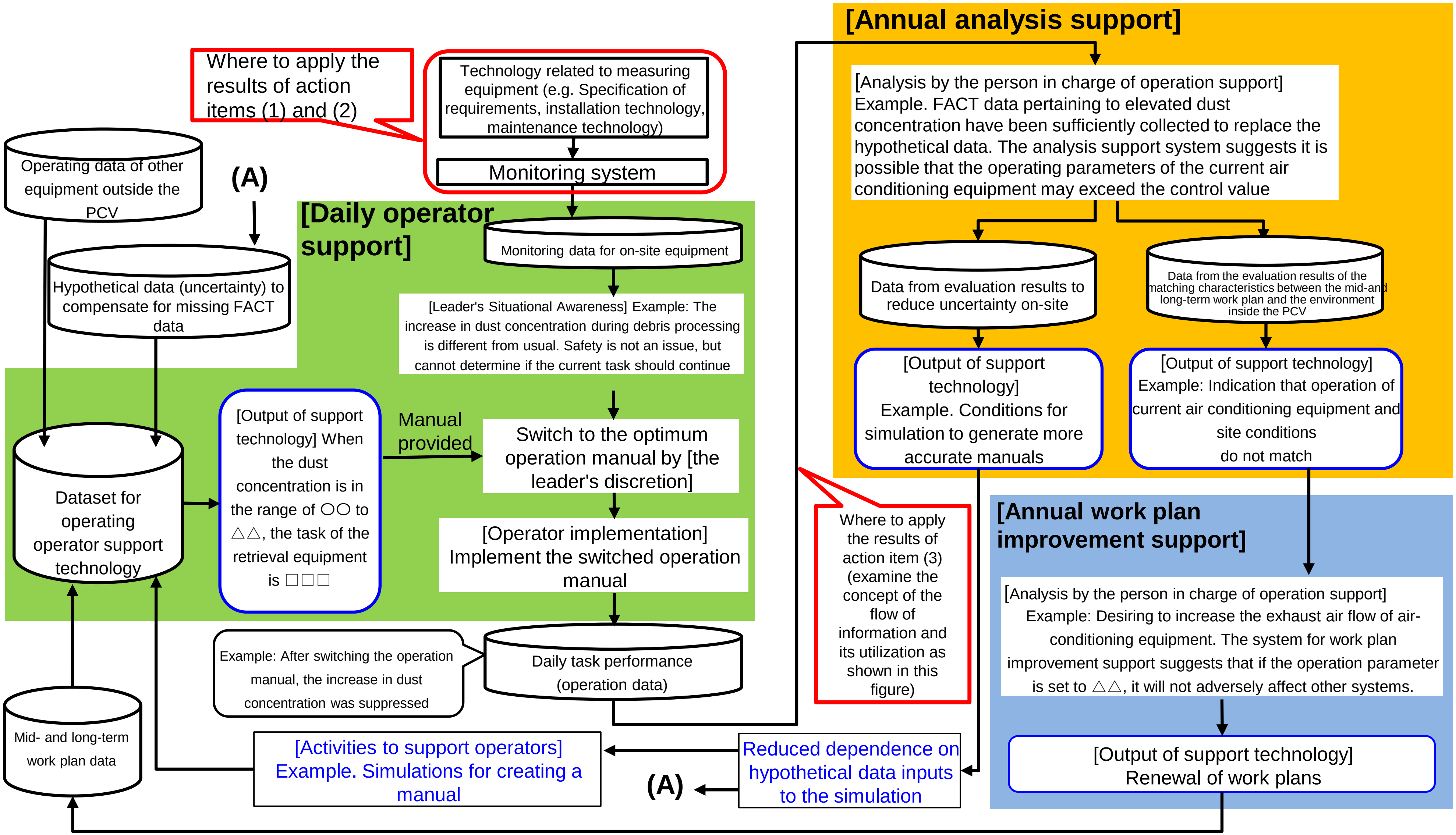
August 2022

International Research Institute for Nuclear Decommissioning

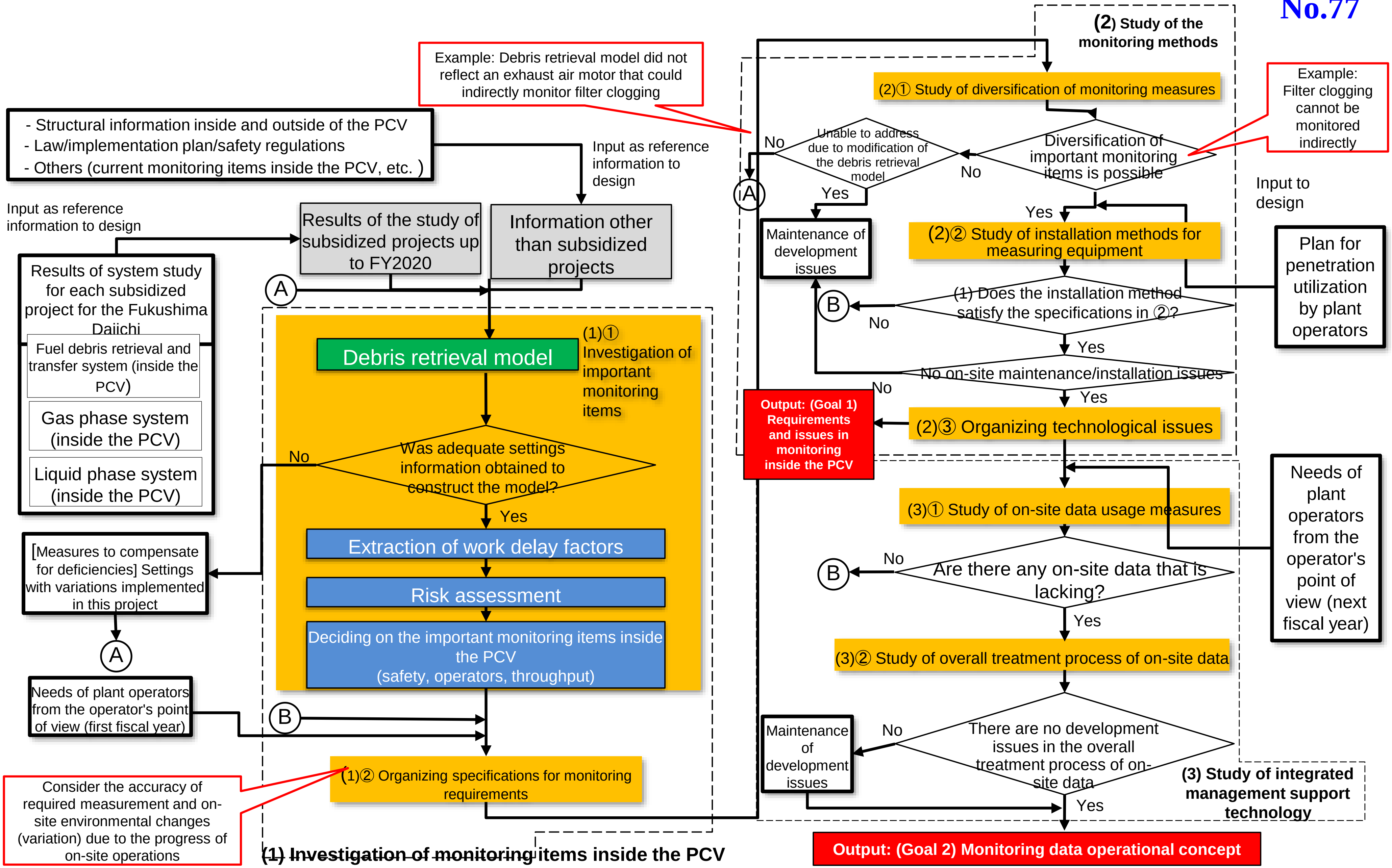
(IRID)

Appendix 2-1: Monitoring data operational concept (roles of three supporting technologies)

- An example of operational concept of information based on a monitoring system is shown below. Operational data (FACT data) obtained from the monitoring system is utilized for operator support, analysis support, and work plan improvement support respectively. As the operation data is accumulated, analysis to reduce uncertainty will be performed to improve the reliability of the various support technologies.
- Improvements in support technology can contribute to decision-making based on the actual conditions (operating data) on-site to ensure throughput and to improve daily task procedures or mid- and long-term- work plans.



Appendix 3.2-1: Flow of development of the study (detailed version)



The decisions from the reviews are setup at various points to ensure output is in line with the goal

Appendix 3.3-1: Relationship between this project and other research

■ Details of contributions to other projects (delivery)

Contributions to each project are as follows.

[Main results for achieving the goals of this project]

- Important monitoring items (weighted in terms of safety, operators, and throughput) and their implementation methods. Or issues in implementation.

[Contributions to each project based on the above results]

- Important monitoring items for each method can be set and reviewed.
- The necessary monitoring technology for each method can be identified.

[Secondary effect]

- To maintain normal work of each method,

→ Present the evaluation process leading to the determination of monitoring items for the method
(Corresponds to the details of study in Chapter 6)

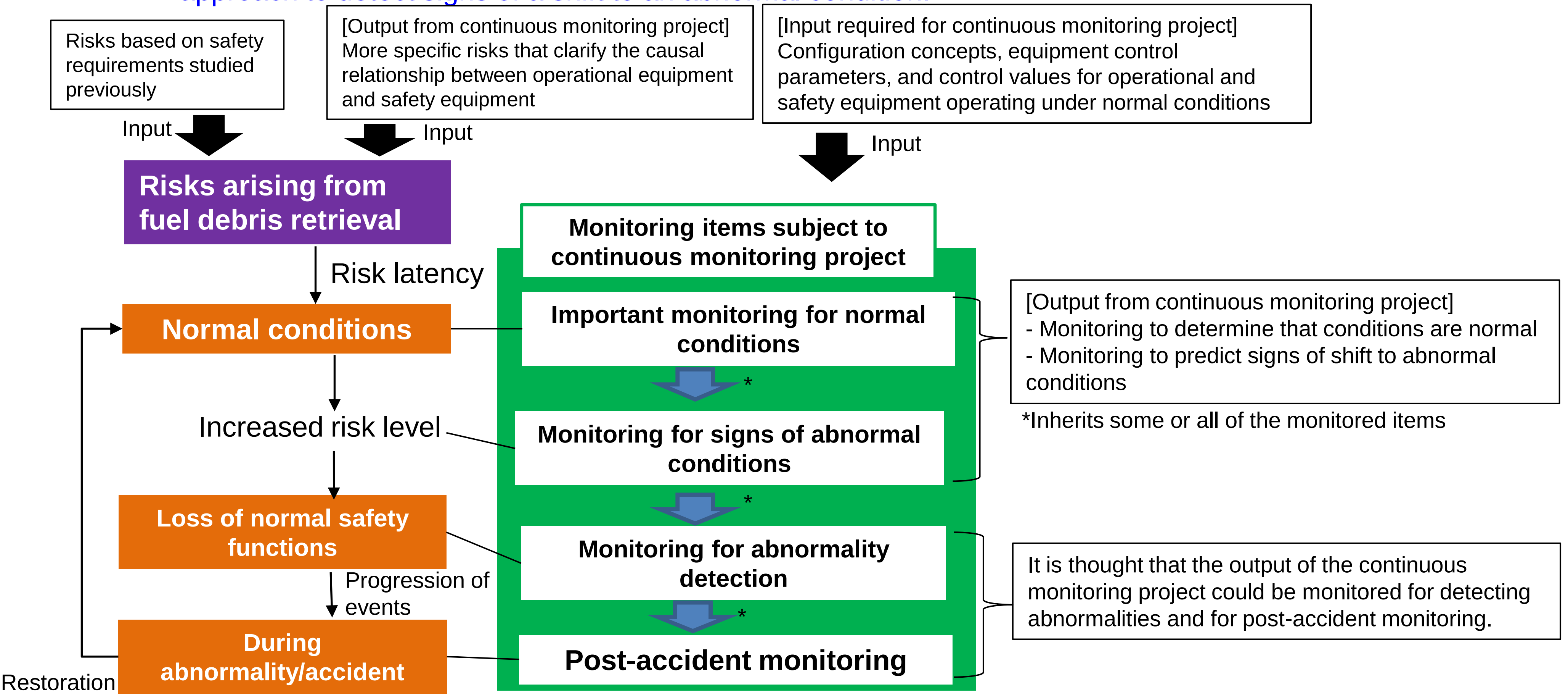
→ Present the process of extracting design conditions for a system that will continue to maintain a state of safety
(Corresponds to the procedure for conducting risk assessments in Section 6.2.4.)

→ Present additional details of study necessary to improve the accuracy of the above two items
(Examples. test data, on-site data, physical model, etc.)

In addition to presenting candidates for important monitoring items that should be adopted for each method, this project presents various design processes to maintain normal work as a secondary effect.

Appendix 6.2.1-1: Prerequisites for the study (contributions of monitoring in accordance with the level of risk)

- This project will study the monitoring items necessary to maintain normal conditions, but the items to be extracted are thought to contribute to the overall risk level. Specifically, the following A) and B) are noted.
  - A) Be more specific about safety risks arising from fuel debris retrieval.
  - B) Not only for monitoring to verify that a safety risk has become a reality under normal conditions and a shift to an abnormal condition has occurred, but monitoring items are also extracted for taking proactive approach to detect signs of a shift to an abnormal condition.



The monitoring system monitors abnormalities and signs of safety measures to help ensure throughput

■ Study results ① "Where will the fuel debris be processed?"

- Fuel debris processing methods are planned by the Fukushima Daiichi subsidized projects "Upgrading of Approach and Systems for Retrieval of Fuel Debris and Reactor Internals" and "Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals,": Processing methods for exposed fuel debris in the air or submerged in water.

- As a result, the processing site is either in air or underwater.

Appendix 6.2.3.1-1: Study of the operational equipment model (equipment operation mode) Details of the results of the study of debris processing work (2/4)

■ Study results ② "What properties does the fuel debris have?"

- The properties of the fuel debris organized in the characterization project(*) were sorted into 7 types (including others) from the viewpoint of work process.

Shape of fuel debris assumed in the characterization project	Primary component	Classifications in the continuous monitoring project
Molten or damaged structures	Fe	Existing structure (with surface contamination)
Damaged CRD/CRD housing	B_4C, Fe	
Damaged core support plate covered with molten debris	Fe	
Unmolten, damaged fuel pins and structures	UO_2, Zry-2	Fuel
A portion of the fuel assembly that remains without melting down	UO_2, Zry-2, $(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Zr(O), Fe	
Rapidly cooled molten core material that has broken into small pieces	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T	- U-rich mass of fuel debris - Fe-rich mass of fuel debris
Solidified relatively early near the upper surface of the molten pool	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Fe	
Slowly cooled down and turned into lumps near the center of the molten pool	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Fe	
Solidified relatively early near the lower surface of the molten pool	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, UO_2, Fe	
Molten debris solidified in the lower head	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Zr(O), Fe_2Zr	
Rapidly cooled molten core material that has broken into small pieces	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T	
Cooled and solidified relatively early on the upper surface of the molten pool during MCCI	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Al-Ca-Si-O	MCCI formations
Molten corium slowly cooled down and turned into lumps during MCCI	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, Al-Ca-Si-O	
Metallic deposit on each part of MCCI	Fe	
Boundary between molten corium pool and concrete	$(U, Zr)O_2$-C, $(Zr, U)O_2$-T, SiO_2, $(Zr, U)SiO_4$, Al-Ca-Si-O	
Not currently defined in the project of Fuel Debris Characterization	---	Others
Powdered fuel debris of 0.1 mm or less generated during processing, etc., among the above-mentioned fuel debris		Fuel debris powder(**)

(*) Research report on "Development of Analysis and Estimation Technologies for Fuel Debris Characterization" (March, 2019)

(**) (**) Among fuel debris powders, those that have the potential of migrating into the gas/liquid phase are referred to as dust

Appendix 6.2.3.1-1: Study of the operational equipment model (equipment operation mode) Details of the results of the study of debris processing work (3/4)

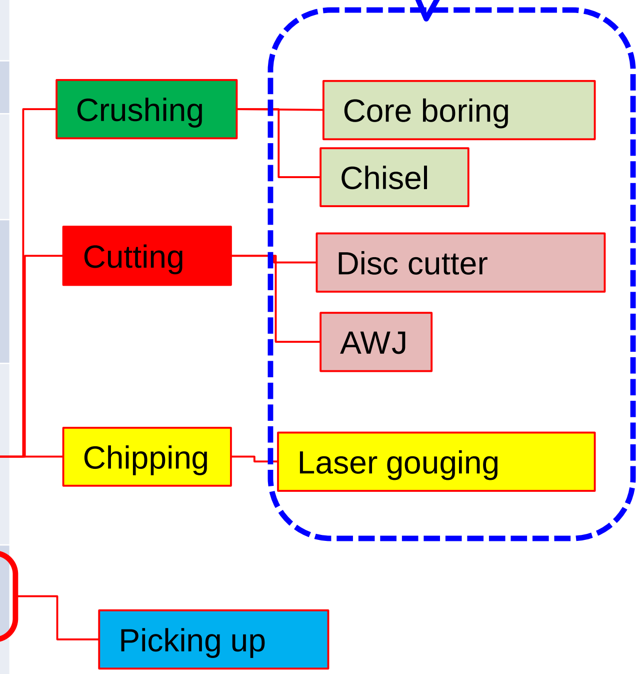
■ Study results ③ “How is it processed?”

- A precondition is set based on the throughput evaluation that does not depend on the method by the project of Upgrading and Method and Systems (*). The same method is adopted in this project.

(*) Project of Upgrading of Methods and Systems for Retrieval of Fuel Debris and Reactor Internals

In the operational equipment model, “crushing, cutting, and picking up” are treated as a group, but in order to extract disturbing the normal conditions specific to the processing method, evaluations are also conducted for items within the dashed lines.

No.	Items	Conditions
1	Fuel debris retrieval timeframe goals	Unit 1: 10 years, Unit 2: 10 years, Unit 3: 10 years
2	Number of fuel debris retrieval days per year	200 days (days other than working days are considered maintenance days)
3	Fuel debris processing hours per day	Within 10 hours
4	Amount of fuel debris	Assuming Unit 3 which has the largest total volume. (CRD instrumentation tube adhesion: 6 tons*, inside the pedestal: maximum 222 tons, outside the pedestal: maximum 146 tons, total: 374 tons)
5	Fuel debris processing tools	1. MCCI: chisel processing, ultrasonic core boring, etc. 2. CRD with instrumentation tube adhesion: disc cutter, AWJ, laser, etc. 3. Adhesion of metals: Disc cutter, AWJ, laser, etc.
6	Fuel debris processing speed	1. Chisel processing, ultrasonic core boring: Based on the results of elemental tests of this project. 2. Disc cutter, AWJ, Laser: Processing speed similar to removal of interfering objects. 3. Core boring: 3.25 kg/h (FY2016 test results) 4. Laser gouging: 4.76 kg/h (FY2016 test results)
	Method of collecting fuel debris	Proven collection methods such as grabbing and scooping are applied as an estimated condition, and the results of elemental tests are also taken into consideration.
8	Fuel debris handling speed	Proven handling methods are applied as an estimated condition, and the results of elemental tests are also taken into consideration.



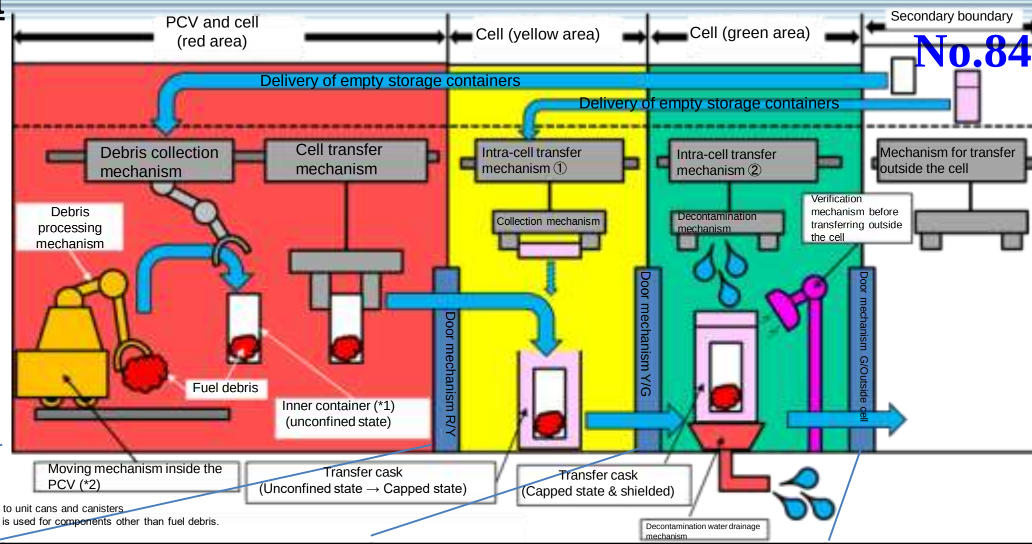
■ Study results ④ What is used for collecting fuel debris?

- The fuel debris powder (dust) shown in the study results ② is collected by a filter installed on the gas/liquid phase treatment systems of the safety equipment, and is not included in the operational equipment model.
- In the Fukushima Daiichi subsidized project, "Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals," the following construction methods are being investigated.
  Top-access retrieval method: Plan ①/Plan ②
  Side-access retrieval method: Plan A, Plan B, and Plan C
- For the above five methods, the following applications of containers for collecting fuel debris are being considered.
  Top-access retrieval method: Plan ① → Transfer containers
  Top-access retrieval method: Plan ② → Unit cans
  Side-access retrieval method: Plans A, B, C → Unit cans (Plans A and C also use canisters)
- Any of the above are containers for initially collecting the processed materials in the PCV atmosphere. These containers may be collected into another container for safety reasons during transfer out of the primary boundary.
- For example, unit cans do not have safety functions (confinement, shielding, heat removal, etc.) other than criticality prevention function through dimensional control, so collection must be into containers such as casks.
- Therefore, in the operational equipment model, the container where the fuel debris is stored is called the "inner container (general term for unit cans and storage canisters)". Furthermore, a container that stores the inner container and is safely transferred out of the primary boundary is established as a "transfer cask."

Fuel debris is directly stored in the inner container and stored in the transfer cask before transferred out of the primary boundary

Appendix 6.2.3.1-2: Environmental conditions of cell equipment

[1] Debris Retrieval Project (FY2020 Final Report), 4.1.1.1(3)(i)-pp.130 to 131
[2] Debris Retrieval Project (FY2020 Final Report), 4.1.1.1(3)(i)-p.3, Table 4.1.1.1(3)(i) – 3
[3][9]Debris Retrieval Project (FY2020 Final Report), 4.1.2.4(2)-p.2, Table 4.1.2.4(2) – 2
[4] Debris Retrieval Project (FY2020 Final Report), 4.1.2.4(3)-p.18, Table 4.1.2.4(3) – 11
[5] METI, Decontamination Technology Catalogue, High-Pressure Water Jet Removal Method
https://www.meti.go.jp/earthquake/nuclear/pdf/120626/120626_01j.pdf
[6] Debris Retrieval Project (FY2020 Final Report), 4.1.1.1(3)(i)-p.2, Table 4.1.1.1(3)(i)-2, Assumes the container surface will become contaminated to the same degree as the well and RPV inner surface by passage inside the PCV
[8] (Container outer surface area x container surface contamination concentration) x dust dispersion rate x 24 hours ÷ cell spatial volume
[9] When there is an upward flow with a velocity of 10 [cm/s] inside the cell



* 1 Refers to unit cans and canisters
*2 "Move" is used for components other than fuel debris.

Parameters	Cell (R)	Cell (Y)	Cell (G)	Secondary boundary
Container surface dose rate	Gamma ray: approx. 1.0E+05 [mSv/h] [1] Neutron radiation: approx. 10 [mSv/h] [1]	Same as that on the left (Before collection into inner container)	[Gamma rays] Surface: 2 [mSv/h] [4] 1m away from the surface: 0.1 [mSv/h][4]	Same as that on the left
Container surface contamination concentration	1.0E+08 [Bq/cm2] [6]	Same as that on the left (Before collection into inner container)	0.4 [Bq/cm^2] or less [4]	Same as that on the left
Dimension of each cell (assumed in this project)	Cell (R): height 11[m], width 11[m], depth 14[m]	Same as that on the left	Same as that on the left	—
Amount of increase in contamination concentration in the cell due to dust dispersion from the container surface	Dispersion rate: 1.0E-10 [1/s] [2] Concentration of air contamination (24 hours): 1.7 E-03 [Bq/cm^3] [8] Dust particle size [9]: 15 [μm] or less (UO2) 20[μm] or less (Fe), 40[μ m] or less (concrete).	Same as that on the left (Before collection into inner container)	Dispersion rate: 1.0E-10 [1/s] [2] Concentration of air contamination (24 hours): 6.8 E-12 [Bq/cm^3] [8] Dust particle size: Same as left	Same as that on the left
Amount of hydrogen generated from container	Amount generated per unit time: 0.4 [L/h] [3] Total amount generated (24 hours): 9.6 [L]	Same as that on the left (Before collection into inner container)	0 [L/h]	Same as that on the left
Amount of heat generated by the container	68 [W/pc] [9]	Same as that on the left	Same as that on the left	Same as that on the left
Contaminated water from decontamination	None	None	[For high-pressure water jet [5]] Cleaning pressure: 29.4 [MPa], Cleaning flow rate: 170 [L/min] -> 1700 [L] (1 minute cleaning x 10 times)	No

Appendix 6.2.3.1-3: Table of safety functions performed by components that make up the operational equipment (1/2)

- The results of the settings of safety functions for operational equipment are shown on the next page. If the safety functions are disturbed, it is assumed that the operator's accurate and prompt on-site response will be disturbed.

[Explanation of the table shown on the next page]

- For ease of understanding, various requirements are divided into those during processing and those during transportation.
- Classified because, even if the gas phase confinement is the same, the required functions are not all the same between the PCV that processes the fuel debris and the cell that handles the container (e.g. See ID 1 to 3 and ID 4 in the table on the next page).
- The fuel debris processing mechanism and inner container are responsible for dust dispersion and maintaining sub-criticality conditions during fuel debris processing (e.g. ID 2 and 5 in the table on the next page).
- The cells, door mechanisms and transfer casks are responsible for shielding and confinement of the fuel debris and PCV atmosphere (e.g. IDs 1, 4, and 6 in the table on the next page).
- The inner containers and transfer casks are responsible for most of the safety requirements during fuel debris transfer (e.g. IDs 10 to 13 and 15 in the table on the next page).
- Decontamination of the transfer cask is based on the premise of water decontamination, and the contaminated water dispersion prevention function (ID 9 in the table on the next page) was established because the spent decontaminated water is contaminated and there is a possibility of dispersion outside the secondary boundary.

Appendix 6.2.3.1-3: Table of safety functions performed by components that make up the operational equipment (2/2)

Note: Inner container refers to unit cans and canisters [1] Fire and explosion

ID	Safety requirements	Functional requirements	Configuration of components	Design requirements
(A) Requirements during processing				
1	Gas phase confinement (inside the PCV)	PCV/cell damage prevention function	Debris processing mechanism Radiation source collection mechanism	The equipment that maintains the boundary should not exert external forces (collisions, drops, etc.) that can cause deformation
2		Dust dispersion prevention function	Debris processing mechanism	Do not allow generation of PCV dust concentrations exceeding control parameters
3		Function to prevent excessive heatup of fuel debris	Debris processing mechanism	Avoid re-volatilization of radioactive materials due to abnormal temperature rise of debris
4	Gas phase confinement (Inside debris collection and transfer area for cells, etc.)	Static boundary function	Cell (R), Cell (Y), Cell (G), Door mechanism (R/Y), Door mechanism (Y/G), Door mechanism (Y/G)	Avoid excessive release of radioactive materials to the secondary boundary when handling debris or transfer casks
5	Criticality prevention	Debris shape control function	Debris processing mechanism , inner container	Debris processing must maintain the shape that does not cause re-criticality
6	Prevention of external exposure	Shielding function of the cell	Cell (R), Cell (Y), Cell (G), Door mechanism (R/Y), Door mechanism (Y/G), Door mechanism (Y/G)	Do not leak excessive radiation to the secondary boundary
(B) Requirements during transportation				
7	Gas phase confinement (Inside debris collection and transfer area for cells, etc.)	Static boundary function	Cell (R), Cell (Y), Cell (G), Door mechanism (R/Y), Door mechanism (Y/G), Door mechanism (Y/G)	Avoid excessive release of radioactive materials to the secondary boundary when handling debris or transfer casks
8		PCV/cell damage prevention function	Cell transfer mechanism Intra-cell transfer mechanism ① Intra-cell transfer mechanism ②	The equipment that maintains the boundary should not exert external forces (collisions, drops, etc.) that can cause deformation
9	Liquid phase confinement during transfer cask decontamination (water decontamination)	Contaminated water dispersion prevention function	Decontamination water drainage mechanism	Prevent wastewater dispersion from outside the secondary boundary during decontamination of the transfer cask (water decontamination)
10	Confinement of gas phase/liquid phase leak during on-site transfer	Transfer cask confinement function	Transfer cask	Prevent excessive leakage of radioactive materials from the debris inside the container after transfer from the primary boundary
11	Criticality prevention	Debris shape maintenance function of transfer cask	Inner container, transfer cask	Maintain a shape that prevents debris from reaching re-criticality during transfer
12	Prevention of abnormal heatup of debris	Heat removal function of transfer cask	Inner container, transfer cask	Avoid abnormal temperature rise of debris and re-volatilization of radioactive materials during transfer
13	Prevention of external exposure	Shielding function of transfer cask	Transfer cask	No excessive exposure to workers should be caused by radiation after transfer from the primary boundary
14	Prevention of internal exposure	Transfer cask decontamination function	Decontamination mechanism	No excessive internal exposure to workers should be caused by contaminated materials dispersion from the surface of the transfer cask after transfer from the primary boundary
15	Prevention of fire and explosion [1] during on-site transfer	Fire and explosion [1] prevention function of transfer casks	Transfer cask	Ensure that hydrogen generated from the debris inside the vessel does not cause hydrogen combustion, which may damage the vessel or impede other functions

Appendix 6.2.3.2-1: Study of the safety equipment model/Configuration of physical model of environment inside the PCV (1/4)

Using a gas phase system as an example, a physical model of the environment inside the PCV for each safety function is shown.

Safety function (gas phase system)

Physical model of environment inside the PCV(Environmental variables inside the PCV (physical quantity) = Dust concentration inside the PCV)

[Dust concentration reduction function]

Control parameter: Environmental model inside the PCV for dust concentration inside the PCV (Pattern A)

$$A \text{ (Dust concentration inside the PCV)} \times V = \frac{S}{\lambda_d + \lambda_k + \lambda_f}$$

S : Amount of dust generated (= Amount of fuel debris processed [kg/day] × Dust dispersion rate [-])

V : Evaluation volume [m^3] (Example. PCV, cell, etc.)

λ_d : Dust deposit rate(= Dust terminal velocity [m/s] ÷ PCV height [m])

λ_k : Dust ventilation rate (= PCV gas management system exhaust airflow [m^3/h] ÷ PCV volume [m^3])

λ_f : Filter removal rate (= recirculated airflow [m^3/h] ÷ PCV volume [m^3] × HEPA filter efficiency [-])

Appendix 6.2.3.2-1: Study of the safety equipment model/Configuration of physical model of environment inside the PCV (2/4)

Safety function (gas phase system)

Physical model of the environment inside the PCV
(Environmental variables inside the PCV (physical quantity = PCV leakage amount)

[Static Boundary Function]
Control parameter: Physical model of the environment inside the PCV for PCV leakage (Pattern B)

In this study, the amount of PCV leakage is assumed to depend on the size of the PCV opening, and the factors that increase the size of the PCV opening were organized.

Factors that increase size of the PCV opening

- Increase in size of opening due to corrosion
- Increase in size of opening due to deterioration of new structures (cell doors, closures of existing openings, welded parts, etc.)
- Others

Appendix 6.2.3.2-1: Study of the safety equipment model/Configuration of physical model of environment inside the PCV (3/4)

Safety function (gas phase system)

Physical model of the environment inside the PCV
(Environmental variables inside the PCV (physical quantity) = Negative pressure inside the PCV)

[Dynamic Boundary Function]
Control parameter: Physical model of the environment inside the PCV for the degree of negative pressure inside the PCV (Pattern A)

- Steady condition (negative pressure condition)

  $F_{PSA} + f$ (degree of negative pressure inside the PCV) $\times B + F_{cell} = F_{ex}$

  Degree of negative pressure inside the PCV = Atmospheric pressure - PCV pressure

  F_{PSA} : Nitrogen-charged airflow by PSA [m^3/h]

  F_{ex} : PCV gas management system exhaust airflow [m^3/h]

  F_{cell} : Inflow airflow from adjacent cells [m^3/h]

  f (Degree of negative pressure inside the PCV): Flow velocity due to differential pressure between inside and outside of the PCV opening [m/s]

  B : Size of the PCV opening [m^2]

Appendix 6.2.3.2-1: Study of the safety equipment model/Configuration of physical model of environment inside the PCV (4/4)

Safety function (gas phase system)

Physical model of the environment inside the PCV

(Environmental variables inside the PCV (physical quantity) = Exhaust end dust concentration)

[Emission control function]

Control parameter: Physical model of the environment inside the PCV for exhaust end dust concentration (Pattern A)

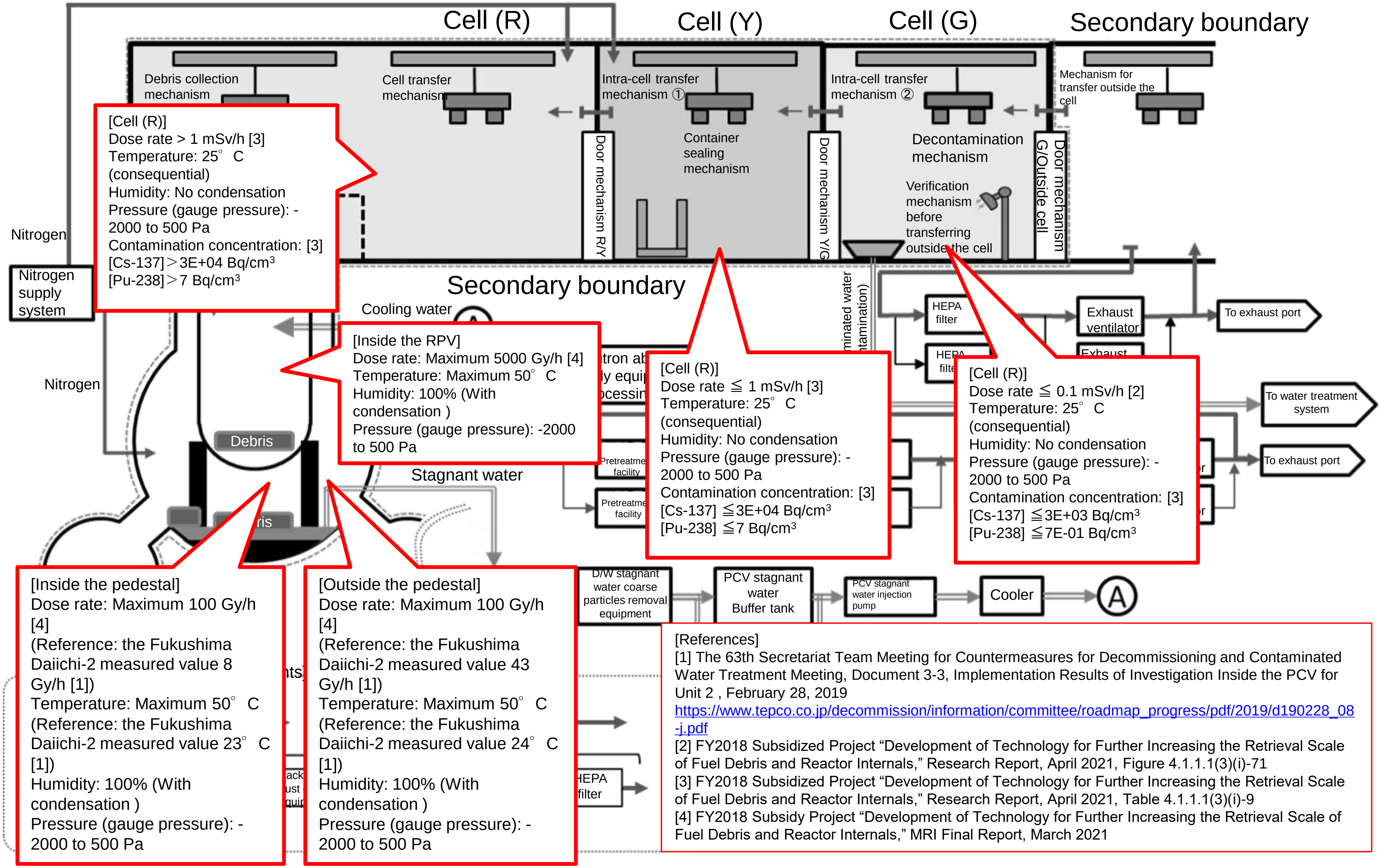
- Exhaust end dust concentration C (kg/m^3)

$$C \text{ (exhaust end dust concentration)} = A \text{ (dust concentration)} \times DF$$

A : Dust concentration (Modeled with dust concentration reduction function [kg/m^3])

DF : Filter efficiency [-]

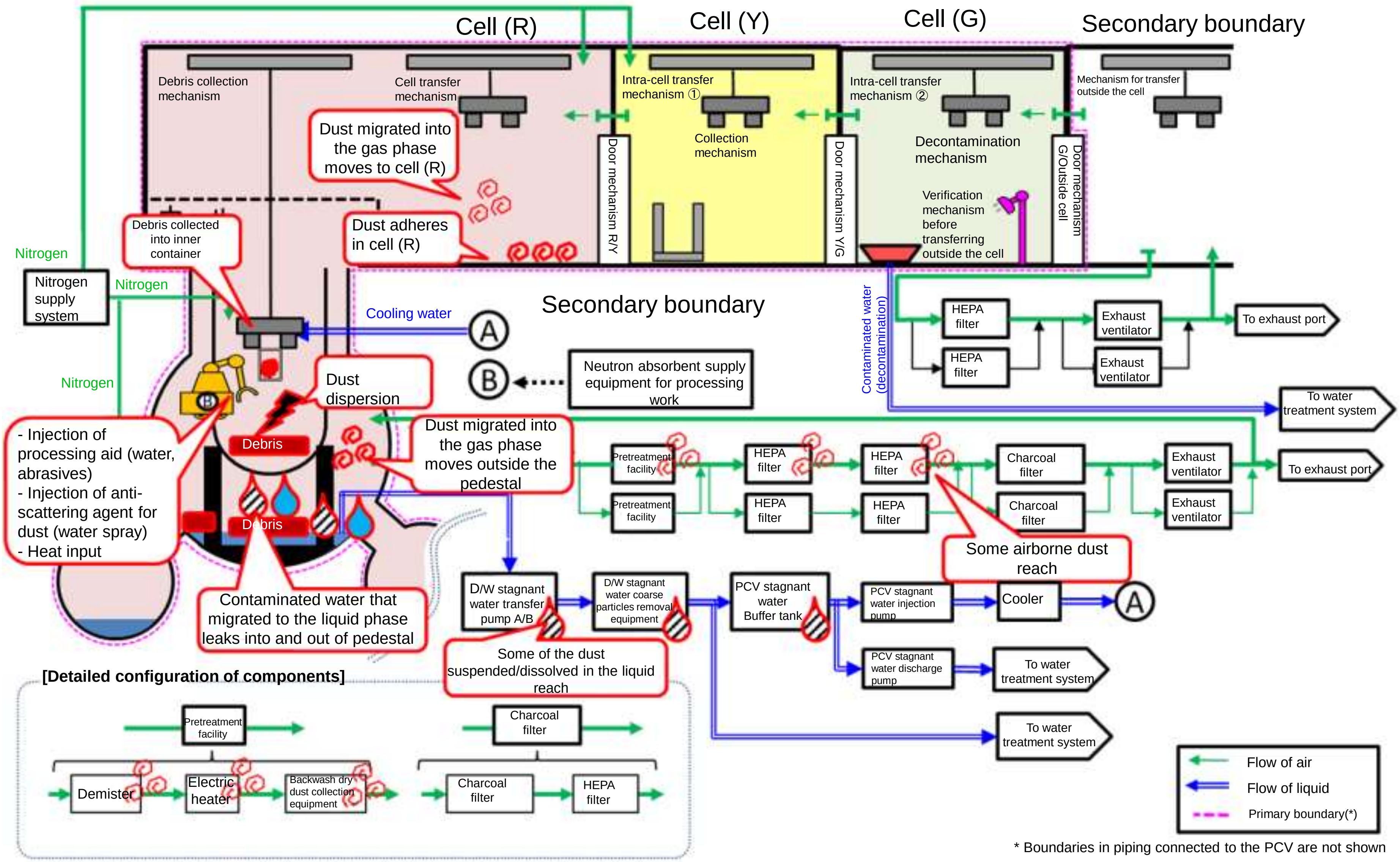
Appendix 6.2.3.3-1: Debris retrieval model (environmental conditions inside the PCV)



[References]
[1] The 63th Secretariat Team Meeting for Countermeasures for Decommissioning and Contaminated Water Treatment Meeting, Document 3-3, Implementation Results of Investigation Inside the PCV for Unit 2 , February 28, 2019
https://www.tepco.co.jp/decommission/information/committee/roadmap_progress/pdf/2019/d190228_08-j.pdf
[2] FY2018 Subsidized Project "Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals," Research Report, April 2021, Figure 4.1.1.1(3)(i)-71
[3] FY2018 Subsidized Project "Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals," Research Report, April 2021, Table 4.1.1.1(3)(i)-9
[4] FY2018 Subsidy Project "Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals," MRI Final Report, March 2021

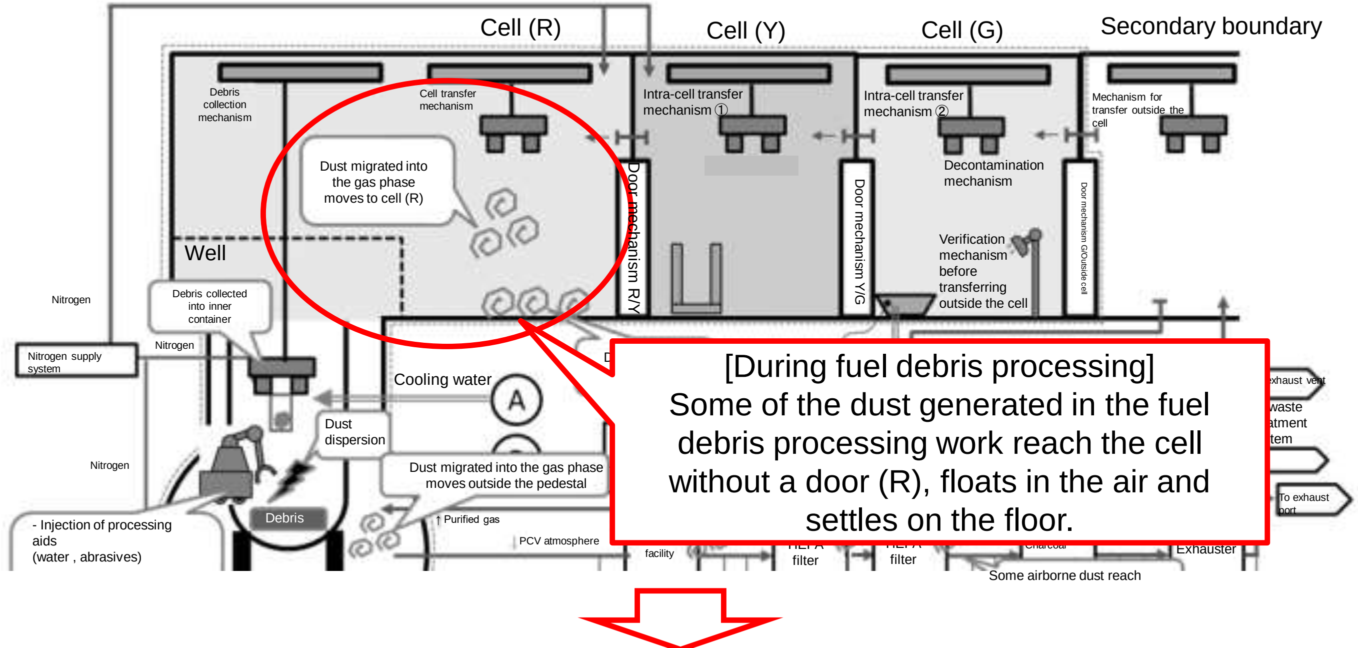
Appendix 6.2.3.3-2: Example of transient changes in environment inside the PCV (1/2)

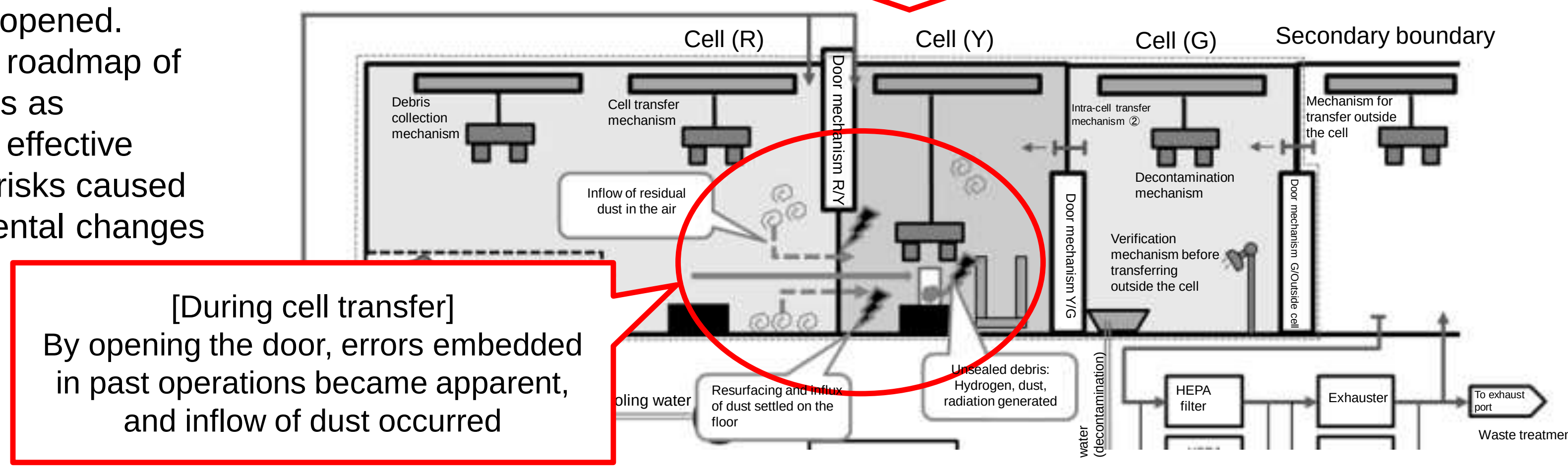
・D: Sa-4: An example of transient changes during "processing of debris" is shown on the next page.



Appendix 6.2.3.3-2: Example of transient changes in environment inside the PCV (2/2)

- An example of how environmental changes inside the PCV that occur during fuel debris processing can adversely affect subsequent work is shown.
- The upper right figure depicts the possibility of some of the dust reach cell (R) due to fuel debris processing in the PCV. The history of changes in the environment will be kept in subsequent roadmaps as well.
- The lower right figure depicts an error event in which the dust remaining in cell (R) flows in when the door for cell (Y) is opened.
- It was verified that the roadmap of environmental changes as described above is an effective method for extracting risks caused by transient environmental changes in the PCV.

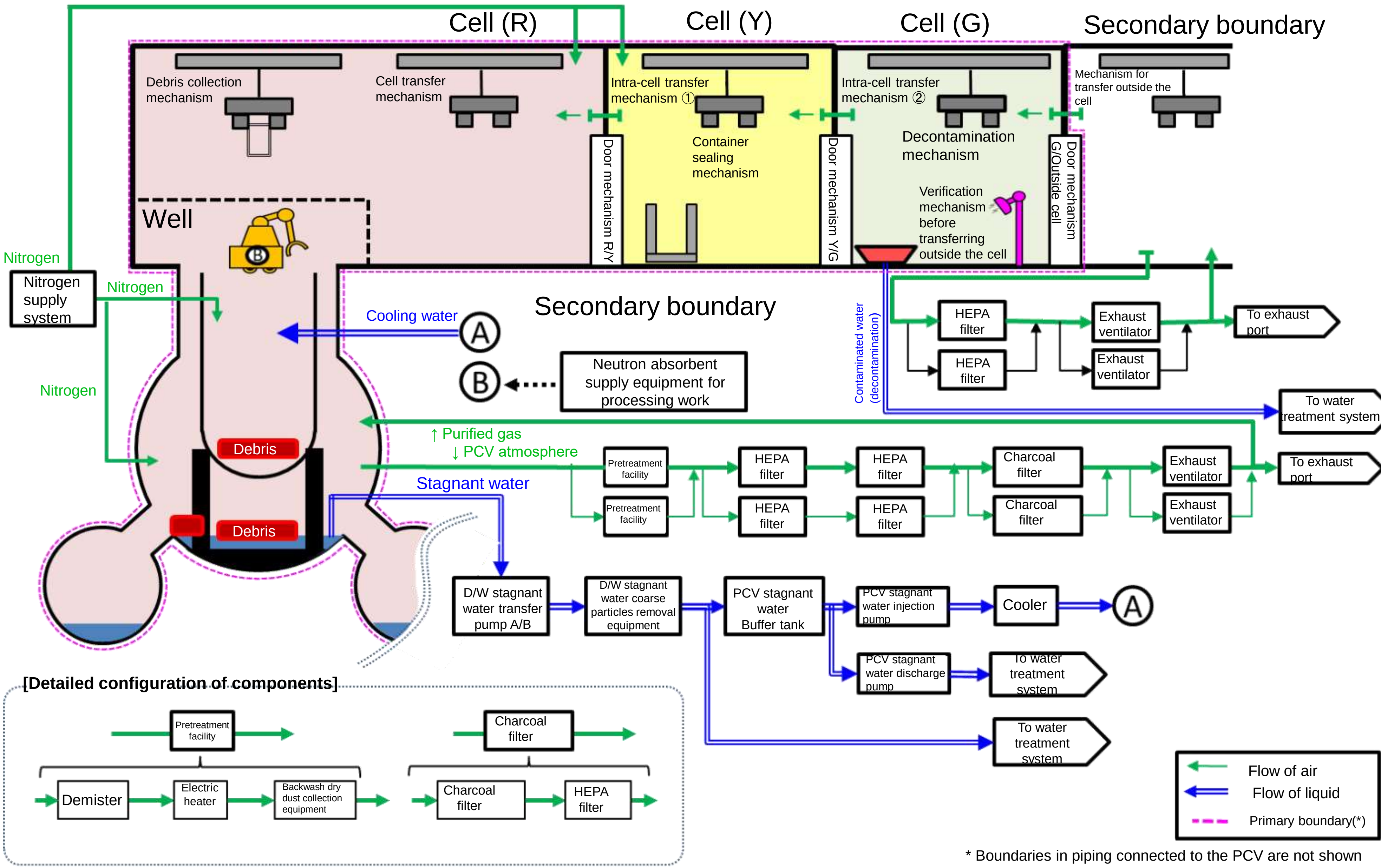




Roadmap of environmental changes is effective for extracting risks due to transient environmental changes in the PCV

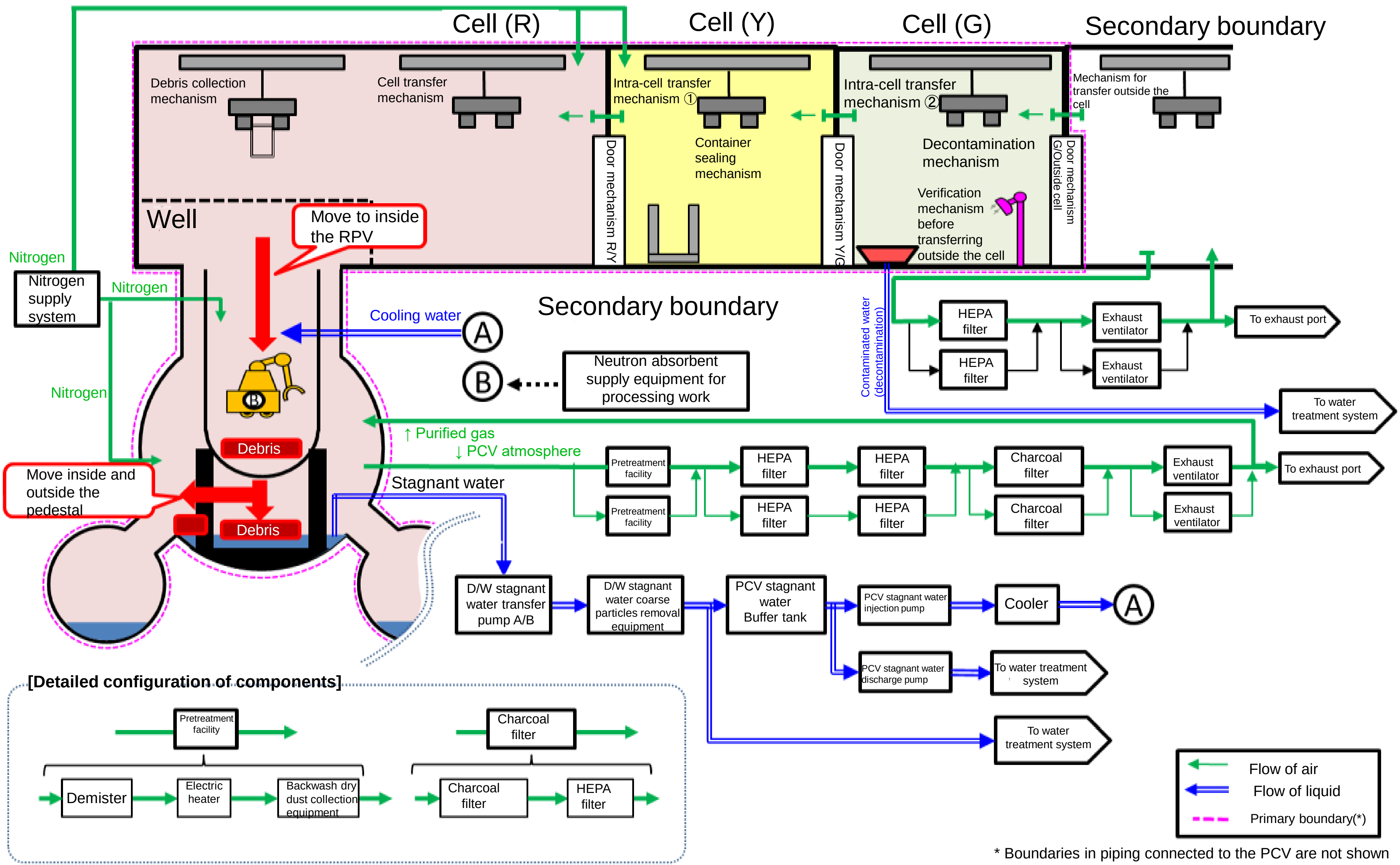
Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (1/10)

ID: Sa-1 “Verification of the overall situation inside the PCV, and operational/safety equipment”



* Boundaries in piping connected to the PCV are not shown

ID: Sa-2 “Approaching the object to be processed”

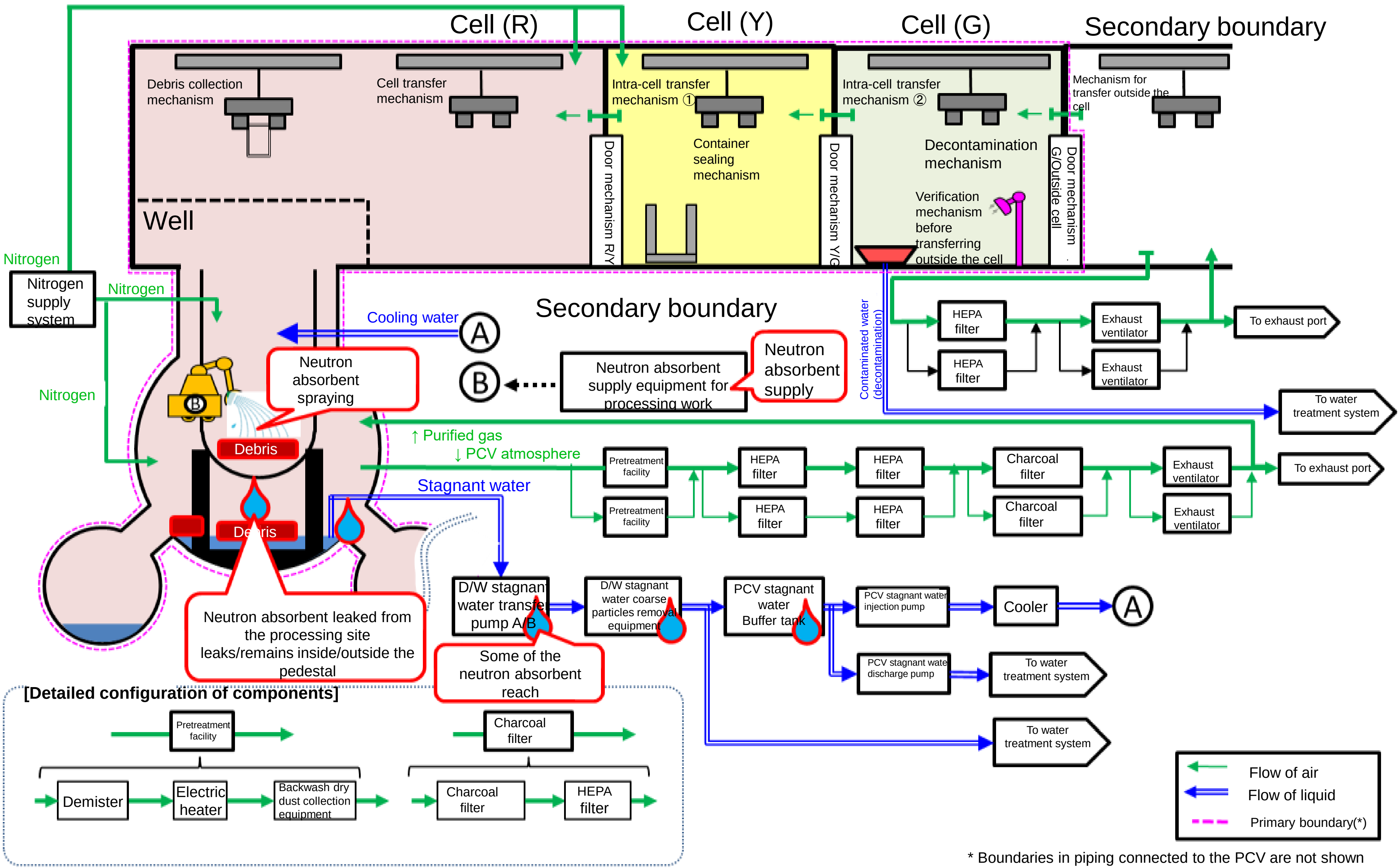


* Boundaries in piping connected to the PCV are not shown

Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (3/10)

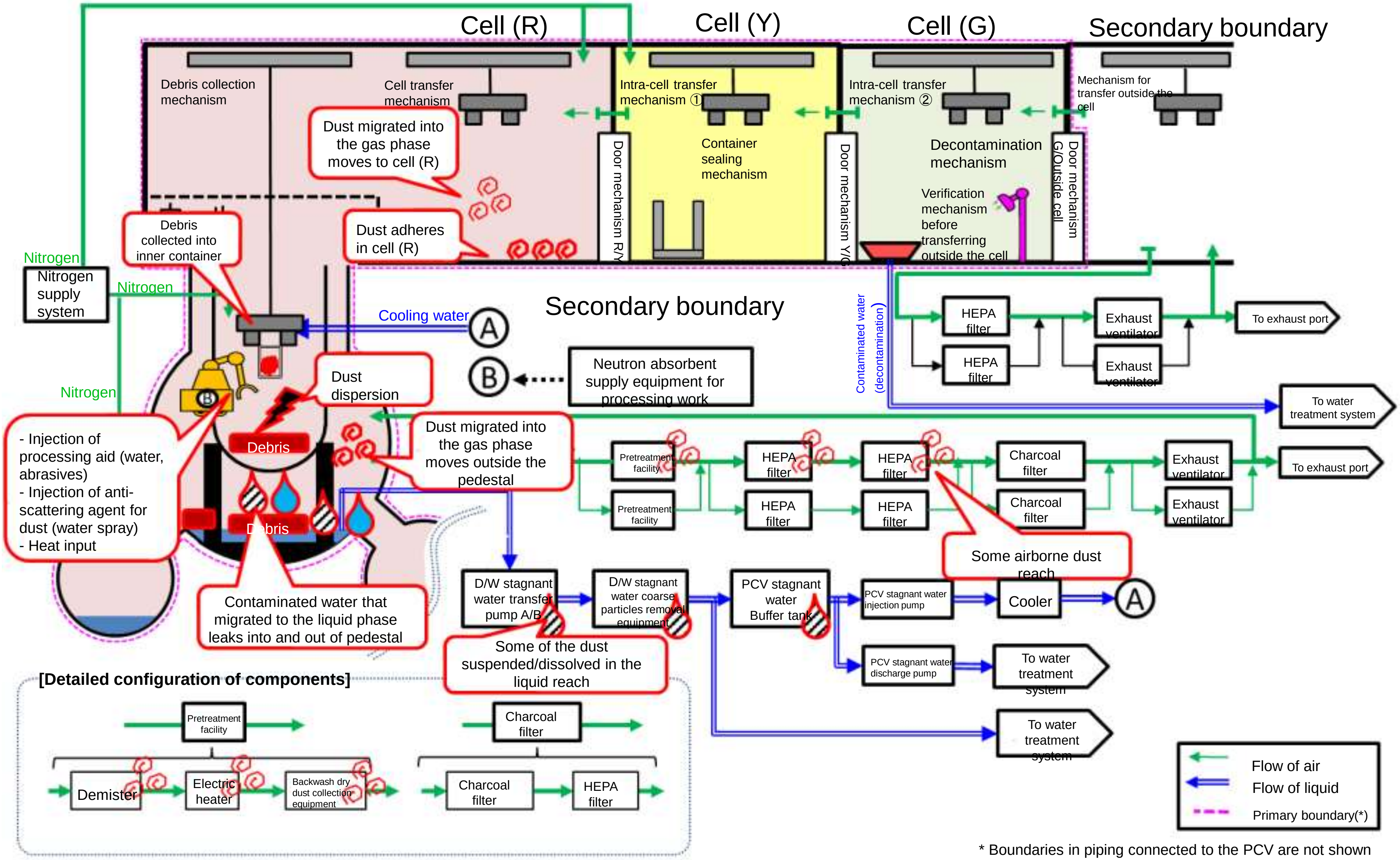
ID: Sa-3 "Work prior to debris processing" *This diagram shows a typical example of work inside the RPV

No.96



* Boundaries in piping connected to the PCV are not shown

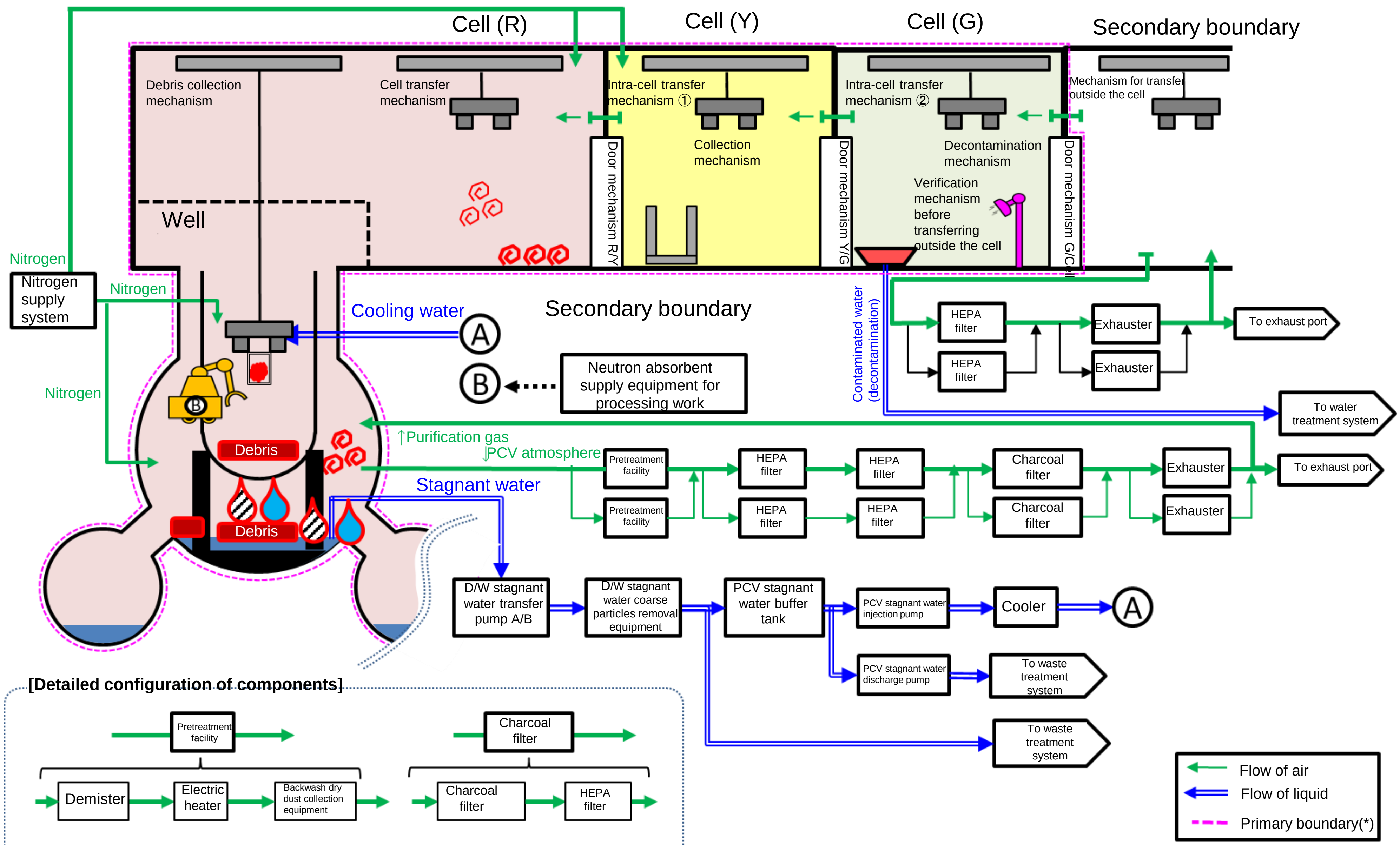
ID: Sa-4 "Processing of debris" *This diagram shows a typical example of work inside the RPV



* Boundaries in piping connected to the PCV are not shown

Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (5/10)

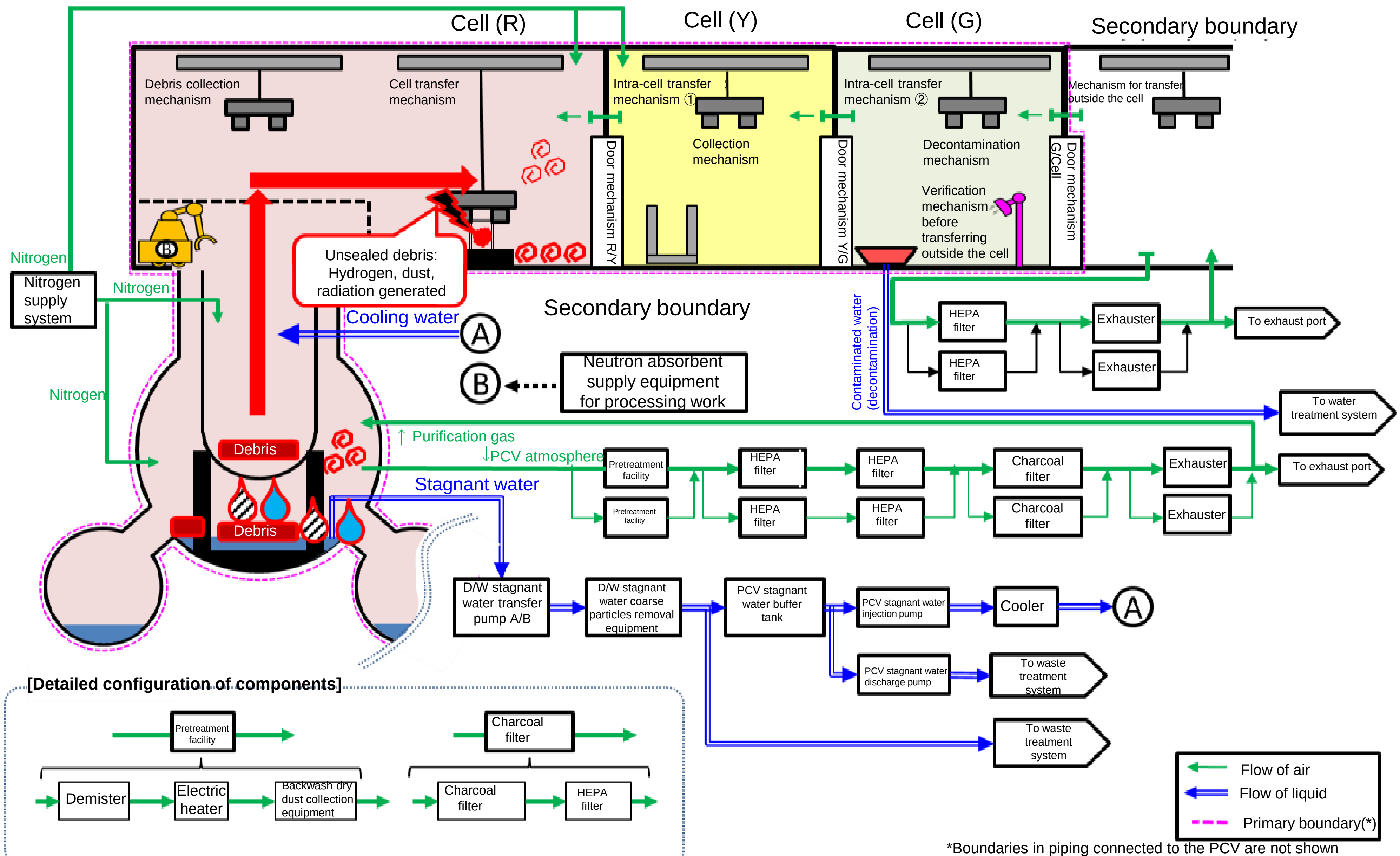
ID: Sa-5 "Various records following processing work"



*Boundaries in piping connected to the PCV are not shown

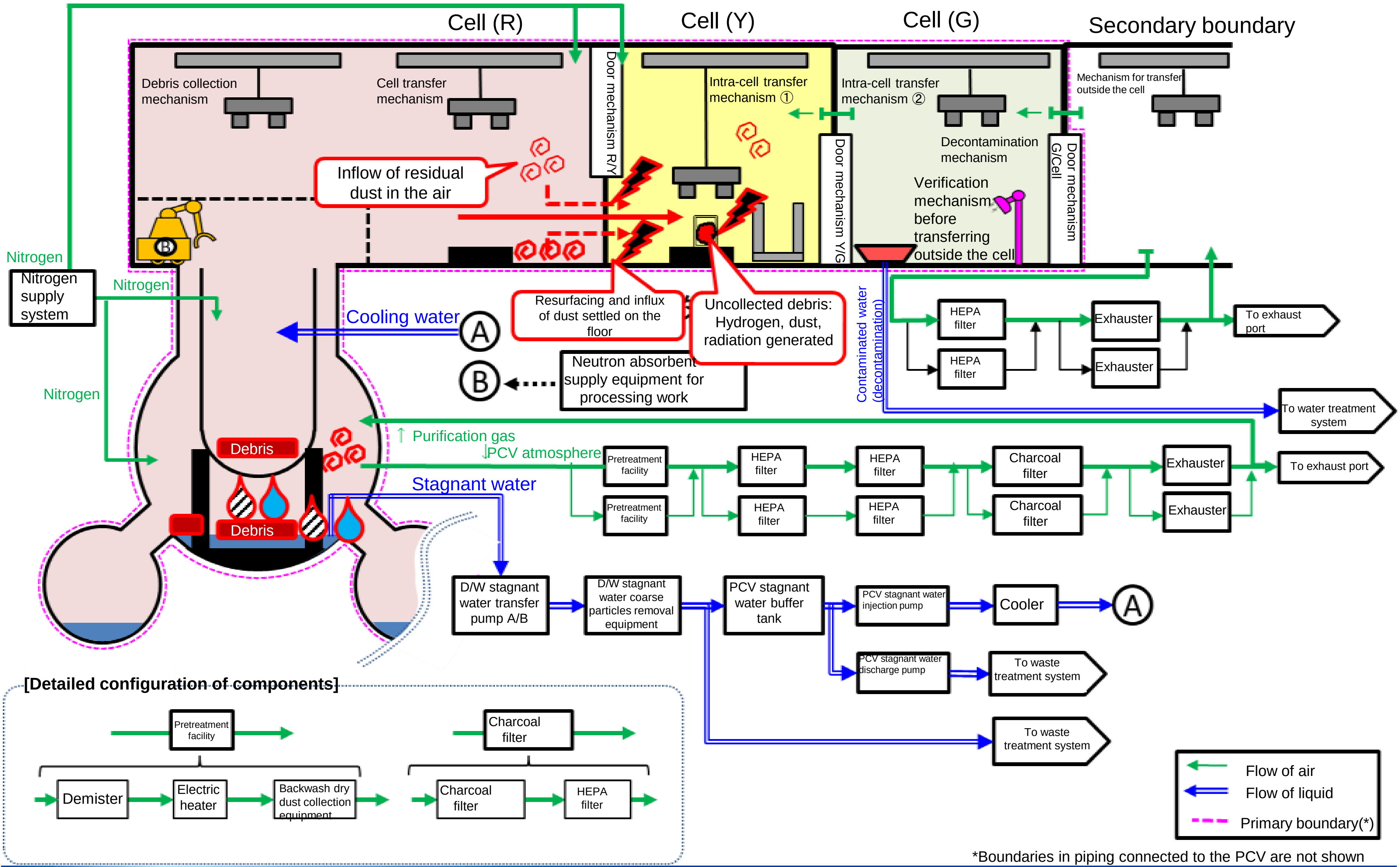
ID: Sa-6 “Cell transfer of debris”

No.99



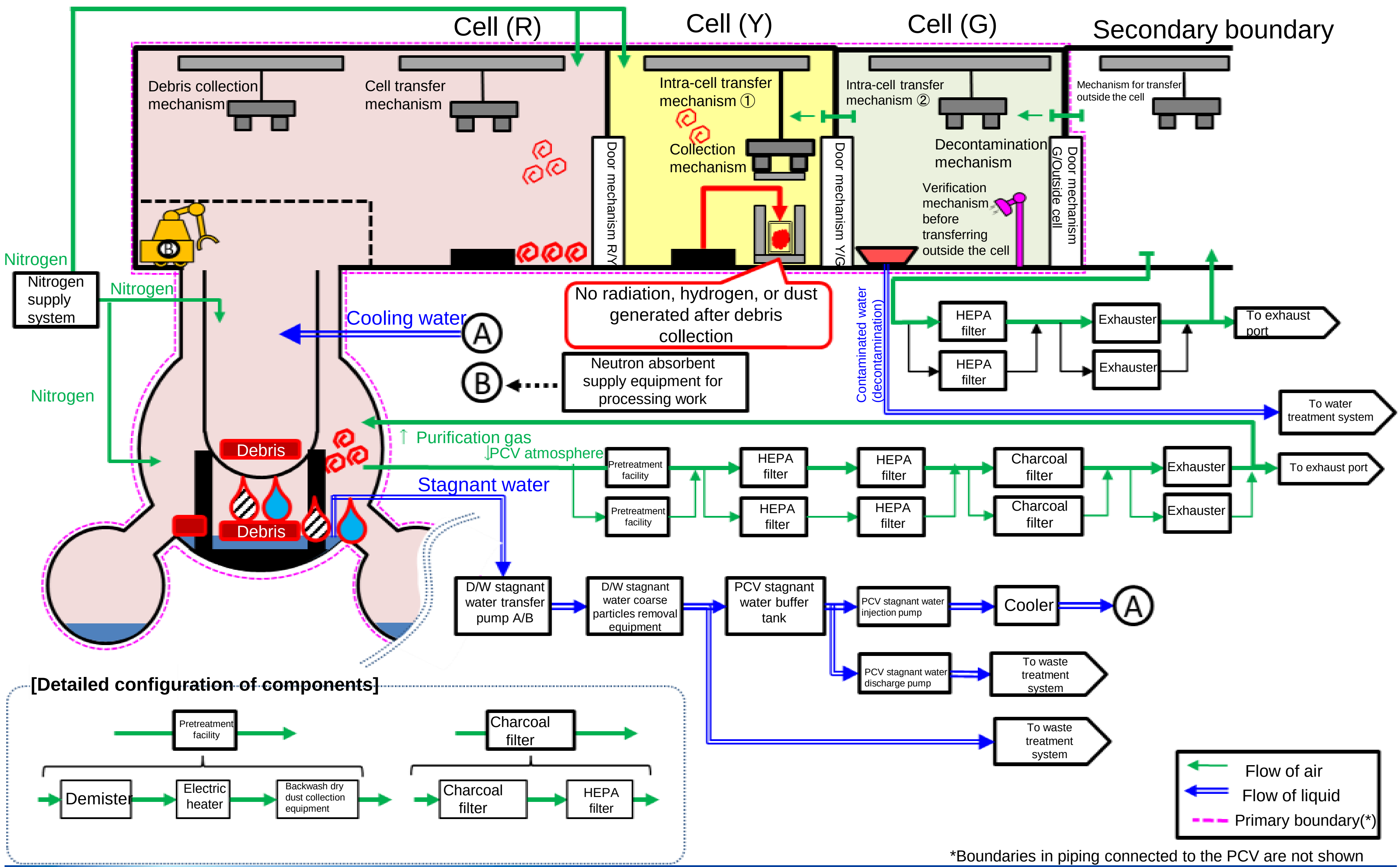
*Boundaries in piping connected to the PCV are not shown

ID: Sa-7 “Transfer of Debris ①”



*Boundaries in piping connected to the PCV are not shown

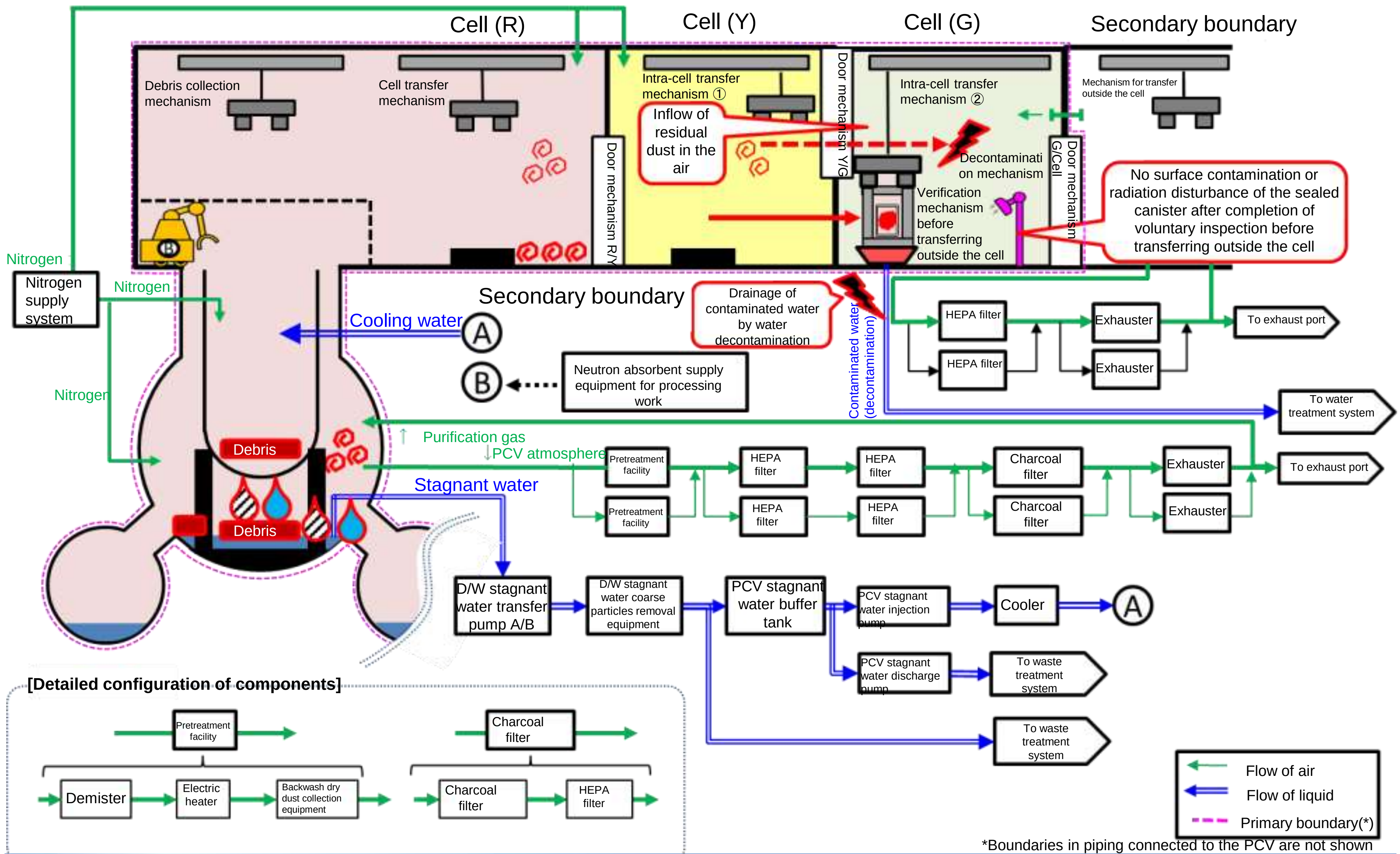
ID: Sa-8 “Collection of debris”



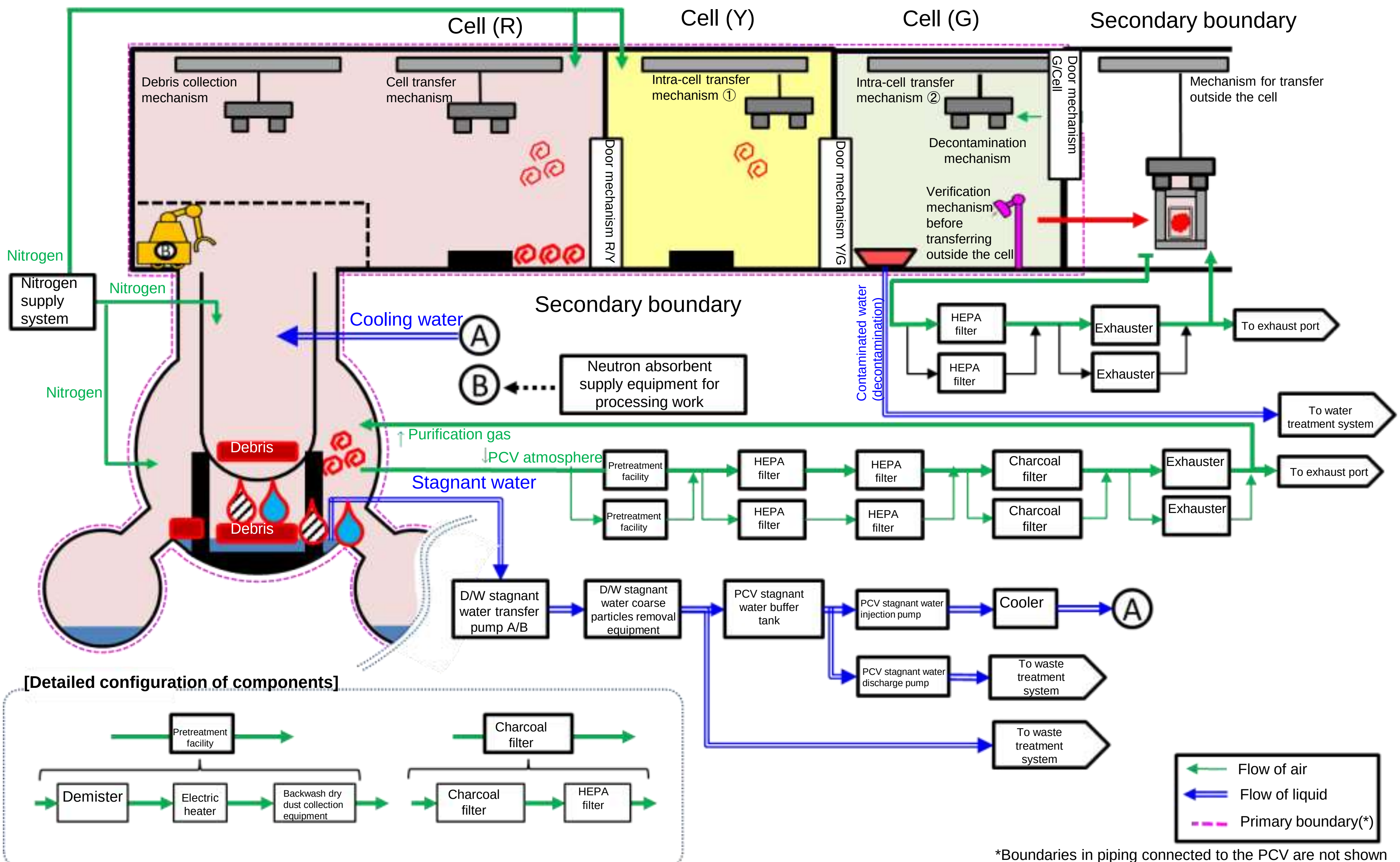
*Boundaries in piping connected to the PCV are not shown

Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (9/10)

ID: Sa-9 “Transfer of debris ②”



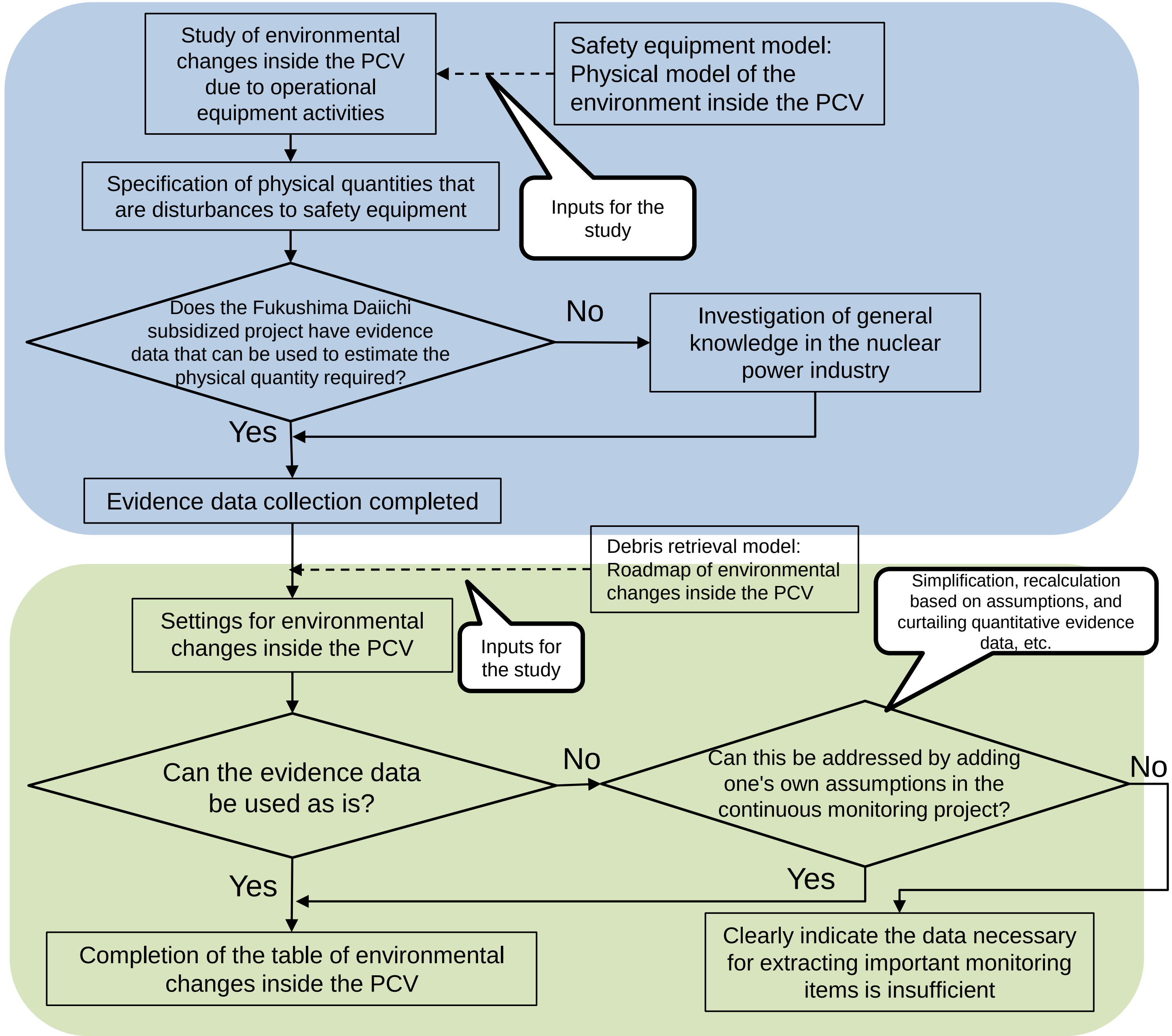
ID: Sa-10 "Transfer of Debris"



*Boundaries in piping connected to the PCV are not shown

Appendix 6.2.4.1-1: Flow of study of environmental changes inside the PCV due to operational equipment activities

- The environment inside the PCV changes with the normal work using operational equipment. A part of this change becomes a disturbance to the safety equipment.
- This section quantifies the environmental changes inside the PCV that are candidates for disturbances, as much as possible. For quantification, knowledge from decommissioning of the Fukushima Daiichi or light-water reactors (i.e., evidence data) will be collected and processed for application in the debris retrieval model.
- Here, processing refers to simplification, recalculation based on assumptions, and curtailing quantitative evidence data, etc.



Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (1/11)

■ Example calculation of environmental changes inside the PCV: When cutting fuel debris lumps (300 kg) with a disc cutter

$M\_fd = \rho\_fd \times V\_fd = 1242.1[g]$

M_fd: Total amount of dust generated [g]
ρ_fd: Hypothetical debris density [g/cm^3] (=11)
V_fd: Deficit volume during processing of hypothetical debris [cm^3] (=112.8)

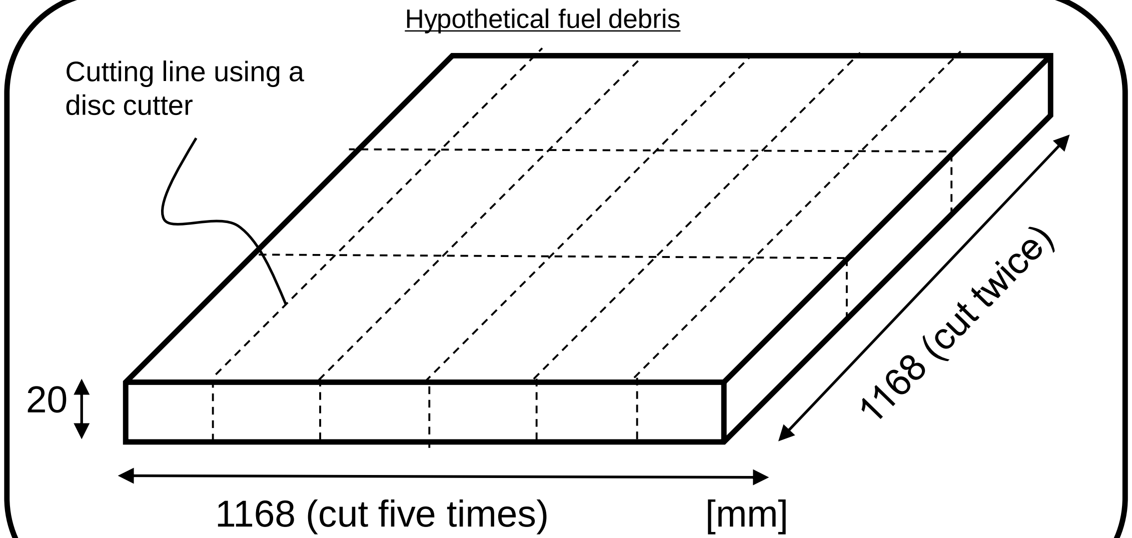
[Total cutting length of hypothetical debris]
1168 mm × 7 times = 8176 mm

×

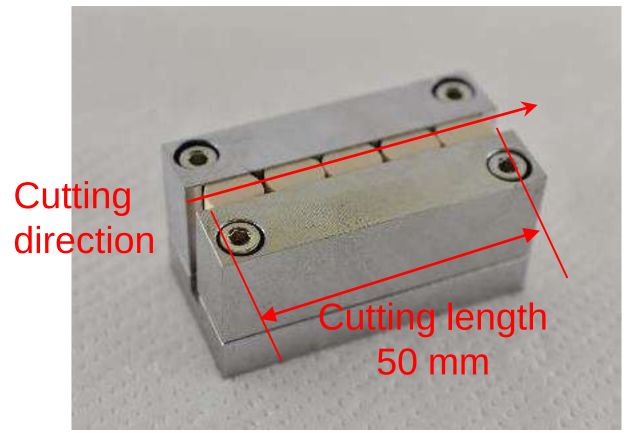
[Test data obtained from project of Development of Technology for Dust Collection System of Fuel Debris]
Deficit volume of test piece with 50 mm cut: 0.69 cm^3
→ Deficit volume per 1mm cut: 0.0138 cm^3/mm

⇒

8176 × 0.0138 =112.8 [cm^3]



*For the sake of simplification, dimensions shown do not match the scale



Reference: Project of Development of Technology for Dust Collection System of Fuel Debris

Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (2/11)

- The following pages show a table of dynamic environmental changes inside the PCV during fuel debris processing using the operational equipment.
  Abbreviations used in the table are explained below.

[Dust collection]
Direct utilization of data from project of Development of Technology for Dust Collection System of Fuel Debris
[Investigation of dust collection]
Direct utilization of research results of other projects by Development of Technology for Dust Collection System of Fuel Debris Project
[Dust collection theory]
Utilization of theoretical calculation values from Development of Technology for Dust Collection System of Fuel Debris Project
[CRIEPI: Central Research Institute of Electric Power Industry]
Direct utilization of the knowledge of the Handbook on Environmental Impact Assessment for Decommissioning Work (third edition), Central Research Institute of Electric Power Industry, March 2007
[Internal investigation]
Direct utilization of knowledge from Development of Technology for Investigation inside the Reactor Pressure Vessel (RPV) Project
[Monitoring]
Settings with assumptions made by project of Development of Continuous Monitoring System in PCV
[Retrieval]
Direct use of project's knowledge in the Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals Project
[Note 1]
Due to lack of data, the mass balance for metal processing obtained from [CRIEPI] was applied

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (1/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	Fuel debris type	Assumed properties: Density [g/cm³]	Assumed properties: Compressive strength [MPa]	Assumed properties: Primary component	Assumed properties: Localized area	Assumed processing methods: Processing mode	Assumed processing methods: Equipment name	Assumed processing methods: Remarks	Dust particle size, Aerial processing (no anti-dispersion agent) ---	Dust particle size, Aerial processing (no anti-dispersion agent) [μm]	Dust particle size, Underwater processing ---	Dust particle size, Underwater processing [μm]	Total amount of dust generated: Aerial processing [g]	Total amount of dust generated: Underwater processing [g]	Mass balance and amount of dust migration, Aerial processing: Mass balance ---	Aerial processing: Mass balance ---	Aerial processing: Mass balance [%]	Aerial processing: Amount of dust migration [g]	Underwater processing: Mass balance ---	Underwater processing: Mass balance ---	Underwater processing: Mass balance [%]	Underwater processing: Amount of dust migration [g]	Amount of processing aid injected: Input materials	Amount of processing aid injected: Total amount of input	Amount of anti-scattering agent injected (Only for aerial processing): Input materials	Amount of anti-scattering agent injected (Only for aerial processing): Total amount of input	Others: Input materials	Others: Total amount of input
1	Fuel	11	[Characterization] Stump fuel: 230 Unmolten fuel: 280	[Characterization] UO2,Zry-2,(U,Zr)O2-C,(Zr,U)O2-T,Zr(O),Fe	Inside the RPV	Cutting	Disc cutter	Blade diameter: 200 mm Blade thickness: 1 mm Number of revolutions: 1000 rpm	Airborne	All in range of peak particle size [dust collection] 2 to 3 (mass concentration distribution) [Dust collection] 0.1 to 0.3 (number concentration and distribution)	Floating in water	[Dust collection theory] 50 or less	655.16	655.16	Airborne	[Dust collection]	6	39.3	Airborne	[Central Research Institute of Electric Power Industry]	2.00E-05	0.0	[Dust collection] [Aerial processing] Water: 1 L/min	198 L(*)	[Dust collection] (*) Mist: 0.05 L/min	9.9 L(*)	[Dust collection] Temperature of fuel debris during processing	102 °C
2									Sedimentation	All in median diameter [Dust collection] 0.5 (number distribution) [Dust collection] 32.3 (sediment distribution)	Sedimentation	[Dust collection theory] Above 50			Sedimentation	[Dust collection]	47	307.9	Sedimentation	[Central Research Institute of Electric Power Industry]	99.5	651.9						
3									---	---	---	---			Peripheral dispersion	[Monitoring]	47	307.9	Floating in water	[Monitoring]	0.5	3.3						
										No data																		
4						Cutting	AWJ	---		No data																		
5						Chipping	Laser gouging	---																				

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (2/9)

No.108

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected			Amount of anti-scattering agent injected (Only for aerial processing)			Others		
															Aerial processing				Underwater processing												
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration									
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input		Input materials	Total amount of input		Input materials	Total amount of input	
6	Mass of fuel debris	11	Craft and on the bedrock (upper section):2 000 Other than above mentioned : 230	[U-rich] (U,Zr)O2-C,(Zr,U)O2-T, [Fe-rich] UO2, Fe,Zry-2, α-Zr(O), SUS/Fe, Fe2(Zr,U), ZrB2, Fe2B, Zr(O), Fe2Zr	Pedestal inside the PCV (floor/inside/outside) drywell	Cutting	Disc cutter	Blade diameter: 200 mm Blade thickness: 1 mm Number of revolutions: 1000 rpm	Airborne	All in range of peak particle size [Dust collection] 2 to 3 (mass concentration distribution) [Dust collection] 0.1 to 0.3 (number concentration and distribution)	Airborne	Unknown	1242.1	1242.1	Airborne	[Dust collection]	4	49.7	Airborne	[Central Research Institute of Electric Power Industry]	2.00E-05	0.0	[Aerial processing] Water: 1 L/min	198	L (*)	[Dust collection] Mist: 0.05 L/min		L (*)	---	---	
7									Sedimentation	All in median diameter [Dust collection] 0.3 (number distribution) [Dust collection] 7.9 (sediment distribution)	Sedimentation	[Dust collection theory] Above 50			Sedimentation	[Dust collection]	37	459.6	Sedimentation	[Monitoring]	99.5	1235.9									
8									Peripheral dispersion	Either airborne/sedimentation	Floating in water	[Dust collection theory] 50 or less			Peripheral dispersion	[Monitoring]	59	732.9	Floating in water	[Central Research Institute of Electric Power Industry]	0.5	6.2									
9						Cutting	AWJ	---	No data																						
10						Chipping	Laser gouging	Processing speed: 2 m/min Irradiation beam diameter: approx. Φ5 mm Processing pitch: 2.5 mm Distance between workpieces: 40 mm	Airborne	[Base] 0.096 to 3.3	Airborne	Unknown	8938.6	8938.6	Airborne	[Investigation of dust collection]	0.009	0.8	Airborne	[Investigation of dust collection]	2.00E-03	0.2	[Base] [Both in air and underwater processing] Water: 36 L/min	7128	L (*)	---	---	---	[Base] [Both in air and underwater processing] 20 kW	3960	kJ (*)

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (3/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X / Y	Z	AA / AB	AC	AD / AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected		Amount of anti-scattering agent injected (Only for aerial processing)		Others	
									Aerial processing (no anti-dispersion agent)		Underwater processing				Aerial processing				Underwater processing									
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks					Aerial processing	Underwater processing	Mass balance		Amount of dust migration		Mass balance		Amount of dust migration							
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input	Input materials	Total amount of input
11	Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than above mentioned: 230	[U-rich] (U,Zr)O2-C,(Zr,U)O2-T, [Fe-rich] UO2, Fe,Zry-2, α-Zr(O), SUS/Fe, Fe2(Zr,U), ZrB2, Fe2B, Zr(O), Fe2Zr	Pedestal inside the PCV (floor/inside/outside) drywell	Cutting	Laser gouging	Processing speed: 2 m/min Irradiation beam diameter: approx. Φ5 mm Processing pitch: 2.5 mm Distance between workpieces: 40 mm	Sedimentation	[Base] Less than 4 mm, 250 μm to 1 mm is most dominant, followed by less than 250 μm	Sedimentation	[Base] Less than 4 mm, 250 μm to 1 mm is most dominant, followed by less than 250 μm	8938.6	8938.6	Sedimentation	[Investigation of dust collection]	91.8	8205.6	Sedimentation	[Investigation of dust collection]	91.1	8143.1	[Base] [Both in air and underwater processing] Water: 36 L/min	7128 L (*)	---	--- ---	[Base] [Both in air and underwater processing] 20 kW	3960 kJ (*)
12									Floating in water	[Dust collection theory] 50 or less	Floating in water	[Base] 0.096 to 1.1			Floating in water	[Investigation of dust collection]	8.1	724.0	Floating in water	[Investigation of dust collection]	8.2	733.0						
13									Underwater dissolution	---	Underwater dissolution	---			Underwater dissolution	[Investigation of dust collection]	0.05	4.5	Underwater dissolution	[Investigation of dust collection]	0.04	3.6						

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (4/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected			Amount of anti-scattering agent injected (Only for aerial processing)			Others		
															Aerial processing				Underwater processing												
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration									
		[g/cm³]	[MPa]						---	[µm]	---	[µm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input		Input materials	Total amount of input		Input materials	Total amount of input	
14	Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than above mentioned: 230	[U Rich] $(U,Zr)O_2$-C, $(Zr,U)O_2$-T, [Fe-rich] UO_2, Fe, Zry-2, α-Zr(O), SUS/Fe, $Fe_2(Zr,U)$, ZrB_2, Fe_2B, Zr(O), Fe_2Zr	Pedestal inside the PCV (floor/inside/outside) drywell	Crushing	Core boring	Jig type: Impregnated bits Number of revolutions: 150 to 300 rpm Drilling speed: 2.86 mm/min Diameter: Φ66 mm Feed pressure: 15 kN	Airborne	[Dust collection theory] 40 or less	Floating in water	Unknown	83922	83922	Airborne	[Investigation of dust collection]	0.003	2.4	Airborne	[Central Research Institute of Electric Power Industry]	2.00E-05	0.0	[Dust collection] [Aerial processing] Water: 1 L/min	1386	L (*)	Unknown	-	-	---	---	---
15									Sedimentation ①	SUS304; [125 µm or more] 125 to 500 µm is dominant [125 µm or less] 1 to 110 µm is dominant	Underwater migration	[Dust collection theory] 50 or less			Sedimentation	[Monitoring]	99.997	83919.9	Underwater migration	[Central Research Institute of Electric Power Industry]	0.5	419.6									
16									Sedimentation ②	Aluminum oxide; [125 µm or more] 125 µm is dominant [125 µm or less] 0.3 to 80 µm is dominant	Sedimentation	---[Dust collection theory] 50 or less			-	-	---	---	Sedimentation	[Monitoring]	99.5	83502.7									
17						Crushing	Chisel			No data																					

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (5/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

A B C D E F G H I J K L M N C P Q R S T U V W X Y Z AA AB AC AD AE

	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected		Amount of anti-scattering agent injected (Only for aerial processing)		Others	
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Aerial processing: Mass balance			Aerial processing: Amount of dust migration	Underwater processing: Mass balance			Underwater processing: Amount of dust migration						
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input	Input materials	Total amount of input
18	Existing structures	8	1300 Core support plate	Fe,B4C	Pedestal inside the PCV (floor/inside/outside)	Cutting	Disc cutter	Similar to matrix 1H	Airborne	All in range of peak particle size [Dust collection] 2 or more (mass concentration distribution) [Dust collection] 0.1 to 0.3 (number concentration and distribution)	Floating in water	[Monitoring] 45 or less	3407.9	3407.9	Airborne	[Dust collection]	7	113.2	Airborne	[Central Research Institute of Electric Power Industry]	2.00E-05	0.0	[Dust collection] [Aerial processing] Water: 1 L/min	198 L (*)	[Dust collection] [Aerial processing] Mist: 0.05 L/min	9.9 L (*)	---	--- ---
19									Sedimentation	All in median diameter [Dust collection] 0.5 (number distribution) [Dust collection] 41.5 (sediment distribution)	Sedimentation	[Monitoring] Above 45			Sedimentation	[Dust collection]	43	695.1	Sedimentation	[Monitoring]	99.5	1608.4						
20									Peripheral dispersion	Either airborne/sedimentation	---	---			Peripheral dispersion	[Monitoring]	50	808.2	Floating in water	[Central Research Institute of Electric Power Industry]	0.5	8.1						

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (6/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X Y	Z	AA	AB	AC	AD AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected		Amount of anti-scattering agent injected (Only for aerial processing)			Others	
															Aerial processing				Underwater processing										
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration							
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input		Input materials	Total amount of input
21	MCCI formations	8	1300 Core support plate	Fe,B4C	Pedestal inside the PCV (floor/inside/outside)	Cutting	AWJ	Jet pressure: 343 MPa Cutting speed: 50 mm/min Distance between workpieces: approx. 2 mm Nozzle angle: 0 deg	Airborne	[Monitoring] 20 or less	Floating in water	[Monitoring] 45 or less	2950	2950	Airborne	[Central Research Institute of Electric Power Industry]	2.E-05	0.0	Airborne	[Central Research Institute of Electric Power Industry]	2.00E-05	0.0	[Internal investigation] [Underwater processing] Water: 3.7 L/min	733 L (*)	---	---	---	Internal investigation] [Underwater processing] Garnet: 500 g/min	99 kg
22									Sedimentation	[Dust collection theory] Above 20	Sedimentation	[Monitoring] Above 45			Sedimentation	[Monitoring]	97	2861.5	Sedimentation	[Monitoring]	97	2861.5						Particle size [mm]:	
23									Floating in water	Unknown	---	---			Floating in water	[Central Research Institute of Electric Power Industry]	3	88.5	Floating in water	[Central Research Institute of Electric Power Industry]	3	88.5						Mesh width 0.18 mm (nominal), less than 0.45 mm	
24						Chipping	Laser gouging	With water flow as processing aid	No data																				

Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (9/11)

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (7/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected			Amount of anti-scattering agent injected (Only for aerial processing)			Others		
															Aerial processing				Underwater processing												
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration									
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input		Input materials	Total amount of input		Input materials	Total amount of input	
25	MCCI formations	3.86	22	(U,Zr)O2-C,(Zr,U)O2-T, Al-Ca-Si-O,Fe,SiO2,(Zr, U)SiO4	Pedestal floor drywell	Cutting	Disc cutter	Cutter size, number of revolutions	Airborne	All in range of peak particle size [Dust collection] 2 to 3 (mass concentration distribution) [Dust collection] 0.1 to 0.3 (number concentration and distribution)	Floating in water	[Dust collection]: 0.5 (number distribution) [Dust collection]: 5.2 (volume distribution)	3407.9	3407.9	Airborne	[Dust collection]	6	204.5	Airborne	[Central Research Institute of Electric Power Industry] Note 1	2.00E-05	0.0	[Dust collection] [Aerial processing] Water: 1 L/min	198	L (*)	[Dust collection] [Aerial processing] Mist: 0.05 L/min	9.9	L (*)	---	---	---
26									Sedimentation	All in median diameter [Dust collection] 0.6 (number distribution) [Dust collection] 8.4 (sediment distribution)	Sedimentation	[Dust collection theory] Above 50			Sedimentation	[Dust collection]	37	1260.9	Sedimentation	[Central Research Institute of Electric Power Industry] Note 1	99.5	3390.8									
27									Peripheral dispersion	Either airborne/sedimentation	---	---			Peripheral dispersion	[Monitoring]	57	1942.5	Floating in water	[Monitoring] Note 1	0.50	17.0									

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (8/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected			Amount of anti-scattering agent injected (Only for aerial processing)			Others		
															Aerial processing				Underwater processing												
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration									
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input		Input materials	Total amount of input		Input materials	Total amount of input	
28	Existing structures	8	1300 Core support plate	Fe,B 4C	Pedestal floor drywell	Cutting	AWJ	---	No data																						
29						Chipping	Laser gouging	---	No data																						
30						Crushing	Core boring	---	No data																						
31						Crushing	Chisel	Jig type: Air drive system Blows per minute: 1250 bpm Total Length: 480 mm Jig arrangement: 2 chisels in parallel operation	Airborne	[Dust collection theory] 40 or less	Floating in water	[Dust collection theory] 150 or less	36289	36289	Airborne	[Monitoring]	2.65	961.7	Airborne	[Monitoring]	1.07	388.3	---	---	----	Unknown	---	---	---	---	---
32									Sedimentation	[Monitoring] 10 mm Less than	Sedimentation	[Monitoring] Less than 10 mm			Sedimentation	[Monitoring]	97.35	35327.7	Sedimentation	[Monitoring]	98.93	35901.1									

Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (9/9)

* Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
	Fuel debris type	Assumed properties				Assumed processing methods			Dust particle size,				Total amount of dust generated		Mass balance and amount of dust migration								Amount of processing aid injected			Amount of anti-scattering agent injected (Only for aerial processing)			Others		
															Aerial processing				Underwater processing												
		Density	Compressive strength	Primary component	Localized area	Processing mode	Equipment name	Remarks	Aerial processing (no anti-dispersion agent)		Underwater processing		Aerial processing	Underwater processing	Mass balance			Amount of dust migration	Mass balance			Amount of dust migration									
		[g/cm³]	[MPa]						---	[μm]	---	[μm]	[g]	[g]	---	---	[%]	[g]	---	---	[%]	[g]	Input materials	Total amount of input		Input materials	Total amount of input		Input materials	Total amount of input	
33	With neutron absorbent (TX-10) MCCI formations	2.1	---	[Neutron absorbent] Sodium silicate1, cement, primary sodium phosphate, water, gadolinium oxide	Sprayed on fuel debris	Crushing	Chisel	Jig type: Electric flat chisel Width: 32 mm Impact force: 20 J/time Full load blows per minute: 2200 bpm Crushing depth: approx. 5 cm	---	---	Floating in water	[Retrieval] 0.48 μm *With neutron absorbent	---	---	-	-	---	---	-	-	---	---	---	---	-	---	---	---	[Retrieval] Amount of neutron absorbent injected	3	L

Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (1/14)

(i) Static environmental changes inside the PCV

- The amount of gas and radioactive leakage from the PCV, which is a control parameter for the static boundary function, depends on the size of the PCV opening. Therefore, an increase in the size of the PCV opening is extracted as one of the risks in the section of the Study of the safety equipment model.
- It is conceivable that deterioration events for PCV under static environment may increase the size of the opening of existing damaged sections and generate new damaged sections.
- Corrosion phenomena are cited as static environmental changes that cause these deterioration events.
- Since the inside of the PCV is in a highly humid environment, it is expected that the liquid film will adhere to the walls in the gas phase and corrosion of the PCV wall surface will occur not only in the liquid phase where stagnant water exists and at the gas-liquid interface, but also in the gas phase.
- Therefore, the previous findings on corrosion phenomena assumed inside the PCV will be investigated, and based on the investigation results, whether corrosion phenomena can be extracted as an important monitoring item or not will be studied.

Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (2/14)

(i) Static environmental changes inside the PCV

(a) Investigation results of previous findings (① Corrosion behavior of carbon steel in the liquid phase section)

- In the liquid phase, 4.4 kGy/h gamma radiation increased the corrosion weight loss of carbon steel by 1.7 times compared to the non-irradiation condition, and 0.2 kGy/h gamma radiation was almost the same as the non-irradiated conditions. [1](Figure 1)

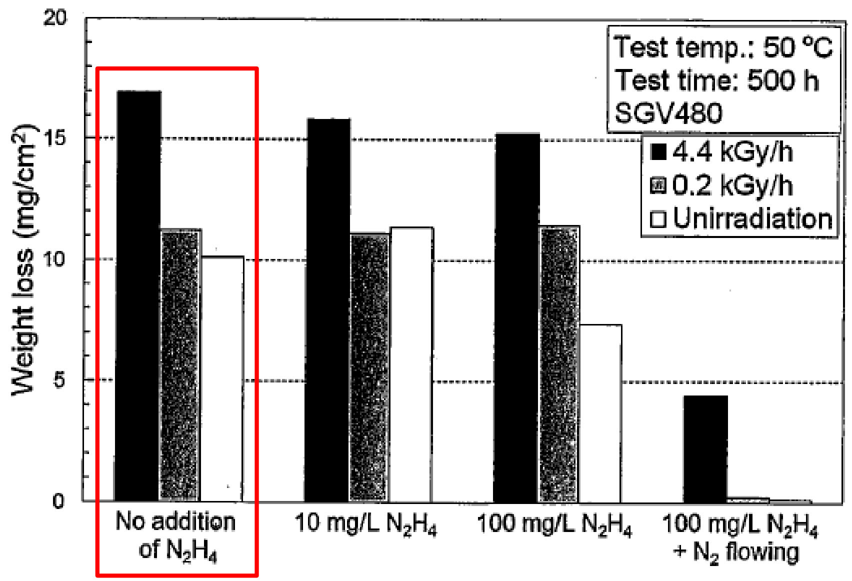


Figure 1 Effect of gamma radiation on corrosion rate of carbon steel (50° C) [1]

(Source) 1) Nakano et al., *Corrosion of carbon steel and low-alloy steel in diluted seawater containing hydrazine under gamma-rays irradiation*, Journal of Japanese Papers of Japan Atomic Energy Agency (In Japanese), 13, 1, pp.1-6, 2014.

(i) Static environmental changes inside the PCV

(a) Investigation results of previous findings (② Corrosion behavior of carbon steel in the area of liquid film adhesion in the gas phase section)

- It was verified that the corrosion rate increases when the liquid film thickness is approximately 10 to 100 μm when in the gas phase environment with liquid film adhesion. [2)~4)](Figure 2)
- In a corrosion test in a gamma radiation environment in which a liquid film adhered to the inner surface of a cylindrical container, the maximum corrosion depth under the liquid film corrosion environment in the gas phase is approximately 1.9 times that of the liquid phase. It was verified that the maximum corrosion depth under the liquid film corrosion environment in the gas phase is approximately 1.8 times at 4 kGy/h and approximately 1.5 times at 0.2 kGy/h that of the non-irradiated conditions due to the superimposed irradiation. [5)6)]

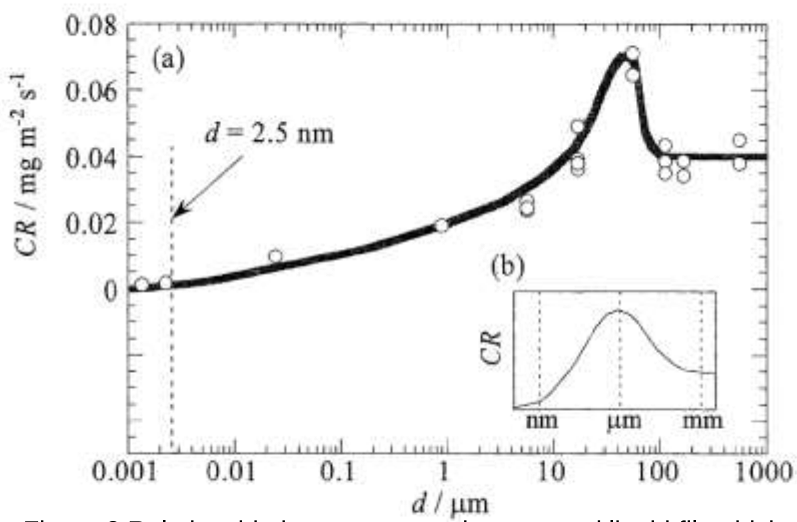


Figure 2 Relationship between corrosion rate and liquid film thickness (a) Data from Hosoya et al. (b) Tomashov's model [2)]

(Source)
2) Hosoya et al., *Zairyo-to-Kankyo* (Materials and the Environment)(in Japanese), 54, pp.391-395, 2005.
3) Katayama et al., *Relationship between corrosion rate of steel and water film thickness under thin layer of artificial seawater*, Journal of Japan Institute of Metals, 65, 4, pp. 298–302, 2001.
4) Yamamoto et al., *Continuous Corrosion Rate Measurement of Carbon Steel in Outdoor Environment Using AC-Impedance Method* , Journal of Japan Institute of Metals, 65, 6, pp.465–469, 2001.
5) Tsuchiya et al., “Corrosion evaluation of carbon steel piping in gas-liquid humid environment,” *Zairyo-to-Kankyo* (Materials and the Environment) 2021, A-106, 2021.
6) Tsuchiya et al., “Impact Assessment of Irradiation Effects on Corrosion Behavior of Carbon Steel Under Atmospheric Humidity,” 68th Symposium on Materials and the Environment 2021, C-112, 2021.

(i) Static environmental changes inside the PCV

(a) Investigation results of previous findings (③ Corrosion behavior of carbon steel at the gas-liquid interface)

- In the semi-immersion test, it was verified that the corrosion rate near the gas-liquid interface was 2.8 to 3.0 times greater than that in the liquid phase, and the irradiation increased the corrosion rate at the gas-liquid interface by 1.61 times. [7](Figure 3)

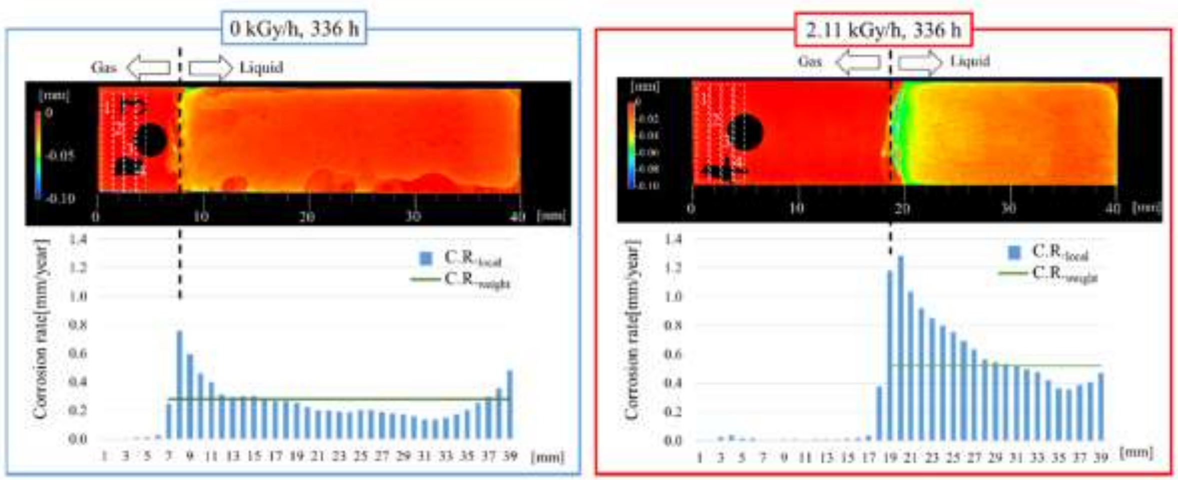


Table 1 Estimation of water film and irradiation effects on corrosion rates

mm/year	Water film effect	0 kGy/h	Irradiation effect	2.11 kGy/h	Water film effect
$C.R._{weight}$ Full immersion	×2.8	0.255	×1.65	0.421	×3.0
$C.R._{local}$ At water line		0.795	×1.61	1.28	

Figure 3 Results of corrosion rate evaluation of the test piece in each region under irradiation (2.11 kGy/h) and non-irradiated conditions after 336h[7]

(Source) 7) Abe et al., “Corrosion Rate and Long-term Prediction of Carbon Steel at Water Line under Gamma Ray Irradiation,” 67th Symposium on Materials and the Environment 2020, A-309, 2020.

(i) Static environmental changes inside the PCV

(a) Investigation results of previous findings (③ Corrosion behavior of carbon steel at gas-liquid interface)

- In a corrosion test in a gamma radiation environment in which a liquid film adhered to the inner surface of a cylindrical container, the maximum corrosion depth of the gas-liquid interface in a non-irradiation environment was approximately 5.7 times that of the liquid phase. It was verified that the maximum corrosion depth at the gas-liquid interface is approximately 1.7 times greater at 4 kGy/h and approximately 1.2 times greater at 0.2 kGy/h due to the superimposed irradiation. [6)] (Figure 4)
- It was verified that the corrosion rate in air-solution alternating condition is 3 to 5 times greater than that in the liquid phase. In addition, it was verified that the corrosion rate in air-solution alternating condition does not increase linearly with increasing oxygen concentration in the air, and that the slope in the low concentration range (0 to 5%) is greater than that in the high concentration range (5 to 20.8%). [8)9)]

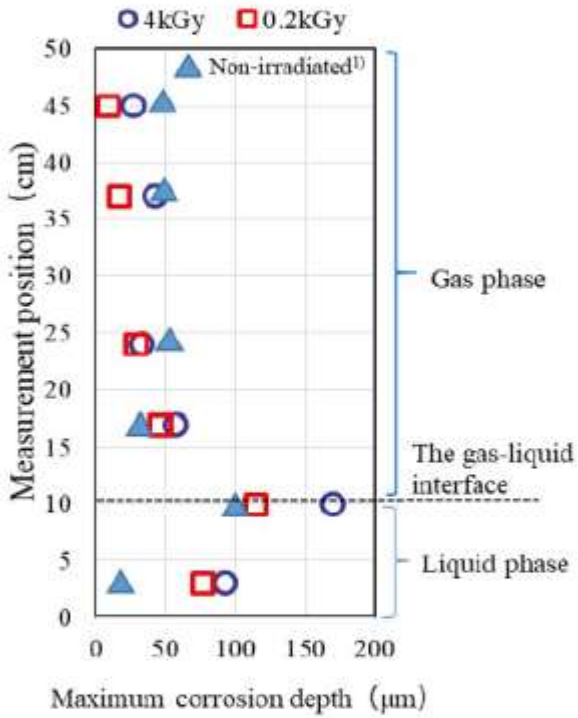


Figure 4 Relationship between cylindrical container height and maximum erosion depth (gamma radiation, 500h) [6)]

(Source)

6) Tsuchiya et al., "Impact Assessment of Irradiation Effects on Corrosion Behavior of Carbon Steel Under Atmospheric Humidity," 68th Symposium on Materials and the Environment 2021, C-112, 2021.
8) Ohtani et al., "Effects of seawater components on corrosion rate of steel in air/solution alternating condition," *Zairyo-to-Kankyo* (Materials and the Environment), 69, pp.246-252, 2020.
9) Ohtani et al., "Effect of oxygen concentration on corrosion rate of carbon steel in air/solution alternating condition," 67th Symposium on Materials and the Environment 2020, A-308, 2020.

(i) Static environmental changes inside the PCV

(b) Summary of investigation results of previous findings and data expansion policy,

- It was shown that the corrosion rate of the gas phase section under liquid film adhesion increased by approximately 1.9 times that of the liquid-phase section, and furthermore, there is a possibility that the superimposed irradiation may increase the corrosion rate by up to approximately 1.8 times. Based on the corrosion rate in the liquid phase, there is a possibility that the corrosion rate may increase by approximately 3.4 times in an irradiation environment with liquid film adhesion.
- It was shown that the corrosion rate at the gas-liquid interface increased by a maximum of approximately 5.7 times that of the liquid phase, and furthermore, there is a possibility that the superimposed irradiation may increase the corrosion rate by up to 1.7 times. Based on the corrosion rate in the liquid phase, there is a possibility that the corrosion rate may increase by approximately 9.7 times at the gas-liquid interface in an irradiation environment.
- Considering these increased corrosion rates, it is possible that the PCV wall, which is the boundary, could rapidly erode and thin out, and the corrosion phenomenon could potentially be a factor that impedes fuel debris retrieval operations.
- In this project, some material tests will be conducted for the purpose of verifying the previous findings, and based on the expanded findings and the results of the investigation of previous findings, corrosion events will be examined to see if they can be extracted as important monitoring items.

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

- From the results of the investigation of previous findings in item (i), it was verified that the corrosion rate increases when there is a liquid film on the surface.
- On the other hand, there are many unclear points about corrosion behavior in the presence of a thin liquid film in an irradiation environment.
- Therefore, in order to evaluate the effect of irradiation dose rate on the corrosion behavior of carbon steel in the presence of a thin liquid film, a corrosion test under γ-ray irradiation was conducted on test pieces with a liquid film of a certain thickness formed on the surface.

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

➢ Test conditions

- Test material: carbon steel (JIS G 3118 SGV480) (Table 1, Figure 5)
- Temperature: room temperature
- Time: 50, 100, 500 h
- Dose rate (gamma rays): 0, 0.2, 3 kGy/h
- Liquid film thickness: 0.4, 4, 30, 40 μm (control method is described below)
- External appearance of test equipment: See Figure 6

Table 1 Chemical composition of test material (wt.%)

Type of steel	C	Si	Mn	P	S
JIS G 3118 SGV480	≦ 0.27	0.15 ~0.40	0.85 ~1.20	≦ 0.020	≦ 0.020
Analyzed value	0.10	0.16	1.43*	0.014	0.003

*: "For every 0.01% decrease in the upper limit of C, the upper limit of Mn may be increased by 0.06%. However, JIS states, "the maximum value of Mn is 1.60%," and this satisfies the standard.

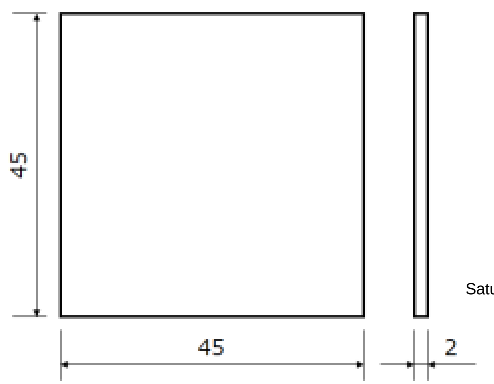


Figure 5 Shape of test piece

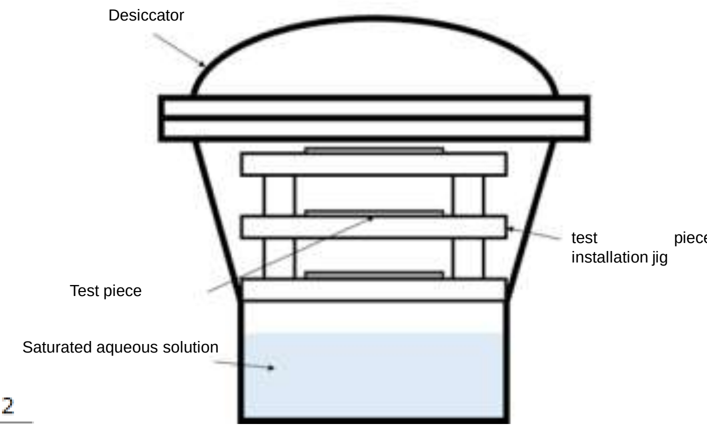


Figure 6 Illustration of test equipment

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

- Method of controlling liquid film thickness
  - Controlled by the amount of sea salt particles adhering to the surface of the test piece and the relative humidity inside the test container (Figures 7 and 8)
  - When a saturated aqueous solution of salt is present in a sealed container, it is possible to create an atmosphere of constant relative humidity depending on the type of salt (Table 2)

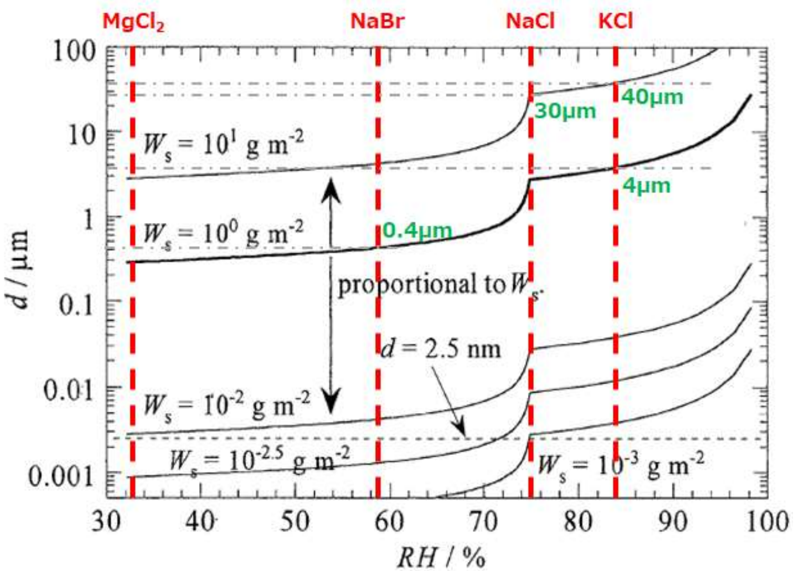


Fig. 7 Evaluation results of liquid film thickness when sea salt particle adhesion and relative humidity are varied[2)]

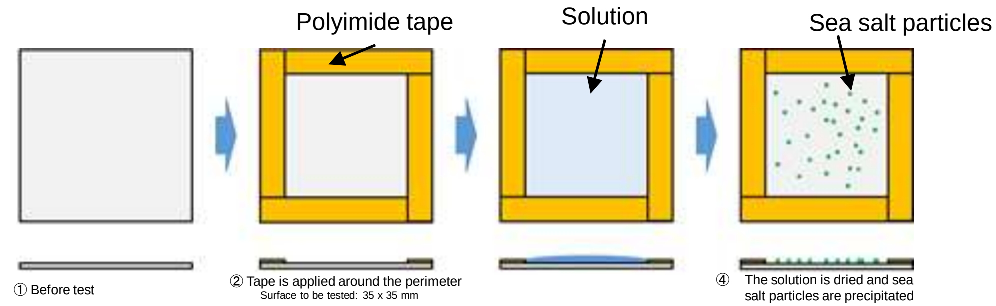


Figure 8 Sea salt particle adhesion procedure

Table 2 Measured values of various salts at a fixed point of humidity in the test matrix[10)]

Table 1 Relative humidity values of the humidity fixed point at 22.3℃

	$MgCl_2$	NaBr	NaCl	KCl
Relative humidity (measured)	33.2 ±0.2	58.6 ±0.4	75.3 ±0.5	84.2 ±0.5
Relative humidity (literature)	32.93±0.17	58.36±0.42	75.39±0.13	84.73±0.28
difference	0.3	0.2	−0.1	−0.5

(Source) 2) Hosoya et al., *Zairyo-to-Kankyo* (Materials and the Environment), 54, pp.391-395, 2005.
10) Kitano et al., *A Method to Realize Humidity Fixed Points by Saturated Salt Solutions*, Transactions of the Society of Instrument and Control Engineers, 23, 12, pp.1246-1253, 1987.

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

➢ Test matrix

Table 3 Test matrix

No.	Test piece	Temperature	Dose rate (kGy/h)	Relative humidity (%)	Sea salt particle adhesion amount (g/m²)	Liquid film thickness (μm)	Test duration (h)	Number of N
1	SGV480 Slab	Room temperature	0 (non-irradiated)	59	1	0.4	50	3
2				84	1	4		
3				75	10	30		
4				84	10	40		
5				59	1	0.4	100	3
6				84	1	4		
7				75	10	30		
8				84	10	40		
9				59	1	0.4	500	3
10				84	1	4		
11				75	10	30		
12				84	10	40		
13			0.2	59	1	0.4	500	3
14				84	1	4		
15				75	10	30		
16				84	10	40		
17			3	59	1	0.4	500	3
18				84	1	4		
19				75	10	30		
20				84	10	40		

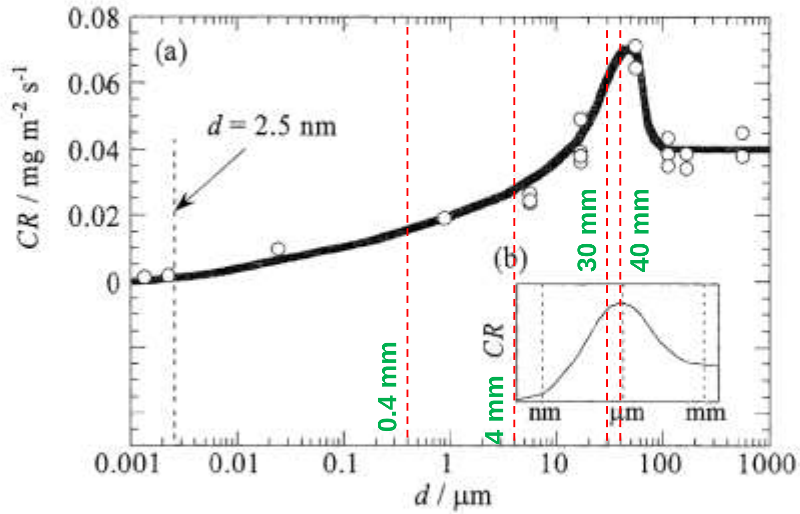


Figure 9 Comparison of target liquid film thickness and previous findings[2)]

➢ Evaluation on the effect of liquid film thickness on the amount of corrosion by setting the liquid film thickness as a parameter (Figure 9)

➢ Evaluation on the effect of irradiation dose on the amount of corrosion by setting the irradiation dose as a parameter

(Source) 2) Hosoya et al., *Zairyo-to-Kankyo* (Materials and the Environment), 54, pp.391-395, 2005.

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

➤ Corrosion test results under non-irradiated conditions

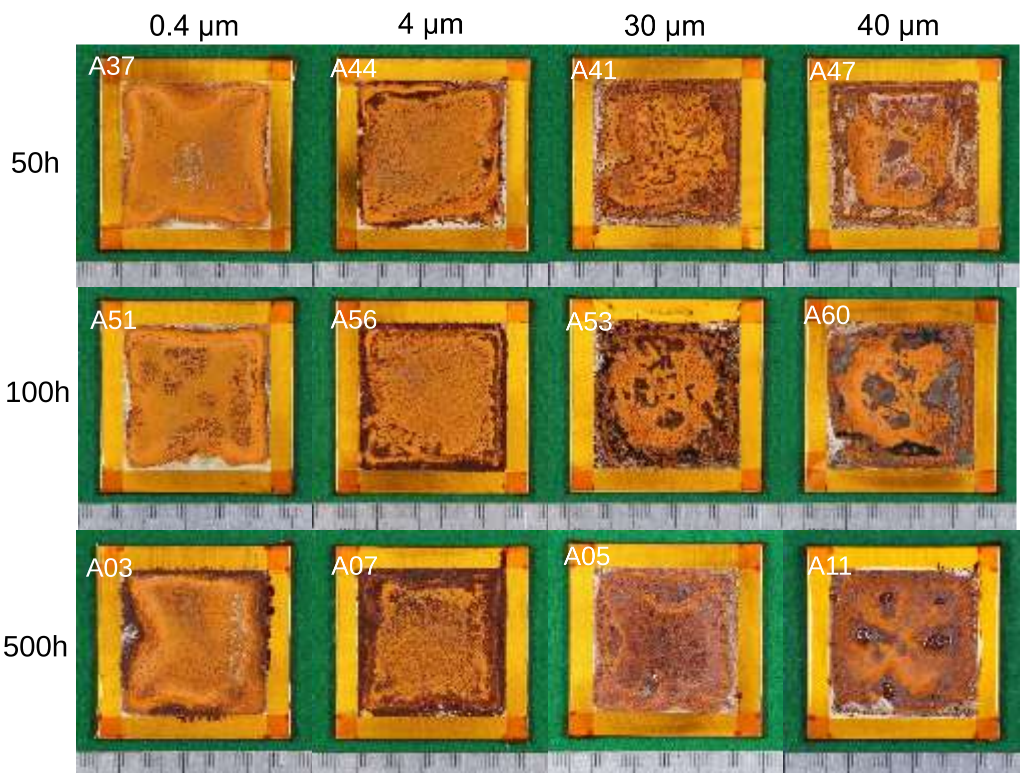


Figure 10 Results of visual observation after corrosion test in non-irradiation environment (typical example)

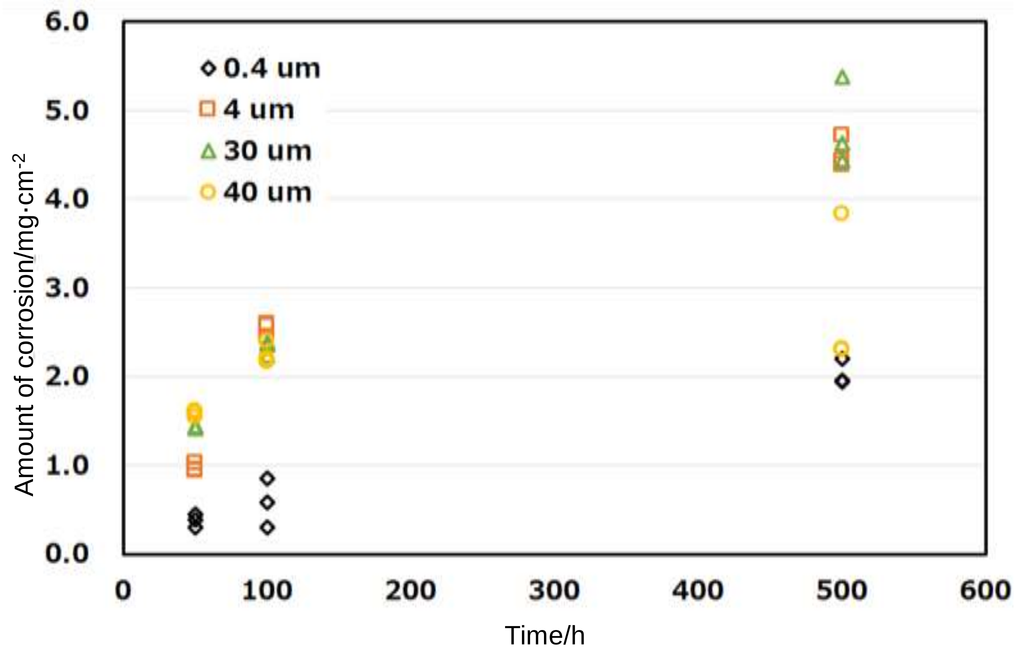


Fig. 11 Amount of corrosion over time under non-irradiated conditions

➤ The amount of corrosion increased with increasing test time, regardless of the liquid film thickness (Figure 11)

➤ The amount of corrosion increased at 4 μm and 30 μm.

(ii) Status of studies related to corrosion evaluation of structures

(a) Corrosion test

- Corrosion test results under irradiated conditions (500h)

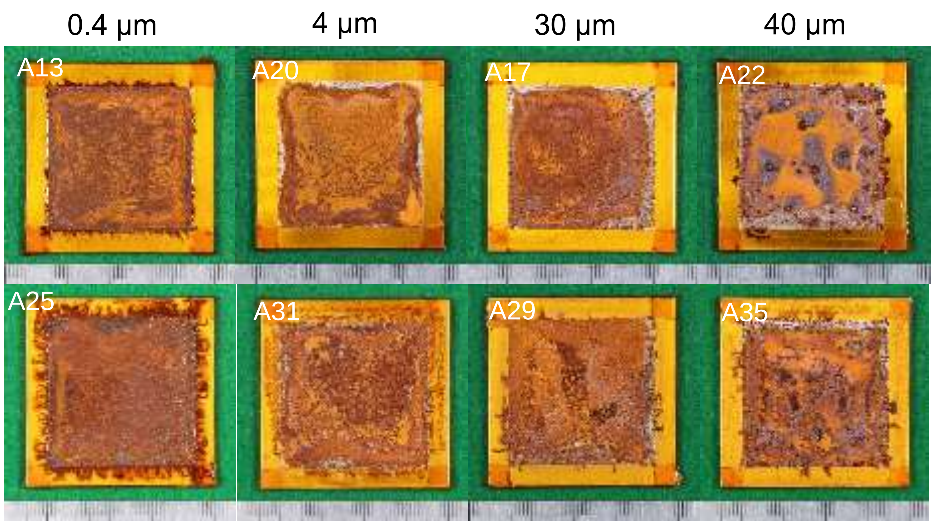


Figure 12 Results of visual observation after corrosion test in irradiation environment (typical example)

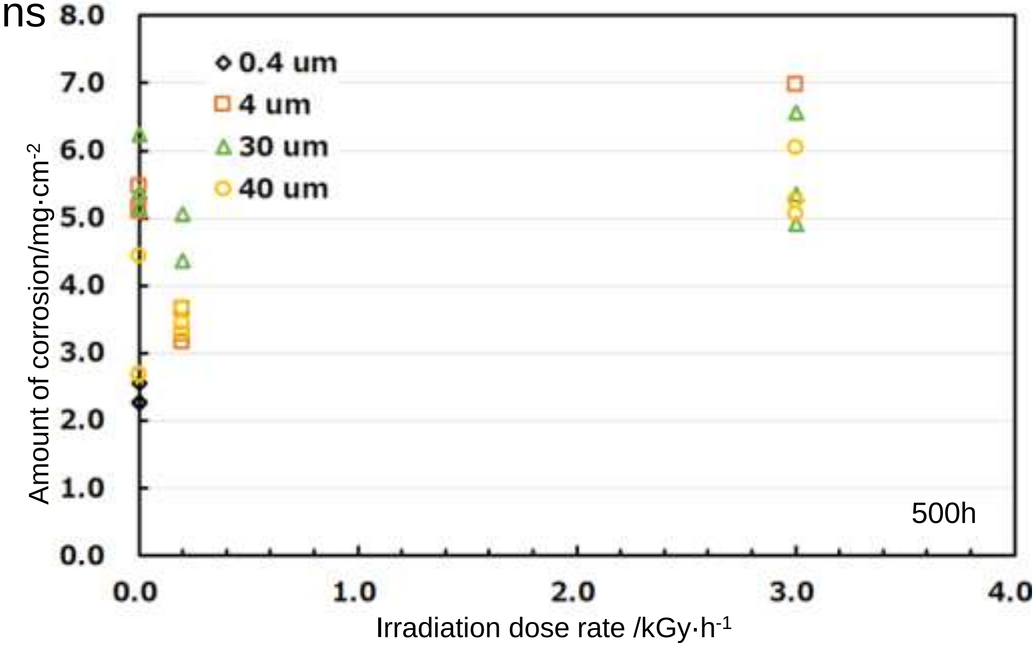


Figure 13 Estimated amount of corrosion in irradiation environment (Revised at 25° C)

- Comparing dose rates of 0.2 kGy/h and 3 Gy/h, the amount of corrosion at 3 kGy/h is approximately 1.2 to 2 times larger, verifying that corrosion accelerates as the dose rate increases (Figure 13)

(ii) Status of studies related to corrosion evaluation of structures

(b) Corrosion evaluation of structures

- Comparing the corrosion test results in a non-irradiation environment with previous findings [2)], the values at 30 μm and 40 μm were lower than the conventional knowledge (Figure14)
- 30 to 40 μm is the thickness of the liquid film near the transition zone where the amount of corrosion increases in the previous findings. Since the actual measurement of the liquid film thickness was not verified in this test, it is considered that the results were not necessarily match the previous findings[2)].
- On the other hand, several previous findings have shown that the corrosion rate accelerates under the condition where a thin liquid film adheres, so corrosion in a gas phase environment with a liquid film adhesion is a subject that should be watched carefully.

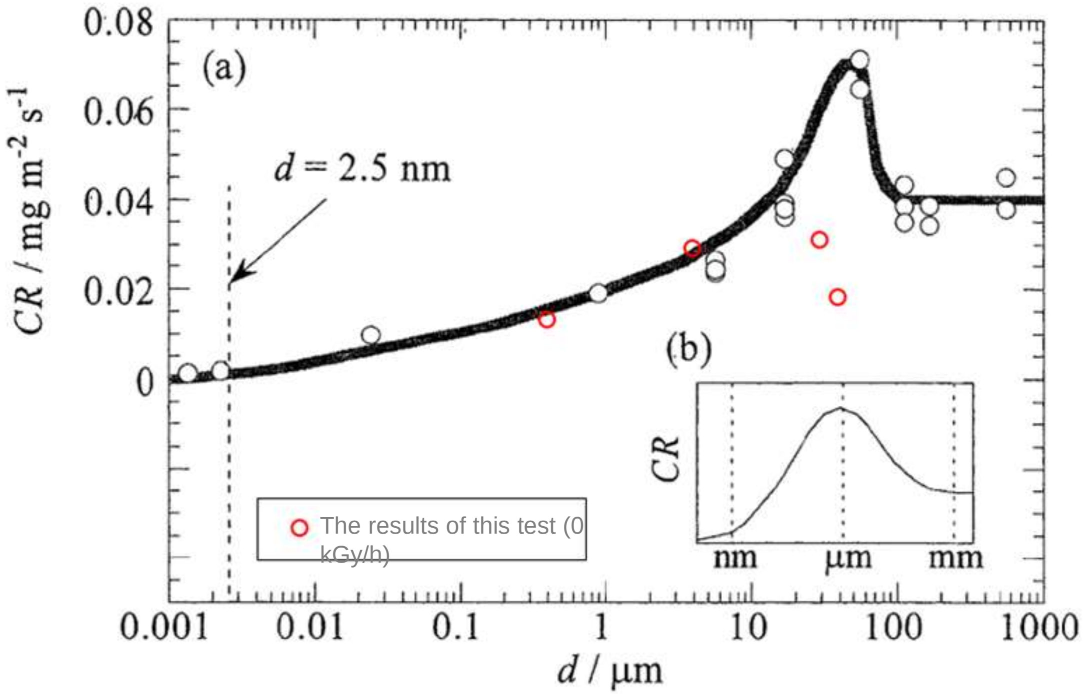


Figure 14 Relationship between corrosion rate and liquid film thickness (this test result is over plotted)
(a) Data from Hosoya et al. (b) Tomashov's model [2)]

(Source) 2) Hosoya et al., *Zairyo-to-Kankyo* (Materials and the Environment), 54, pp.391-395, 2005.

(ii) Status of studies related to corrosion evaluation of structures

(b) Corrosion evaluation of structures

- Regarding the irradiation effect in a gas phase environment with a liquid film adhesion, when the irradiation effect was examined based on 0.2 kGy/h, it was found that the corrosion rate accelerated by approximately 1.2 to 2 times at 3 kGy/h (See Figure 13 above).
    - In the liquid phase, it was verified that there was almost no difference in corrosion rate between non-irradiated and 0.2 kGy/h, and a 1.5-fold increase in corrosion rate was observed between 0.2 kGy and 4.4 kGy/h (see Figure 1 above[1])).
    - In the gas-liquid interface, it was verified that an approximately 1.6-fold increase in corrosion rate was observed between the non-irradiation and 2.11 kGy/h. (see Fig. 3 above[7)]).
- The acceleration magnification by irradiation verified in this test was comparable to the previous findings.

Based on the results of the investigation of previous findings and the results of the corrosion test, it is expected that the corrosion rate in actual PCV will be significant at areas of thin liquid film adhesion in the gas-phase section and at the gas-liquid interface. Therefore, when verifying the state of corrosion of structures, it is desirable to extract monitoring items focusing on corrosion in these areas.

(Source) 1) Nakano et al., *Corrosion of carbon steel and low-alloy steel in diluted seawater containing hydrazine under gamma-rays irradiation*, Journal of Japanese Papers of Japan Atomic Energy Agency (In Japanese), 13, 1, pp.1-6, 2014.
7) Abe et al., "Corrosion Rate and Long-term Prediction of Carbon Steel at Water Line under Gamma Ray Irradiation," 67th Symposium on Materials and the Environment 2020, A-309, 2020.

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (1/12)

■ Extraction methods from the risk assessment table

Analysis number	Important monitoring items								
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements
An-Ki-1	HEPA filter	Reduction of dust concentration	Acceleration of deterioration of dust concentration reduction function inside the PCV	The effective flow path area of the HEPA filter is reduced and the filter performance cannot be maintained	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure, and this tendency is affected by the amount and particle size distribution of the dust flowing in.
	Same as above	Same as above	Same as above	Same as above			(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)	

Extracted from Item 6 (Detection requirements) and replace names and important monitoring items

■ Safety equipment (gas phase confinement equipment)

This number is linked to Appendix 6.2.4.3-2

Table. Important monitoring items for gas phase confinement equipment in "Model ID Sa-4: Processing of debris" (1/2)

Analysis number	Important monitoring items
An-Ki-1, 4, 6, 8, 31, 33, 48, 51, 53, 55	HEPA filter differential pressure
An-Ki-1,28,48	Amount and particle size distribution of dust at HEPA filter inlet
An-Ki-2,3,29,30,49,50,	Dust concentration ratio on upstream/downstream sides of HEPA filter
An-Ki-2,29,49	Amount and chemical properties of dust at HEPA filter inlet (pH, chloride ion concentration, chemical composition)
An-Ki-3,10,30,50	Amount and nuclide composition of dust at HEPA filter inlet
An-Ki-4,6,31,33,51,53	Amount of mist at HEPA filter inlet
An-Ki-5,7,9,32,34,52,54,56	Relative humidity at HEPA filter inlet
An-Ki-5,7,32,34	Amount of mist sprayed at processing point
An-Ki-8,55	Amount and particle size distribution of abrasives at HEPA filter inlet
An-Ki-9,13,37,56,60	Amount of heat input at processing point

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (2/12)

■ Safety equipment (gas phase confinement equipment)

This number is linked to Appendix 6.2.4.3-2

Table. Important monitoring items for gas phase confinement equipment in "Model ID Sa-4: Processing of debris" (2/2)

Analysis number	Important monitoring items
An-Ki-10,11,12,13,57,58,59,60	Temperature differential before and after the electric heater
An-Ki-11,12,58,59	Amount of mist at electric heater inlet
An-Ki-14,15	Differential pressure between inside and outside of the PCV
	Amount and chemical properties (pH, chloride ion concentration) of mist flying to the PCV wall near the D/W water surface
An-Ki-16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27	Differential pressure between inside and outside of the PCV + pressure inside the system
An-Ki-16	Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at filter casing inlet
An-Ki-17	Amount and nuclide composition of dust at filter casing inlet
An-Ki-18,19	Amount of mist at filter casing inlet
An-Ki-20, 24	Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at exhaust line inlet
An-Ki-21,25	Amount and nuclide composition of dust at exhaust line inlet
An-Ki-22,23,26,27	Amount of mist at exhaust line inlet
An-Ki-28	HEPA filter differential pressure + differential pressure between inside and outside of the PCV
An-Ki-35,36,37	Airflow rate of exhauster
An-Ki-35	Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at exhauster inlet
An-Ki-36	Amount and nuclide composition of dust at exhauster inlet
An-Ki-38,39,40,41,42	Demister differential pressure + differential pressure between inside and outside of the PCV
An-Ki-38	Amount and particle size distribution of dust at demister inlet
An-Ki-39	Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at demister inlet
An-Ki-40	Amount and nuclide composition of dust at demister inlet
An-Ki-41,42	Amount of mist at demister inlet
An-Ki-43,44,45,46,47	Differential pressure of dry backwash filter + differential pressure between inside and outside of PCV
An-Ki-43	Amount and particle size distribution of dust at dry backwash filter inlet
An-Ki-44	Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at dry backwash filter inlet
An-Ki-45	Amount and nuclide composition of dust at dry backwash filter inlet
An-Ki-46,47	Amount of mist at dry backwash filter inlet
An-Ki-52	Amount of processing aid (mist) sprayed at processing point
An-Ki-54	Amount of anti-dispersion agent (mist) sprayed at processing point
An-Ki-57	Amount and nuclide composition of dust at electric heater inlet

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (3/12)

■ Safety equipment (liquid phase confinement equipment)

This number is linked to Appendix 6.2.4.3-2

Table. Important monitoring items for liquid phase confinement equipment in “Model ID Sa-4: Processing of debris”

Analysis number	Important monitoring items
An-Eki-1.2.3.4.5.7	D/W stagnant water transfer pump flow rate
An-Eki-1	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the D/W stagnant water transfer pump
An-Eki-2,3	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the D/W stagnant water transfer pump
An-Eki-4,5,7	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the D/W stagnant water transfer pump
An-Eki-6,13	Water temperature inside the PCV
	Amount of heat input at processing point
An-Eki-8,9,10,11,12,14	PCV stagnant water discharge pump flow rate
An-Eki-8	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the PCV stagnant water discharge pump
An-Eki-9,10	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the PCV stagnant water discharge pump
An-Eki-11,12,14	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the PCV stagnant water discharge pump
An-Eki-15	D/W water level
	Chemical properties (pH, chloride ion concentration, chemical composition) of D/W wall in liquid phase
An-Eki-16,19	Flow rate in the system
An-Eki-16	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the piping
An-Eki-17,24,25	Flow rate in the system + amount of leakage
An-Eki-17	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the liquid system
An-Eki-18, 20, 21	Flow rate in the system + leak detection
An-Eki-18, 20, 22	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the liquid system
An-Eki-19	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the piping
An-Eki-21,26	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the liquid system
An-Eki-22	PCV stagnant water buffer tank water level + leak detection
An-Eki-23,26	Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment
An-Eki-23,24	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment
An-Eki-25	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (4/12)

No.133

■ Safety equipment (cooling equipment)

This number is linked to Appendix 6.2.4.3-2

Table. Important monitoring items for cooling equipment in "Model ID Sa-4: Processing of debris"

Analysis number	Important monitoring items
An-Rei-1,2,3,4	D/W stagnant water transfer pump flow rate
An-Rei-1	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the D/W stagnant water transfer pump inlet
An-Rei-2	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the D/W stagnant water transfer pump inlet
An-Rei-3	Amount of abrasives in the transferring liquid flowing into the D/W stagnant water transfer pump inlet
An-Rei-4	Amount, particle size distribution, and particle density of abrasives in the coolant flowing into the D/W stagnant water transfer pump
An-Rei-5,11	Water temperature inside the PCV
	Amount of heat input at processing point
An-Rei-6,7	Cooler inlet/outlet temperatures
An-Rei-6	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the cooler inlet
An-Rei-7	Amount of abrasives flowing into the cooler inlet
An-Rei-8,9,10,12	PCV stagnant water injection pump flow rate
An-Rei-8	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the PCV stagnant water injection pump inlet
An-Rei-9	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the PCV stagnant water injection pump inlet
An-Rei-10	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the PCV stagnant water injection pump
An-Rei-12	Amount of abrasives in the transferring liquid flowing into the PCV stagnant water injection pump
An-Rei-13	Amount of water in the PCV stagnant water buffer tank + amount of leakage
An-Rei-13,16,18	Chemical properties (pH, chloride ion concentration, chemical composition) of the coolant flowing into the liquid system
An-Rei-14,17	Flow rate in the system
An-Rei-14	Amount, particle size distribution, and particle density of dust in the coolant flowing into the piping
An-Rei-15,16,18,19,21,22	Flow rate in the system + amount of leakage
An-Rei-15	Amount, particle size distribution, and particle density of dust in the coolant flowing into the liquid system
An-Rei-17	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the piping
An-Rei-19,23	Amount, particle size distribution, and particle density of abrasives in the coolant flowing into the liquid system
An-Rei-20, 23	Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment
An-Rei-20, 21	Amount, particle size distribution, and particle density of dust in the coolant flowing into the D/W stagnant water coarse particle removal equipment
An-Rei-22	Chemical properties (pH, chloride ion concentration, chemical composition) of the coolant flowing into the D/W stagnant water coarse particle removal equipment

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (5/12)

■ Safety equipment (liquid phase/sub-criticality maintenance equipment)

This number is linked to Appendix 6.2.4.3-2

Table. Important monitoring items for liquid phase/sub-criticality maintenance

Analysis number	Important monitoring items
An-Rin-1,2,3,4,5,6,7	Amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment
An-Rin-1	Amount of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment
An-Rin-2,4	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment
An-Rin-3	Chemical properties (pH, chloride ion concentration, chemical composition) of the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment
An-Rin-5	Amount of abrasives in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment
An-Rin-6,7	Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (6/12)

■ Operational equipment

Table. Important monitoring items for operational equipment in “Model ID Sa-1: Verification of the overall situation inside the PCV, and operational/safety equipment”

Analysis number	Important monitoring items
---	No important monitoring items due to the environment inside the PCV

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-2: Approaching the object to be processed”

Analysis number	Important monitoring items
Saku-A-1	Presence of interfering objects unaffected by darkness
Saku-A-2	Presence of interfering objects unaffected by fog
Saku-A-3	Presence of interfering objects unaffected by dripping water
Saku-A-4	Presence of interfering objects unaffected by noise
Saku-B-1	Time to reach destination
	Velocity of water flow on the transfer route
Saku-B-2	Degree of influence of equipment on hot spots (radiation resistance)
	Location of hot spot on the transfer route
Saku-B-3	Transfer route detection unaffected by soaring sediment
Saku-B-4	Current location detection unaffected by darkness
Saku-B-5	Current location detection unaffected by fog
Saku-B-6	Current location detection unaffected by dripping water
Saku-B-7	Current location detection unaffected by noise

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (7/12)

■ Operational equipment

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-3:

Analysis number	Important monitoring items
Saku-A-1	Submerged debris detection unaffected by darkness
Saku-A-2	Submerged debris detection unaffected by fog
Saku-A-3	Submerged debris detection unaffected by dripping water
Saku-A-4	Submerged debris detection unaffected by noise
Saku-A-5	Application time for neutron absorbent
	Velocity of water flow at the neutron absorbent application area
Saku-A-6	Detection of neutron absorbent application status unaffected by darkness
Saku-A-7	Detection of neutron absorbent application status unaffected by fog
Saku-A-8	Detection of neutron absorbent application status unaffected by dripping water
Saku-A-9	Detection of neutron absorbent application status unaffected by blind spots due to surrounding structures

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (8/12)

■ Operational equipment

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in "Model ID Sa-4:

Analysis number	Important monitoring items
Saku-B-1	Fuel debris properties (compressive strength) in the processing area
Saku-A-1	Dust concentration at the processing site unaffected by darkness
	Debris temperature unaffected by darkness
Saku-A-2	Dust concentration at the processing site unaffected by fog
	Debris temperature unaffected by fog
Saku-A-3, 5	Dust concentration at the processing site unaffected by dripping water
Saku-A-3	Debris temperature unaffected by dripping water
Saku-A-4	Dust concentration at the processing site unaffected by noise
	Debris temperature unaffected by noise
Saku-A-5	Debris temperature unaffected by dust dispersion
Saku-A-6	Neutron flux unaffected by darkness
	Debris dimensions unaffected by darkness
Saku-A-7	Neutron flux unaffected by fog
	Debris dimensions unaffected by fog
Saku-A-8	Neutron flux unaffected by dripping water
	Debris dimensions unaffected by dripping water
Saku-A-9	Neutron flux unaffected by dust dispersion
	Debris dimensions unaffected by dust dispersion
Saku-A-10	Neutron flux unaffected by background (noise)
	Debris dimensions unaffected by background
Saku-A-11	Neutron flux around the location of the fall
	Structural strength of structure leading to fall mode
Saku-A-12	Dust concentration at the processing site
	Amount of anti-dispersion agent (mist) reaching the processing area
Saku-B-2	Time to reach the processing area
	Three-dimensional shape (dimensions) of structure at the processing site
Saku-B-3	Degree of wear and tear of processing jigs
	Compressive strength of debris to be processed

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (9/12)

■ Operational equipment

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-4:

Analysis number	Important monitoring items
Saku-B-4	Degree of influence of equipment on hot spots (radiation resistance)
	Source location of hot spots at the processing site
Saku-B-5, 10, 11, 12, 13, 14, 15	Amount of debris filling the inner container
Saku-B-5	Velocity and flow rate of cooling water in the debris processing area
Saku-B-6	Dimensions of processed debris unaffected by darkness
Saku-B-7	Dimensions of processed debris unaffected by fog
Saku-B-8	Dimensions of processed debris unaffected by dripping water
Saku-B-9	Dimensions of processed debris unaffected by sediments, powder from cutting (dust), or neutron absorbers floating in water
Saku-B-10	Velocity and flow rate of cooling water in the debris collection area
Saku-B-11	Relative position of debris and inner container unaffected by darkness
Saku-B-12	Relative position of debris and inner container unaffected by fog
Saku-B-13	Relative position of debris and inner container unaffected by dripping water
Saku-B-14	Relative position of debris and inner container unaffected by sediments, powder from cutting (dust), or neutron absorbers floating in water
Saku-B-15	Relative position of debris and inner container unaffected by noise
Saku-B-16	Amount of debris filling the inner container unaffected by darkness
Saku-B-17	Amount of debris filling the inner container unaffected by fog
Saku-B-18	Amount of debris filling the inner container unaffected by dripping water
Saku-B-19	Amount of debris filling the inner container unaffected by sediments, powder from cutting (dust), or neutron absorbers floating in water
Saku-B-20	Amount of debris filling the inner container unaffected by noise

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (10/12)

■ Operational equipment

Table. Important monitoring items for operational equipment in “Model ID Sa-5:

Analysis number	Important monitoring items
---	No important monitoring items due to the environment inside the PCV

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-6: Cell

Analysis number	Important monitoring items
Saku-A-1	Presence of interfering objects unaffected by darkness
Saku-A-2	Presence of interfering objects unaffected by fog
Saku-A-3	Presence of interfering objects unaffected by dripping water
Saku-A-4	Presence of interfering objects unaffected by noise
Saku-B-1	Time to reach destination
	Velocity of water flow on the transfer route
Saku-B-2	Degree of influence of equipment on hot spots (radiation resistance)
	Location of hot spot on the transfer route
Saku-B-3	Transfer route detection unaffected by soaring sediment
Saku-B-4	Current location of the inner container unaffected by inner container radiation
Saku-B-5	Transfer route detection unaffected by dust
Saku-B-6	Current location of the inner container unaffected by noise

Appendix 6.2.4.3-1 : Quick reference table of important monitoring items (11/12)

■ Operational equipment

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-7: Transfer of debris ① (Cell R → Cell Y)”

Analysis number	Important monitoring items
Saku-B-1	Detection of transfer line interference unaffected by the inner container radiation
Saku-B-2	Detection of transfer line interference unaffected by dust
Saku-A-1	Dust concentration at cell (Y)
	Dust concentration at cell (R)
Saku-A-2	Hydrogen concentration/or oxygen concentration in cell (Y)
	Amount of hydrogen generated in the inner container
Saku-B-3	Air dose rate of cell (Y)
	Surface dose rate of inner container
Saku-B-4	Transfer route detection unaffected by soaring dust
Saku-B-5	Current location of the inner container unaffected by soaring dust

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-8: Collection of debris”

Analysis number	Important monitoring items
Saku-B-1	Time to verify whether the contents are protruding from the inner container or not
	Presence or absence of contents protruding from the inner container
Saku-B-2	Time to verify whether the inner container is damaged or not
	Presence or absence of damage to the inner container
Saku-B-3	Time to remove foreign matter (debris powder) from the canister
	Amount of foreign matter (debris powder) adhering to the canister
Saku-B-4	Time to complete the inner container collection
	Surface dose rate of inner container

Appendix 6.2.4.3-1: Quick reference table of important monitoring items (12/12)

■ Operational equipment

This number is linked to Appendix 6.2.4.3-3

Table. Important monitoring items for operational equipment in “Model ID Sa-9: Transfer of debris ② (Cell Y → Cell G)”

Analysis number	Important monitoring items
Saku-A-1	Dust concentration at cell (G)
	Dust concentration at cell (Y)
Saku-A-2	Flow rate in the system
Saku-A-2,3	Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the piping
Saku-A-3	Flow rate in the system + amount of leakage
Saku-B-1	Decontamination completion time of transfer container
	Inspection items not affected by contaminated water (surface dose rate, pressure discharge characteristics, surface contamination concentration)

Table. Important monitoring items for operational equipment in “Model ID Sa-10: Transfer of debris (Cell G → Secondary boundary)”

Analysis number	Important monitoring items
---	No important monitoring items due to the environment inside the PCV

■ Supplementary information before presentation of evaluation results: Classification of indirect factors affecting safety functions (1/2)

In conducting the risk assessment, although it is assumed the disturbances (dust/mist generation, fuel debris properties) generated as a result of the fuel debris retrieval operations would degrade the components that constitute safety functions, the characteristics of the disturbances were taken into consideration and the effects on the components were categorized into the following four categories and extracted as important monitoring items for indirect monitoring.

① Factors in which disturbances directly affect safety functions

- Dust and mist generated at the processing point directly accumulate and adhere to the components, causing adverse effects.
  - ✓ Components are adversely affected due to accumulation of dust (examples of indirect monitoring items: amount and particle size distribution of dust flowing into components)
  - ✓ Components are adversely affected due to accumulation of mist (examples of indirect monitoring items: amount of mist flowing into components)

② Factors in which disturbances indirectly affect safety functions

- Dust and other particles generated at the processing point flow into the components, causing adverse effects due to chemical, radiological changes, and other changes to the parts of the components.
  - ✓ Components are adversely affected as a result of changes in chemical properties (examples of indirect monitoring items: amount and chemical composition of dust flowing into components)
  - ✓ Components are adversely affected as a result of degradation due to irradiation (examples of indirect monitoring items: amount and nuclide composition of dust flowing into components)

■ Supplementary information before presentation of evaluation results: Classification of indirect factors affecting safety functions (2/2)

③ Factors in which disturbances affect the design conditions of equipment that constitute safety system

- Disturbances generated at the processing point adversely affect the equipment by affecting the design conditions of the equipment that constitute safety functions.
  - ✓ Equipment is adversely affected when worsening design conditions (examples of indirect monitoring items: design conditions of equipment (pressure inside the PCV, temperature, relative humidity, composition of gas)

④ Others

- Not applicable to the above categories, but equipment is adversely affected by equipment-specific failure modes while retrieving fuel debris.

Based on the characteristics of the disturbances (dust/mist generation, fuel debris properties), four factors are considered to be degradation modes of the equipment.

■ Procedure for entering the information on disturbances into the risk assessment table (1/2)

- For the Table of environmental changes inside the PCV due to operational equipment activities, the disturbances entered in item 5 of the risk assessment table were classified into disturbances (① to ③) as shown in the table below.

Disturbance ①

Fuel debris type	Assumed properties: Density	Assumed properties: Compressive strength	Assumed properties: Primary component	Assumed properties: Localized area	Assumed processing methods: Processing mode	Assumed processing methods: Equipment name	Assumed processing methods: Remarks	Particle size of dust: Aerial processing (no anti-dispersion agent)		Particle size of dust: Underwater processing	
	[g/cm^3]	[MPa]						---	[μm]	---	[μm]
Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than above mentioned: 230	[U Rich] (U, Zr)O2-C, (Zr, U)O2-T, [Fe Rich] UO2, Fe, Zry-2, α-Zr(O), SUS/Fe, Fe2(Zr, U), ZrB2, Fe2B, Zr(O), Fe2Zr	Pedestal inside the PCV (Floor/Interior/ outside) drywell	Cutting	Disc cutter	Blade diameter: 200 mm Blade thickness: 1 mm Number of revolutions: 1000 rpm	Airborne	All in range of peak particle size 2 to 3 (mass concentration distribution) 0.1 to 0.3 (number concentration distribution)	Airborne	Unknown
								Sedimentation	All in median diameter 0.3 (number distribution) 7.9 (sediment distribution)	Sedimentation	Above 50
								Peripheral dispersion	Either airborne/sedimentation	Floating in water	50 or less

Total amount of dust generated: Aerial processing	Total amount of dust generated: Underwater processing	Mass balance and amount of dust migration: Aerial processing: Mass balance		Aerial processing: Amount of dust migration	Underwater processing: Mass balance		Underwater processing: Amount of dust migration	Amount of processing aid injected: Input materials	Amount of processing aid injected: Total amount of input	Amount of anti-scattering agent injected (Only for aerial processing): Input materials	Amount of anti-scattering agent injected (Only for aerial processing): Total amount of input
[g]	[g]	---	[%]	[g]	---	[%]	[g]				
1242.1	1242	Airborne	4	49.7	Airborne	2E-05	0.0	[Aerial processing] Water: 1 L/min	198 L ↑ (*)	Mist: 0.05 L/min	9.9 L ↑ (*)
		Sedimentation	37	459.6	Sedimentation	99.5	1235.9				
		Peripheral dispersion	59	732.9	Floating in water	0.5	6.2				

Disturbance ②

Disturbance ③

■ Procedure for entering the information on disturbances into the risk assessment table (2/2)

① to ④ on the previous page

No.	Disturbance
①	Particle size and amount of dispersion of dust generated during processing
②	Use of processing aid injected onto processing jigs
③	Use of anti-dispersion agent for dust
④	Others - Heat input during processing - Abrasive input during processing

Important monitoring items extracted

Analysis number	Important monitoring items								
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements
An-Ki-1	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases because the HEPA filter deteriorates and the design value of the exhaust filter efficiency is not ensured.	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure, and this tendency is affected by the amount and particle size distribution of the dust flowing in.
	Same as above	Same as above	Same as above	Same as above			(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)	
An-Ki-14	PCV (Primary Boundary)	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the PCV deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	②	Partial damage caused by corrosion of PCV wall surface due to accumulation of processing aid (mist)	(a) Differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because increase in the size of the opening caused by the corrosion of the PCV wall surface decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the liquid phase chemical properties on the PCV wall surface.
	Same as above	Same as above	Same as above	Same as above			(b) Amount and chemical properties (pH, chloride ion concentration) of mist flying to PCV wall surface near D/W water surface	Indirect (item 5)	

Predict loss of safety functions due to debris retrieval operations by extracting (a) direct/(b) indirect monitoring

Organize the causal relationship between the direct cause of the error and disturbance during debris retrieval operations

Loss of safety function is defined as a factor of throughput reduction (Item 3). Factors affecting the components that constitute safety functions due to disturbances as a result of fuel debris retrieval operations are analyzed, and detection requirements for avoiding work delays are organized

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-1	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure, and this tendency is affected by the amount and particle size distribution of the dust flowing in.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
An-Ki-1	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	①		(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
An-Ki-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage caused by the deterioration of filter elements due to dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Deterioration of filter elements due to accumulation of dust in the HEPA filter causes partial damage to filter elements and decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
An-Ki-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage caused by the deterioration of filter elements due to dust migrating from the processing point to the HEPA filter	(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at HEPA filter inlet	Indirect (item 5)	Deterioration of filter elements due to accumulation of dust in the HEPA filter causes partial damage to filter elements and decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4

[The numbering rules for analysis ID]
Gas phase equipment: An-Ki-Arabic numerals Liquid phase equipment: An-Eki-Arabic numerals
Cooling equipment: An-Rei-Arabic numerals Liquid phase sub-criticality maintenance equipment: An-Rin-Arabic numerals

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-3	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	①	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Partial damage to filter elements due to irradiation of dust accumulated in the HEPA filter decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and nuclide composition of inflowing dust.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-4	Same as above	Same as above	Same as above	Same as above	②	Partial blockage of filter elements due to adhesion of processing aid migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the differential pressure increases due to partial blockage caused by mist that accumulates in the HEPA filter, and because this trend is affected by the amount of inflowing mist due to the processing aid.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

IRID

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-5	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	②	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition, and because this trend is affected by the amount of processing aid (mist) sprayed at the processing point.	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-6	Same as above	Same as above	Same as above	Same as above	③	Partial blockage due to adhesion of anti-dispersion agent migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the mist accumulated in the HEPA filter increases the differential pressure for the HEPA filter, and because this trend is affected by the amount of mist flowing into filter elements due to the anti-dispersion agent.	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-7	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition of the HEPA filter, and because this trend is affected by the amount of anti-dispersion agent (mist) sprayed at the processing point.	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-8	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA filter efficiency does not meet the design value.	④	Partial blockage of filter elements due to accumulation of abrasives migrating from the processing point to the filter	(a) HEPA filter differential pressure	Direct (item 4)	Accumulation of abrasives flowing into the HEPA filter partially clogs the HEPA filter and increases the HEPA filter differential pressure. Selected because this trend is affected by the amount of abrasives flowing into the HEPA filter due to processing.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount and particle size distribution of abrasives at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-9	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by the design condition of relative humidity at the HEPA filter inlet exceeding the assumed design condition with evaporation of D/W stagnant water as a result of heat input during processing	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity at the HEPA filter inlet was verified to deviate from the design condition, and because this trend is affected by the amount of heat input at the processing point.	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied) → 2 series only	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied) → 2 series only	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-10	Electric heater (Pretreatment equipment)	Reduction of dust concentration	Increased dust concentration inside the PCV	The dust concentration inside the PCV increases because the electric heater deteriorates and the design value of the filter is not ensured.	①	Performance degradation of the electric heater caused by irradiation of dust migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount and nuclide composition of inflowing dust.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring /Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-11	Electric heater (Pretreatment equipment)	Reduction of dust concentration	Increased dust concentration inside the PCV	The dust concentration inside the PCV increases because the electric heater deteriorates and the design value of the filter is not ensured.	②	Performance degradation of the electric heater caused by adhesion of processing aid migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of mist inflow due to the processing aid.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at electric heater inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-12	Same as above	Same as above	Same as above	Same as above	③	Performance degradation of the electric heater caused by adhesion of anti-dispersion agent migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of mist inflow due to the anti-dispersion agent.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at electric heater inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-13	Same as above	Same as above	Same as above	Same as above	④	Performance degradation of the electric heater caused by the rise in PCV temperature due to heat input during processing	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of heat input at the processing point which raises the temperature of inflowing gas.	1	It is assumed that the processing work will proceed without exceeding the PCV design temperature	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	It is assumed that the processing work will proceed without exceeding the PCV design temperature	3	Advance detection is possible by constant monitoring of the temperature on the upstream side of the electric heater, and predictability is good	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-14	PCV (Primary boundary)	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the PCV deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	②	Partial damage caused by corrosion of PCV wall surface due to accumulation of processing aid (mist)	(a) Differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because increase in the size of the opening caused by the corrosion of the PCV wall surface decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the liquid phase chemical properties on the PCV wall surface.	4	The impact on safety functions is significant. (Possibility of over-specification in case of increased airflow rate of fan; there are problems with repair after specifying the location of the opening)	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	3	The impact on safety functions is significant, and work are shutdown until PCV repair is completed.	48	48
							(b) Amount and chemical properties (pH, chloride ion concentration) of mist flying to PCV wall surface near D/W water surface	Indirect (item 5)		4	The impact on safety functions is significant. (Possibility of over-specification in case of increased airflow rate of fan; there are problems with repair after specifying the location of the opening)	4	Continuous monitoring is required, but predictability is poor.	3	The impact on safety functions is significant, and work are shutdown until PCV repair is completed.	48	
An-Ki-15	Same as above	Same as above	Same as above	Same as above	③	Partial damage due to corrosion of PCV wall surface by anti-dispersion agent (mist)	(a) Differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because increase in the size of the opening caused by the corrosion of the PCV wall surface decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the liquid phase chemical properties on the PCV wall surface.	4	The impact on safety functions is significant. (Possibility of over-specification in case of increased airflow rate of fan; there are problems with repair after specifying the location of the opening)	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	3	The impact on safety functions is significant, and work are shutdown until PCV repair is completed.	48	48
							(b) Amount and chemical properties (pH, chloride ion concentration) of mist flying to PCV wall surface near D/W water surface	Indirect (item 5)		4	The impact on safety functions is significant. (Possibility of over-specification in case of increased airflow rate of fan; there are problems with repair after specifying the location of the opening)	4	Continuous monitoring is required, but predictability is poor.	3	The impact on safety functions is significant, and work are shutdown until PCV repair is completed.	48	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-16	Filter casing	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the filter casing deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	①	Partial damage due to corrosion of dust migrating from the processing point to the filter casing	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the filter casing causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter casing.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at filter casing inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-17	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to irradiation of dust migrating from the processing point to the filter casing	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the filter casing causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and nuclide composition of dust flowing into the filter casing.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at filter casing inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-18	Filter casing	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the filter casing deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	②	Partial damage due to adhesion of processing aid migrating from the processing point to the filter casing	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the filter casing causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the filter casing.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at filter casing inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-19	Same as above	Same as above	Same as above	Same as above	③	Partial damage due to adhesion of anti-dispersion agent migrating from the processing point to the filter casing	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the filter casing causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the filter casing.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at filter casing inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-20	Duct	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the duct deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	①	Partial damage due to corrosion of dust migrating from the processing point to the duct	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the duct causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, and chemical composition) of dust flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b)(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-21	Duct	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the duct deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	①	Partial damage due to irradiation of dust migrating from the processing point to the duct	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the duct causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and nuclide composition of dust flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-22	Same as above	Same as above	Same as above	Same as above	②	Partial damage due to adhesion of processing aid migrating from the processing point to the duct	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because damage to the duct causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-23	Same as above	Same as above	Same as above	Same as above	③	Partial damage due to adhesion of anti-dispersion agent migrating from the processing point to the duct	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the duct causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

No.155

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-24	Isolation valve (Integration of valves present in the system)	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the isolation valve deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	①	Partial damage due to corrosion of dust migrating from the processing point to the isolation valve	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the isolation valve causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, and chemical composition) of dust flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b)(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-25	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to irradiation of dust migrating from the processing point to the isolation valve	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the isolation valve causes an increase in the primary boundary opening which decreases the differential pressure between inside and outside of the PCV, and because this trend is affected by the amount and nuclide composition of dust flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-26	Same as above	Same as above	Same as above	Same as above	②	Partial damage due to adhesion of processing aid migrating from the processing point to the isolation valve	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the isolation valve causes an increase in the primary boundary opening which decreases the differential pressure between the inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-27	Isolation valve (Integration of valves present in the system)	Static boundary	Decrease in differential pressure between inside and outside of the PCV	As the isolation valve deteriorates and the size of the opening increases, inleakage occurs and decreases the differential pressure between inside and outside of the PCV.	③	Partial damage due to adherence of anti-dispersion agent migrating from the processing point to the isolation valve	(a) Differential pressure between inside and outside of the PCV + pressure inside the system	Direct (item 4)	Selected because partial damage to the isolation valve causes an increase in the primary boundary opening which decreases the differential pressure between the inside and outside of the PCV, and because this trend is affected by the amount of mist flowing into the exhaust line.	1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	4	Post-detection is possible by constant monitoring of the differential pressure between inside and outside of the PCV, but predictability is poor. It may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at exhaust line inlet	Indirect (item 5)		1	Although there is an impact on safety functions, the frequency of occurrence is expected to be low compared to other boundary sections.	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-28	HEPA filter	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As filter elements deteriorate and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because dust accumulation increases the differential pressure, and because this trend is affected by the amount and particle size distribution of dust flowing into the HEPA filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-29	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage caused by the deterioration of filter elements due to dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Deterioration of filter elements due to accumulation of dust in the HEPA filter causes partial damage to filter elements and decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-30	HEPA filter	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As filter elements deteriorate and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Partial damage to filter elements due to irradiation of dust accumulated in the HEPA filter decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and nuclide composition of inflowing dust.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-31	Same as above	Same as above	Same as above	Same as above	②	Partial blockage due to adhesion of processing aid migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because dust accumulation in the HEPA filter increases the HEPA filter differential pressure, and because this trend is affected by the amount of mist flowing into the HEPA filter due to the processing aid.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-32	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition, and because this trend is affected by the amount of processing aid (mist) sprayed at the processing point.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-33	HEPA filter	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As filter elements deteriorate and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	③	Partial blockage due to dispersion of anti-dispersion agent migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because dust accumulation in the HEPA filter increases the HEPA filter differential pressure, and because this trend is affected by the amount of mist flowing into the HEPA filter due to the processing aid.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-34	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition, and because this trend is affected by the amount of anti-dispersion agent (mist) sprayed at the processing point.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-35	Exhauster	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the exhauster deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial damage to the exhauster due to corrosion of dust migrating from the processing point to the exhauster	(a) Airflow rate of exhauster	Direct (item 4)	Corrosion of filter elements due to dust accumulated in the exhauster causes partial damage to the exhauster and decreases the airflow rate of exhauster. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, and chemical composition) of dust flowing into the exhauster.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at exhauster inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-36	Exhauster	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the exhauster deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	Same as above	Partial damage to the exhauster due to irradiation of dust migrating from the processing point to the exhauster	(a) Airflow rate of exhauster	Direct (item 4)	Irradiation of dust accumulated in the exhauster causes partial damage to the exhauster and decreases the airflow rate of exhauster. Selected because this trend is affected by the amount and nuclide composition of inflowing dust.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at exhauster inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-37	Same as above	Same as above	Same as above	Same as above	④	Performance degradation of the exhauster caused by the rise in PCV temperature due to heat input during processing	(a) Airflow rate of exhauster	Direct (item 4)	Selected because the exhaust airflow rate decreases due to performance deterioration of the exhauster, and because this trend is affected by the amount of heat input at the processing point which raises the temperature of inflowing gas.	1	It is assumed that the processing work will proceed without exceeding the PCV design temperature	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
							(b) Amount of heat input at processing point	Indirect (Item 4)		1	It is assumed that the processing work will proceed without exceeding the PCV design temperature	3	Advance detection is possible by constant monitoring of the temperature on the upstream side of the exhaust fan, and predictability is good	1	Because item 7-1 is 1 point	3	
An-Ki-38	Demister (Pretreatment equipment)	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the demister deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial blockage due to accumulation of dust migrating from the processing point to the demister	(a) Demister differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because the differential pressure before and after the demister increases due to partial blockage of the demister, and because this trend is affected by the amount and particle size distribution of inflowing dust.	1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Post-detection is possible by regular monitoring of the demister differential pressure and constant monitoring of the differential pressure between inside and outside of the PCV, and advance detection is possible from signs of the differential pressure between inside and outside of the PCV.	1	Because item 7-1 is 1 point	3	3
							(b) Amount and particle size distribution of dust at demister inlet	Indirect (item 5)		1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-39	Demister (Pretreatment equipment)	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the demister deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	Same as above	Partial damage due to corrosion of dust migrating from the processing point to the demister	(a) Demister differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Corrosion of dust accumulated in the demister causes partial damage to the demister and increases the differential pressure before and after the demister. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) (b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at demister inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-40	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to irradiation of dust migrating from the processing point to the demister	(a) Demister differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Irradiation of dust accumulated in the demister causes partial damage to the demister and increases the differential pressure before and after the demister. Selected because this trend is affected by the amount and nuclide composition of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at demister inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-41	Same as above	Same as above	Same as above	Same as above	②	Partial blockage due to adhesion of processing aid migrating from the processing point to the demister	(a) Demister differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because the differential pressure before and after the demister increases due to partial blockage of the demister, and because this trend is affected by the amount of mist flowing into the demister.	1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Post-detection is possible by regular monitoring of the demister differential pressure and constant monitoring of the differential pressure between inside and outside of the PCV, and advance detection is possible from signs of the differential pressure between inside and outside of the PCV.	1	Because item 7-1 is 1 point	3	3
							(b) Amount of mist at demister inlet	Indirect (item 5)		1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-42	Demister (Pretreatment equipment)	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the demister deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	③	Partial blockage due to adhesion of anti-dispersion agent migrating from the processing point to the demister	(a) Demister differential pressure + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because the differential pressure before and after the demister increases due to partial blockage of the demister, and because this trend is affected by the amount of mist flowing into the demister.	1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Post-detection is possible by regular monitoring of the demister differential pressure and constant monitoring of the differential pressure between inside and outside of the PCV, and advance detection is possible from signs of the differential pressure between inside and outside of the PCV.	1	Because item 7-1 is 1 point	3	3
							(b) Amount of mist at demister inlet	Indirect (item 5)		1	Functionality is ensured by switching between demisters using 2 series of demisters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-43	Dry backwash filter (Pretreatment equipment)	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the dry backwash filter deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial blockage due to accumulation of dust migrating from the processing point to the dry backwash filter	(a) Differential pressure of dry backwash filter + differential pressure between inside and outside of the PCV	Direct (item 4)	Partial blockage of the dry backwash filter increases the differential pressure before and after the dry backwash filter. Selected because this trend is affected by the amount and particle size distribution of dust flowing into the dry backwash filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, and predictability is good.	1	Because item 7-1 is 1 point	1	3
							(b) Amount and particle size distribution of dust at dry backwash filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-44	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion of dust migrating from the processing point to the dry backwash filter	(a) Differential pressure of dry backwash filter + differential pressure between inside and outside of the PCV	Direct (item 4)	Corrosion of dust accumulated in the dry backwash filter causes partial damage to filter elements and decreases the differential pressure before and after the dry backwash filter. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the dry backwash filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at dry backwash filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-45	Dry backwash filter (Pretreatment equipment)	Dynamic boundary	Decrease in differential pressure between inside and outside of the PCV	As the dry backwash filter deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	①	Partial damage due to irradiation of dust migrating from the processing point to the dry backwash filter	(a) Differential pressure of dry backwash filter + differential pressure between inside and outside of the PCV	Direct item 4)	Irradiation of dust accumulated in the dry backwash filter causes partial damage to filter elements and increases the differential pressure before and after the dry backwash filter. Selected because this trend is affected by the amount and nuclide composition of dust flowing into the dry backwash filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at dry backwash filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-46	Same as above	Same as above	Same as above	Same as above	②	Partial blockage due to adhesion of processing aid migrating from the processing point to the dry backwash filter	(a) Differential pressure of dry backwash filter + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because the differential pressure before and after the dry backwash filter increases due to partial blockage of the dry backwash filter, and because this trend is affected by the amount of mist flowing into the dry backwash filter.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, and predictability is good.	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at dry backwash filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-47	Same as above	Same as above	Same as above	Same as above	③	Blockage due to adhesion of anti-dispersion agent migrating from the processing point to the dry backwash filter	(a) Differential pressure of dry backwash filter + differential pressure between inside and outside of the PCV	Direct (item 4)	Selected because the differential pressure before and after the dry backwash filter increases due to partial blockage of the dry backwash filter, and because this trend is affected by the amount of inflowing mist.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, and predictability is good.	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at dry backwash filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-48	HEPA filter	Discharge control	Increase in dust concentration on downstream side of HEPA filter	As the HEPA filter deteriorates and the design value of the filter efficiency is not ensured, the dust concentration inside the PCV increases.	①	Partial blockage of the filter element due to accumulation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the filter differential pressure increases due to partial blockage caused by dust accumulation in the HEPA filter, and because this trend is affected by the amount and particle size distribution of inflowing dust.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-49	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage caused by the deterioration of filter elements due to dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Deterioration of filter elements due to dust accumulated in the HEPA filter causes partial damage to filter elements and decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-50	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstream dust concentration ratio	Direct (item 4)	Partial damage to filter elements due to irradiation of dust accumulated in the HEPA filter decreases the ratio of dust concentration between the upstream and downstream sides. Selected because this trend is affected by the amount and nuclide composition of inflowing dust.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the dust concentration on the downstream side of the filter, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-51	HEPA filter	Discharge control	Increase in dust concentration on downstream side of HEPA filter	As the HEPA filter deteriorates and the design value of the filter efficiency is not ensured, the dust concentration inside the PCV increases.	②	Partial blockage due to adhesion of processing aid migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the HEPA filter differential pressure increases due to partial blockage caused by mist accumulation in the HEPA filter, and because this trend is affected by the amount of mist inflow due to the processing aid.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-52	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition, and because this trend is affected by the amount of processing aid (mist) sprayed at the processing point.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of processing aid (mist) sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-53	Same as above	Same as above	Same as above	Same as above	③	Partial blockage due to adhesion of anti-dispersion agent migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the HEPA filter differential pressure increases due to mist accumulation, and because this trend is affected by the amount of mist inflow due to the anti-dispersion agent.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount of mist at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

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■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-54	HEPA filter	Discharge control	Increase in dust concentration on downstream side of HEPA filter	As the HEPA filter deteriorates and the design value of the filter efficiency is not ensured, the dust concentration inside the PCV increases.	③	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity of gas flowing into the HEPA filter was verified to deviate from the design condition, and because this trend is affected by the amount of anti-dispersion agent (mist) sprayed at the processing point.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of anti-dispersion agent (mist) sprayed at processing point	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-55	Same as above	Same as above	Same as above	Same as above	④	Partial blockage of the HEPA filter elements due to accumulation of abrasives migrating from the processing point to the HEPA filter	(a) HEPA filter differential pressure	Direct (item 4)	Accumulation of abrasives flowing into the HEPA filter partially clogs the HEPA filter and increases the HEPA filter differential pressure. Selected because this trend is affected by the amount of abrasives flowing into the HEPA filter due to processing.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	1	Filter clogging is due to daily accumulation, so predictability is good	1	Because item 7-1 is 1 point	1	3
							(b) Amount and particle size distribution of abrasives at HEPA filter inlet	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-56	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the HEPA filter caused by the design condition of relative humidity at the HEPA filter inlet exceeding the assumed design condition with evaporation of D/W stagnant water as a result of heat input during processing	(a) Relative humidity at HEPA filter inlet	Direct (item 4)	Selected because the relative humidity at the HEPA filter inlet was verified to deviate from the design condition, and because this trend is affected by the amount of heat input at the processing point.	1	Functionality is ensured by switching filters through 2 series of filters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-57	Electric heater (Pretreatment equipment)	Discharge control	Increase in dust concentration on downstream side of the filter	Due to failure of the electric heater, the relative humidity does not decrease and the design condition of the filter (relative humidity of 99% or less) is not ensured, resulting in the deterioration and damage to the filter and an increase in the dust concentration on the downstream side of the filter.	①	Performance degradation of the electric heater caused by irradiation of dust migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount and nuclide composition of dust flowing into the electric heater.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount and nuclide composition of dust at electric heater inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Ki-58	Same as above	Same as above	Same as above	Same as above	②	Performance degradation of the electric heater caused by adhesion of processing aid migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of mist flowing into the electric heater due to the processing aid.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at electric heater inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
An-Ki-59	Same as above	Same as above	Same as above	Same as above	③	Performance degradation of the electric heater caused by adhesion of anti-dispersion agent migrating from the processing point to the electric heater	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of mist flowing into the electric heater due to the anti-dispersion agent.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of mist at electric heater inlet	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (gas phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work delays	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Ki-60	Electric heater (Pretreatment equipment)	Discharge control	Increase in dust concentration on downstream side of the filter	Due to failure of the electric heater, the relative humidity does not decrease and the design condition of the filter (relative humidity of 99% or less) is not ensured, resulting in the deterioration and damage to the filter and an increase in the dust concentration on the downstream side of the filter.	④	Performance degradation of the electric heater caused by the rise in PCV temperature due to heat input during processing	(a) Temperature differential before and after the electric heater	Direct (item 4)	Selected because the temperature differential before and after the electric heater decreases due to performance degradation of the electric heater, and because this trend is affected by the amount of heat input at the processing point which raises the temperature of inflowing gas.	1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	4	Post-detection is possible by constant monitoring of the temperature differential before and after the electric heater, but predictability is poor	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Functionality is ensured by switching between heaters using 2 series of electric heaters (already studied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-1	D/W stagnant water transfer pump	Dynamic boundary	Rise in D/W water level	Due to deterioration of the D/W stagnant water transfer pump, the design value for the pump flow rate is not ensured, resulting in the D/W water level to increase	①	Partial blockage of the pump due to dust contamination migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial blockage caused by dust contamination in the D/W stagnant water transfer pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the D/W stagnant water transfer pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water transfer pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

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■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-3	D/W stagnant water transfer pump	Dynamic boundary	Rise in D/W water level	Due to deterioration of the D/W stagnant water transfer pump, the design value for the pump flow rate is not ensured, resulting in the D/W water level to increase	①	Partial damage due to corrosion of metal components such as impellers caused by the chemical properties of transferring liquid migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the D/W stagnant water transfer pump, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W room water level management related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-4	Same as above	Same as above	Same as above	Same as above	④	Partial blockage of the pump due to abrasive contamination migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial blockage caused by abrasive contamination in the D/W stagnant water transfer pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-5	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion caused by potential difference resulting from accumulation of abrasives migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the D/W stagnant water transfer pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the D/W stagnant water transfer pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but predictability is poor	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-6	D/W stagnant water transfer pump	Dynamic boundary	Rise in D/W water level	Due to deterioration of the D/W stagnant water transfer pump, the design value for the pump flow rate is not ensured, resulting in the D/W water level to increase	④	Performance degradation of the pump caused by the temperature of the transferring liquid, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Water temperature inside PCV	Direct (item 4)	Selected because the temperature of transferring liquid flowing into the D/W stagnant water transfer pump was verified to deviate from the design condition, and because this trend is affected by the amount of heat input at the processing point.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	3
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but detectability of significant fluctuations is good.	1	Because item 7-1 is 1 point	3	
An-Eki-7	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the pump due to abrasives migrating from the processing point to the D/W stagnant water transfer pump coming into contact with the impeller and causing the impeller to wear out	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage caused by abrasive contamination in the D/W stagnant water transfer pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Constant monitoring is required because the equipment is for D/W water level management related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-8	PCV stagnant water discharge pump	Dynamic boundary	Abnormal drainage of PCV stagnant water buffer tank	Due to deterioration of the PCV stagnant water discharge pump, the design value for the pump flow rate is not ensured, resulting in the water level in the PCV buffer tank to increase	①	Partial blockage of the pump due to dust contamination migrating from the processing point to the PCV stagnant water discharge pump	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial blockage caused by dust contamination in the PCV stagnant water discharge pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	2
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	2	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	2	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-9	PCV stagnant water discharge pump	Dynamic boundary	Abnormal drainage of PCV stagnant water buffer tank	Due to deterioration of the PCV stagnant water discharge pump, the design value for the pump flow rate is not ensured, resulting in the water level in the PCV buffer tank to increase	①	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the PCV stagnant water discharge pump	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the PCV stagnant water discharge pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the PCV stagnant water discharge pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-10	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion of metal components such as impellers caused by the chemical properties of transferring liquid migrating from the processing point to the PCV stagnant water discharge pump	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the PCV stagnant water discharge pump, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	2
							(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	2	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	2	
An-Eki-11	Same as above	Same as above	Same as above	Same as above	④	Partial blockage of the pump due to abrasive contamination migrating from the processing point to the PCV stagnant water discharge pump	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial blockage caused by abrasive contamination in the PCV stagnant water discharge pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	2
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	2	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	2	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-12	PCV stagnant water discharge pump	Dynamic boundary	Abnormal drainage of PCV stagnant water buffer tank	Due to deterioration of the PCV stagnant water discharge pump, the design value for the pump flow rate is not ensured, resulting in the water level in the PCV buffer tank to increase	④	Partial damage due to corrosion caused by potential difference resulting from accumulation of abrasives migrating from the processing point to the PCV stagnant water discharge pump	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage to the PCV stagnant water discharge pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the PCV stagnant water discharge pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-13	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the pump caused by the temperature of the transferring liquid, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Water temperature inside PCV	Direct (item 4)	Selected because the temperature of transferring liquid flowing into the PCV stagnant water discharge pump was verified to deviate from the design condition, and because this trend is affected by the amount of heat input at the processing point.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	2
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	2	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	2	
An-Eki-14	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the pump due to abrasives migrating from the processing point to the PCV stagnant water discharge pump coming into contact with the impeller and causing the impeller to wear out	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to partial damage caused by abrasive contamination in the PCV stagnant water discharge pump, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the torus room stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	2
							(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	2	The equipment is used to establish circulation cooling by periodically draining water from the buffer tank, and requires monitoring during operation, but predictability is poor.	1	Because item 7-1 is 1 point	2	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-15	D/W	Static boundary	Decrease in D/W water level	As the D/W deteriorates and the size of the opening increases, the leakage to the torus room increases and the D/W water level decreases.	①	Partial damage due to corrosion caused by changes in the water quality of stagnant water migrating from the processing point to the D/W	(a) D/W water level	Indirect (Item 4)	Selected because the D/W water level decreases as the size of the opening in the D/W increases, and because this trend is affected by the conditions for water quality at the D/W wall surface.	1	The impact on the safety functions is small. (When the D/W water level decreases excessively, the flow rate of the D/W stagnant water transfer pump can be adjusted.)	3	Post-detection is possible by constant monitoring of the D/W water level, and detectability is good. However, it may be difficult to identify the area of damage.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of D/W wall surface in liquid phase	Indirect (item 5)		1	The impact on the safety functions is small. (When the D/W water level decreases excessively, the flow rate of the D/W stagnant water transfer pump can be adjusted.)	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-16	Piping	Static boundary	Decrease in the flow rate of transferring liquid in the system	Due to deterioration of the piping, the design value of flow rate for the transferring liquid in the system is not ensured, resulting in the water level in the connected boundary or tank to increase or decrease.	①	Partial blockage due to accumulation of dust migrating from the processing point to the piping	(a) Flow rate in the system	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage in the piping, and because this trend is affected by the amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the piping	1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into piping	Indirect (item 5)		1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-17	Piping	Static boundary	Decrease in the flow rate of transferring liquid in the system	As the piping deteriorates and the size of the boundary opening increases, the amount of transferring liquid decreases.	①	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the piping	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because the flow rate of transferring liquid in the system decreases due to occurrences of leaks resulting from damage to the piping, and because this trend is affected by the amount and particle size distribution of dust flowing into the piping.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into liquid system	Indirect (item 5)		1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-18	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion caused by changes in the water quality of stagnant water migrating from the processing point to the piping	(a) Flow rate in the system + leak detection	Direct (item 4)	Selected because the flow rate of transferring liquid in the system decreases due to occurrences of leaks resulting from damage to the piping, and because this trend is affected by the chemical properties (pH, chloride ion concentration, and chemical composition) of dust flowing into the piping.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)		1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-19	Piping	Static boundary	Same as above	Due to deterioration of the piping, the design value of flow rate for the transferring liquid in the system is not ensured, resulting in the water level in the connected boundary or tank to increase or decrease.	④	Partial blockage due to accumulation of abrasives migrating from the processing point to the piping	(a) Flow rate in the system	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage in the piping, and because this trend is affected by the amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into the piping	1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into piping	Indirect (item 5)		1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

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■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1	■ Score table for item 7-2	■ Score table for item 7-3
[4 points] No countermeasures have been determined [3 points] Countermeasures exist, but they are still under development [2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.	[4 points] Requires constant monitoring during task and predictability is poor [3 points] Requires constant monitoring during task but predictability is good [2 points] Requires regular monitoring and predictability is poor [1 point] Requires regular monitoring and predictability is good	[4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task [2 points] Countermeasures exist, but throughput decreases due to workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/In direct monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of represe ntation
An-Eki-20	Valves (Integration of valves present in the system)	Static boundary	Decrease in the flow rate of transferring liquid in the system	As the valve deteriorates and the size of the boundary opening increases, the amount of transferring liquid decreases.	①	Partial damage due to corrosion caused by dust migrating from the processing point to the valve	(a) Flow rate in the system + leak detection	Direct (item 4)	Selected because the flow rate of transferring liquid in the system decreases due to occurrences of leaks resulting from damage to the valve, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the liquid-phase system.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)		1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-21	Same as above	Same as above	Same as above	The valve deteriorates and the amount of transferring liquid deviates from the control value.	④	Adhesion of the valve due to accumulation of abrasives migrating from the processing point to the valve	(a) Flow rate in the system + leak detection	Direct (item 4)	Selected because the flow rate of transferring liquid in the system decreases due to blockage resulting from adhesion of the valve, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the liquid-phase system.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into liquid system	Indirect (item 5)		1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-22	PCV stagnant water buffer tank	Static boundary	Decrease in the flow rate of transferring liquid in the system	Due to damage to the PCV stagnant water buffer tank, the coolant throughput is reduced, and the site boundary radiation dose/worker exposure dose deviates from the control value.	①	Partial damage due to corrosion caused by accumulation and adhesion of dust migrating from the processing point to the PCV stagnant water buffer tank	(a) Water level of PCV stagnant water buffer tank + leak detection	Direct (item 4)	Selected because the water level in the buffer tank decreases due to damage to the PCV stagnant water buffer tank, and this tendency is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the PCV stagnant water buffer tank.	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)		1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-23	D/W stagnant water coarse particles removal equipment	Static boundary	Decrease in the flow rate of transferring liquid in the system	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value of flow rate for the transferring liquid in the system is not ensured, resulting in the D/W water level to increase	①	Partial blockage due to accumulation of dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage of the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system and the differential pressure before and after the D/W stagnant water coarse particle removal equipment, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-24	Same as above	Same as above	Same as above	Due to deterioration of the D/W stagnant water coarse particle removal equipment, leakage occur, and the site boundary radiation dose/worker exposure dose deviates from the control value.	Same as above	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because leaks occur due to damage to the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the liquid system	1	Same as above	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase confinement equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Eki-25	D/W stagnant water coarse particles removal equipment	Static boundary	Decrease in the flow rate of transferring liquid in the system	Due to deterioration of the D/W stagnant water coarse particle removal equipment, leakage occur, and the site boundary radiation dose/worker exposure dose deviates from the control value.	①	Partial damage due to corrosion caused by changes in the water quality of stagnant water migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because leaks occur due to damage to the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the liquid system	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Eki-26	Same as above	Same as above	Same as above	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value of flow rate for the transferring liquid in the system is not ensured, resulting in the D/W water level to increase	④	Partial blockage due to accumulation of abrasives migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage of the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the amount, particle size distribution, and particle density of dust in the transferring liquid flowing into the liquid system	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system and the differential pressure before and after the D/W stagnant water coarse particle removal equipment, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-1	D/W stagnant water transfer pump	Cooldown of debris	Increase in PCV liquid phase temperature	Due to deterioration of the D/W stagnant water transfer pump, the design value for the pump flow rate is not ensured, resulting in the PCV liquid phase temperature to increase.	①	Partial damage to the D/W stagnant water transfer pump due to corrosion of metal components such as impellers, caused by dust contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because partial damage due to corrosion caused by dust in the D/W stagnant water transfer pump reduces the pump flow rate, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the D/W stagnant water transfer pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid at D/W stagnant water transfer pump inlet	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for securing the PCV cooling water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the D/W stagnant water transfer pump due to contamination and entrapment of dust contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water transfer pump inlet	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for securing the PCV cooling water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	

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■ Risk assessment table (cooling equipment)

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-3	D/W stagnant water transfer pump	Cooldown of debris	Increase in PCV liquid phase temperature	Due to deterioration of the D/W stagnant water transfer pump, the design value for the pump flow rate is not ensured, resulting in the PCV liquid phase temperature to increase.	④	Partial damage to the D/W stagnant water transfer pump due to abrasives discharged during AWJ processing in the coolant migrating from the processing point to the D/W stagnant water transfer pump coming into contact with the impeller, and causing the impeller to wear out	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer pump, and because this trend is affected by the amount and particle size distribution of abrasives in the transferring liquid flowing into the D/W stagnant water transfer pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of abrasives in the transferring liquid flowing into D/W stagnant water transfer pump inlet	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for securing the PCV cooling water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-4	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the D/W stagnant water transfer pump due to contamination and entrapment of abrasives contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer pump, and because this trend is affected by the temperature of coolant flowing into the liquid system.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of abrasives in the coolant flowing into D/W stagnant water transfer pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for securing the PCV cooling water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-5	Same as above	Same as above	Same as above	Same as above	Same as above	Performance degradation of the pump caused by the coolant temperature, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Water temperature inside PCV	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer pump inlet, and because this trend is affected by the temperature of transferring liquid flowing into the D/W stagnant water transfer pump inlet.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for securing the PCV cooling water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-6	Cooler	Cooldown of debris	Degradation of cooling function due to reduced amount of heat removal in the cooler	Attenuation of heat removal due to changes in the properties of cooler components	①	Performance degradation of the cooler caused by changes in the properties of metal components due to dust contained in the coolant migrating from the processing point to the cooler	(a) Cooler inlet/outlet temperature	Direct (item 4)	Selected because it is possible to detect the functional deterioration of the cooler through the temperature differential before and after the cooler, and because this trend is affected by the amount of dust in the transferring liquid flowing into the cooler.	1	When the circulation cooling system shutdown, the external water injection system using RO treated water as a water source is activated (multiplexing). In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for reactor water injection cooldown and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	3
							(b) The chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into cooler inlet	Indirect (item 5)		1	When the circulation cooling system shutdown, the external water injection system using RO treated water as a water source is activated (multiplexing). In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Continuous monitoring is required, and predictability is good.	1	Because item 7-1 is 1 point	3	
An-Rei-7	Same as above	Same as above	Same as above	Same as above	④	Partial damage to the cooler due to abrasives discharged during AWJ processing in the coolant migrating from the processing point to the cooler coming into contact with the piping inside the cooler, and causing the piping to wear out	(a) Cooler inlet/outlet temperature	Direct (item 4)	Selected because it is possible to detect the functional deterioration of the cooler through the temperature differential before and after the cooler, and because this trend is affected by the amount of abrasives in the transferring liquid flowing into the cooler.	1	When the circulation cooling system shutdown, the external water injection system using RO treated water as a water source is activated (multiplexing). In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for reactor water injection cooldown and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	3
							(b) Amount of abrasives flowing into cooler inlet	Indirect (item 5)		1	When the circulation cooling system shutdown, the external water injection system using RO treated water as a water source is activated (multiplexing). In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Continuous monitoring is required, and predictability is good.	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1	■ Score table for item 7-2	■ Score table for item 7-3
[4 points] No countermeasures have been determined [3 points] Countermeasures exist, but they are still under development [2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.	[4 points] Requires constant monitoring during task and predictability is poor [3 points] Requires constant monitoring during task but predictability is good [2 points] Requires regular monitoring and predictability is poor [1 point] Requires regular monitoring and predictability is good	[4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task [2 points] Countermeasures exist, but throughput decreases due to workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-8	PCV stagnant water injection pump	Cooldown of debris	Degradation of cooling function due to reduced coolant throughput	Functional deterioration of the pump	①	Partial damage to the PCV stagnant water injection pump due to corrosion and deformation of metal components such as impellers caused by dust contained in the coolant migrating from the processing point to the PCV stagnant water injection pump	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the PCV stagnant water injection pump, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the PCV stagnant water injection pump.	1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into PCV stagnant water injection pump inlet	Indirect (item 5)		1	Supported by multiplexing and sacrificial anodes. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for PCV cooling water injection and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-9	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the pump due to contamination and entrapment of dust contained in the coolant migrating from the processing point to the PCV stagnant water injection pump	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the PCV stagnant water injection pump, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the PCV stagnant water injection pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into PCV stagnant water injection pump inlet	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for PCV cooling water injection and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-10	Same as above	Same as above	Same as above	Same as above	④	Partial damage to the pump due to contamination and entrapment of abrasives discharged during AWJ processing in the coolant migrating from the processing point to the PCV stagnant water injection pump	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the PCV stagnant water injection pump, and because this trend is affected by the amount of abrasives in the transferring liquid flowing into the PCV stagnant water injection pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into PCV stagnant water injection pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for PCV cooling water injection and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-11	PCV stagnant water injection pump	Cooldown of debris	Degradation of cooling function due to reduced coolant throughput	Functional deterioration of the pump	④	Performance degradation of the pump caused by the coolant temperature, which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(a) Water temperature inside PCV	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer pump inlet, and because this trend is affected by the temperature of transferring liquid flowing into the D/W stagnant water transfer pump inlet.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of heat input at processing point	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for PCV cooling water injection and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	
An-Rei-12	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the pump due to abrasives discharged during AWJ processing in the coolant migrating from the processing point to the D/W stagnant water injection pump coming into contact with the impeller, and causing the impeller to wear out	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the PCV stagnant water injection pump, and because this trend is affected by the amount of abrasives in the transferring liquid flowing into the PCV stagnant water injection pump.	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of abrasives in the transferring liquid flowing into PCV stagnant water injection pump	Indirect (item 5)		1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Although the equipment is used for PCV cooling water injection and required to operate during retrieval operations, detectability for significant functional deterioration is good	1	Because item 7-1 is 1 point	3	

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■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring /Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-13	PCV stagnant water buffer tank	Cooldown of debris	Degradation of cooling function due to reduced coolant throughput	Due to damage to the PCV stagnant water buffer tank, the coolant throughput is reduced, and the temperature inside the PCV deviates from the control value.	①	Deterioration due to corrosion caused by dust contained in the cooling water migrating from the processing point to the PCV stagnant water buffer tank	(a) Amount of water in the PCV stagnant water buffer tank + amount of leakage	Direct (item 4)	Selected because occurrences of leaks due to damage to the PCV stagnant water buffer tank which makes it impossible to secure a water source for the cooling system, reduces the coolant throughput in the system, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the PCV stagnant water buffer tank.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-14	Piping	Same as above	Decrease in the flow rate of coolant in the system	Due to deterioration of the piping, the design value for the flow rate of coolant in the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	①	Partial blockage due to accumulation of dust migrating from the processing point to the piping	(a) Flow rate in the system	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage in the piping, and because this trend is affected by the amount and particle size distribution of dust in the coolant flowing into the piping	1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into piping	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	

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■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-15	Piping	Cooldown of debris	Decrease in the flow rate of coolant in the system	Due to leakage caused by deterioration of the piping, the coolant throughput is reduced, and the temperature inside the PCV deviates from the control value.	①	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the piping	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because occurrences of leaks due to damage to the piping reduces the flow rate of coolant in the system, and because this trend is affected by the amount and particle size distribution of dust flowing into the piping.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-16	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion caused by changes in the water quality of the coolant migrating from the processing point to the piping	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because occurrences of leaks due to damage to the piping reduces the flow rate of coolant in the system, and because this trend is affected by the chemical properties (pH, chloride ion concentration, and chemical composition) of dust flowing into the piping.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-17	Piping	Static boundary	Same as above	Due to deterioration of the piping, the design value for the flow rate of coolant in the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	④	Partial blockage due to accumulation of abrasives migrating from the processing point to the piping	(a) Flow rate in the system	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage in the piping, and because this trend is affected by the amount and particle size distribution of abrasives in the transferring liquid flowing into the piping	1	If there is a significant trend toward blockage, it can be handled by flushing the piping.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into piping	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Item 1 Target equipment	Item 2 The function that the target is responsible for	Item 3 Work delay factor (= error)	Item 4 Direct causes of error	Item 5-1 Indirect causes of error	Item 5-2 Reasons to be selected	Item 6-1 Detection requirements to avoid work	Item 6-2 Direct monitoring/Indirect monitoring	Item 6-3 Reason for selection of detection requirements	Item 7-1 Point	Item 7-1 Presence or absence of countermeasures for disturbing functions	Item 7-2 Point	Item 7-2 Effects on accurate and prompt on-site response by workers	Item 7-3 Point	Item 7-3 Impact on throughput due to error handling (Indirect causes)	Item 7-4 (Evaluation Results) Individual	Item 7-4 (Evaluation Results) Point of representation
An-Rei-18	Valves (Integration of valves present in the system)	Static boundary	Decrease in the flow rate of coolant in the system	Due to leakage caused by deterioration of the valve, the coolant throughput is reduced, and the temperature inside the PCV deviates from the control value.	①	Partial damage due to corrosion caused by dust migrating from the processing point to the valve	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because occurrences of leaks due to damage to the valve reduces the flow rate of coolant in the system, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the liquid-phase system.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-19	Same as above	Same as above	Same as above	Due to adhesion caused by deterioration of the valve, the coolant throughput is reduced, and the temperature inside the PCV deviates from the control value.	④	Adhesion of the valve due to accumulation of abrasives migrating from the processing point to the valve	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because the flow rate of coolant in the system decreases due to blockage resulting from adhesion of the valve, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the liquid-phase system.	1	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to cooling, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-20	D/W stagnant water coarse particles removal equipment	Static boundary	Decrease in the flow rate of coolant in the system	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value for the flow rate of coolant in the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	①	Partial blockage due to accumulation of dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment	Direct (item 4)	Select because the flow rate in the system decreases due to blockage of the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the amount and particle size distribution of dust in the coolant flowing into the D/W stagnant water coarse particle removal equipment	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system and the differential pressure before and after the D/W stagnant water coarse particle removal equipment, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

Important monitoring items: Items 1–6-3. Weighted evaluation of important monitoring items: Items 7-1–7-4.

■ Risk assessment table (cooling equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rei-21	D/W stagnant water coarse particles removal equipment	Static boundary	Decrease in the flow rate of coolant in the system	Due to deterioration of the D/W stagnant water coarse particle removal equipment, leaks occur, and the temperature inside the PCV deviates from the control value.	①	Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because leaks occur due to damage to the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the chemical properties (pH, chloride ion concentration, and chemical composition) of coolant flowing into the liquid system	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-22	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage due to corrosion caused by changes in the water quality of stagnant water migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because leaks occur due to damage to the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the chemical properties (pH, chloride ion concentration, and chemical composition) of coolant flowing into the liquid system	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	3	With constant monitoring of the flow rate in the system and leak detection, post-detection is possible, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rei-23	Same as above	Same as above	Same as above	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value for the flow rate of coolant in the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	④	Partial blockage due to accumulation of abrasives migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Flow rate in the system + differential pressure before and after D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because the flow rate in the system decreases due to blockage of the D/W stagnant water coarse particle removal equipment, and because this trend is affected by the amount and particle size distribution of dust in the coolant flowing into the liquid system	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system and the differential pressure before and after the D/W stagnant water coarse particle removal equipment, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount, particle size distribution, and particle density of abrasives in the coolant flowing into liquid system	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase/sub-criticality maintenance equipment)

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring /Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rin-1	D/W stagnant water coarse particles removal equipment	Criticality prevention	Approaching Criticality	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value for removed particle size is not ensured, and the accumulation of particles in the PCV stagnant water buffer tank increases, approaching criticality.	①	Partial damage to the mesh of the filter section in the equipment due to contact with dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rin-2	Same as above	Same as above	Same as above	Same as above	Same as above	Partial damage to the mesh of the filter section in the equipment due to corrosion caused by the potential difference resulting from accumulation of dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Risk assessment table (liquid phase/sub-criticality maintenance equipment)

No.188

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/ Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rin-3	D/W stagnant water coarse particles removal equipment	Criticality prevention	Approaching Criticality	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value for removed particle size is not ensured, and the accumulation of particles in the PCV stagnant water buffer tank increases, approaching criticality.	①	Partial damage to the mesh of the filter section in the equipment due to corrosion caused by changes in the water quality of the stagnant water migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rin-4	Same as above	Same as above	Same as above	Same as above	Same as above	Decrease in the efficiency of centrifugal removal resulting from insufficient flow rate in the equipment caused by increased density of the transferring liquid due to dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rin-5	Same as above	Same as above	Same as above	Same as above	④	Partial damage to the mesh of the filter section in the equipment due to contact with abrasives migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of abrasives in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	Because the cyclone is structured so that dust does not easily accumulate, the frequency of occurrence is low, and because the auto-strainer automatically discharges the contaminants after a blockage is detected, the impact on safety functions is considered to be small.	3	Detection of trends and post-detection are possible through constant monitoring of the flow rate in the system and the differential pressure before and after the D/W stagnant water coarse particle removal equipment, and detectability is good.	1	Because item 7-1 is 1 point	3	4
							(b) Amount of abrasives in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	

IRID

■ Risk assessment table (liquid phase/sub-criticality maintenance equipment)

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Requires constant monitoring during task and predictability is poor
[3 points] Requires constant monitoring during task but predictability is good
[2 points] Requires regular monitoring and predictability is poor
[1 point] Requires regular monitoring and predictability is good

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Analysis number	Important monitoring items									Weighted evaluation of important monitoring items							
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	Item 7-1		Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Work delay factor (= error)	Direct causes of error	Indirect causes of error	Reasons to be selected	Detection requirements to avoid work	Direct monitoring/Indirect monitoring	Reason for selection of detection requirements	Point	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
An-Rin-6	D/W stagnant water coarse particles removal equipment	Criticality prevention	Approaching Criticality	Due to deterioration of the D/W stagnant water coarse particle removal equipment, the design value for removed particle size is not ensured, and the accumulation of particles in the PCV stagnant water buffer tank increases, approaching criticality.	④	Partial damage to the mesh of the filter section in the equipment due to corrosion caused by the potential difference resulting from accumulation of abrasives migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of abrasives in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	
An-Rin-7	Same as above	Same as above	Same as above	Same as above	Same as above	Decrease in the efficiency of centrifugal removal resulting from insufficient flow rate in the equipment caused by increased density of the transferring liquid due to abrasives migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment	Direct (item 4)	Selected because large particles pass through the D/W stagnant water coarse particle removal equipment due to damage to the equipment, and because this trend is affected by the amount and particle size distribution of abrasives in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	1	The impact on safety functions is small, and the frequency of occurrence is expected to be low.	4	Post-detection is possible from the amount and particle size distribution of dust downstream of the D/W stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	4
							(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point	4	

■ Supplemental information prior to presentation of assessment results: Additional procedures specific to work equipment prior to risk assessment

- Unlike safety equipment, work equipment combines multiple actions to perform work within the PCV. For example, the work of "processing fuel debris" consists of repetition of check and action operations (operation group) as shown in STEP 2 below.
- Check items are defined as determining the nature of the next action (e.g. whether to use a disk cutter or AWJ for fuel debris processing) or execution/non-execution (e.g. whether to process with a disk cutter, etc.) do.
- Work equipment risk assessments are performed separately for groups of actions. Therefore, as a pre-stage of risk assessment, it is necessary to define a group of actions for each task (so-called task separation).
- The procedure for performing work separation and risk assessment is shown below. See the following pages for specific work methods.

Classification of work steps → **Risk assessment**

STEP 1: Work step definition

ID	Work Name
Sa-1	Verification of the overall situation and operational/safety equipment inside the PCV
Sa-2	Approaching the object to be processed
Sa-3	Work prior to debris processing
Sa-4	Processing of debris
Sa-5	Various records following processing work
Sa-6	Cell transfer of debris
Sa-7	Transfer of debris ①
Sa-8	Collection of debris
Sa-9	Transfer of debris ②
Sa-10	Transfer of debris

STEP 2: Action group definition (for Sa-4)

ID	Action group	
i	(check)	Determine the method for debris processing
ii	(action)	Debris processing (cutting/chipping/crushing/picking up)
iii	(check)	Verify if the debris has been processed as expected
iv	(action)	Debris is stored in the inner container
v	(check)	Check whether debris is safely stored in the inner container

Input for action group definition: Equipment configuration block diagram, table of operational functions, table of safety functions

Step 3: Setting work delay factors (=errors)

[Error analysis table] Set factors that delay work for each action

Step 4: Entry into the risk assessment table

[Risk evaluation table] From STEP4 onwards, the flow is the same as for risk assessment of safety equipment.

Input for work delay factor extraction: List of disturbances to work equipment

■ Risk assessment procedures specific to operational equipment

- The execution procedure of STEP 1 and 2 shown on the previous page is shown.

○Step 1 of work

ID	Work Name
Sa-1	Verification of the overall situation and operational/safety equipment inside the PCV
Sa-2	Approaching the object to be processed
Sa-3	Work prior to debris processing
Sa-4	Processing of debris
Sa-5	Various records following processing work
Sa-6	Cell transfer of debris
Sa-7	Transfer of debris ①
Sa-8	Collection of debris
Sa-9	Transfer of debris ②
Sa-10	Transfer of debris

(1) Select one work to be analyzed from the work steps.

○ Work detail sheet to determine the attributes of the action group in STEP2

(2) Enter ID items a to k based on the debris retrieval model information.

ID	attribute	Concrete actions
a	Goal	Debris is finely divided and stored in the inner container
b	Environment	Inside the PCV
C	Safety	[Gas phase] Dust scattering prevention function, PCV damage prevention function, debris overheating prevention function, [Criticality] Debris shape control function
d	Components	[Debris processing equipment] Debris processing mechanism, [Debris sealed storage/transfer equipment] Radiation source storage mechanism
e	Target	Debris (fuel, fuel debris mass (U-rich, Fe-rich), existing structures, MCCI formations)
f	preceding work	ID: Sa3
g	Work start condition	Condition 1: Successful completion of preceding work
h	Action group	Refer to action group sheet
i	End of work condition	Completion of debris storage in the inner vessel
j	Takeover next work	Delivery of the inner container containing debris (*Refer to item k)
k	Others	Debris stored in the inner container maintains a subcritical state

(3) Set a group of actions to achieve the contents described in ID a and i

○ Operation group sheet for STEP2

ID	Movement		Remarks
i	(check)	Determine the processing method for <target>	
ii	(action)	Processing (cutting/cracking/crushing/picking up) of <target> by <equipment: debris processing mechanism>	
iii	(check)	Confirm the processing result of <target>	Confirmation of processing results: Refers to confirming whether the debris has been subdivided to a size that fits in the inner container.
iv	(action)	Store <target> in <equipment: inner container> with <equipment: radiation source storage mechanism>	
v	(check)	Safety confirmation of <target: debris> stored in the inner container	Safety confirmation: Refers to confirmation that debris is not spilled from the inner container and that the subcritical state is maintained.

■ Risk assessment procedures specific to operational equipment

- The procedures for executing STEP 2 to 3 shown on page 1/59 of this Appendix is described.
- The word "error" used in this document is synonymous with work delay factor.

○ STEP2 Action group (reprint of previous page)

ID	Movement		Remarks
i	(check)	Determine the processing method of the <Target >	
ii	(action)	Processing (cutting/chipping/crushing/picking up) of <Target> by < Equipment: Debris processing mechanism>	
iii	(check)	Verify the processing results of <target>	by processing and solidification
iv	(Action)	<Equipment: Radiation source storage mechanism> stores <Target> to <Equipment: Inner container> >	
v	(check)	Verify the safety of the <Target: Debris> stored in the inner container	Safety of chipped state

○ STEP3 Table of disturbances to operational equipment

Analysis ID	Classification	Locations	Disturbance candidate
Gairan-1	Static element	PCV	Inside the PCV is in a state of darkness
Gairan-2	Static element	PCV	Fog is generated inside the PCV
Gairan-3	Static element	PCV	Airflow is occurring inside the PCV due to heat generated by the debris
Gairan-4	Static element	PCV	Airflow is occurring inside the PCV due to inleakage from existing openings
Gairan-5	Static element	PCV	Airflow is occurring inside the PCV due to nitrogen injection
Gairan-6	Static element	PCV	Water is dripping inside the PCV due to the injection of cooling water

Deploy the error analysis sheet for each defined action

① Enter top events that impede defined actions and delay work

② Enter the functions involved in the action of interest. Candidate entries are those related to either ID c (related to safety function) or d (related to operational function) on the task detail sheet

○ STEP3 Error analysis table

ID	Action group sheet I D	Error mode that stagnates work	Featured features	Disturbance of interest	Disturbance of interest	Error generating mechanisms	Supplementary information
1	i	Deciding how to process debris takes time	Work	Disturbance-22		The properties of debris and the selected processing method are incompatible, and it takes time to determine the processing method.	
2	ii	Debris processing takes time	Gas phase	Gairan-1	Gairan-20	Excessive heatup of debris in the dark (poor visibility) and volatilization of radioactive materials	
3	ii	Same as above	Gas phase	Gairan-2	Gairan-20	Excessive heatup of debris due to fog (poor visibility) causing volatilization of radioactive materials	
4	ii	Same as above	Gas phase	Gairan-6	Gairan-20	Debris is excessively heated by dripping water (poor visibility), and radioactive materials volatilize	
5	ii	Same as above	Gas ph[illegible]	Gairan-24	Gairan-20	Excessive heating of debris with high background (noise) and volatilization of radioactive materials	
6	ii	Same as above	[illegible]hase	Gairan-19	Gairan-20	Dust scattering (poor visibility) overheats debris and volatilizes radioactive materials	
7	ii	Same as above	[illegible]riticality	Gairan-1	Gairan-21	Debris is processed into an inappropriate shape in the dark (with poor visibility), and the debris approaches a critical state.	
8	ii	Sam[illegible]	[illegible]lity	Gairan-2	Gairan-21	Debris is processed into an inappropriate shape by fog (poor visibility), and the debris approaches a critical state.	
9	ii	Sam[illegible]	[illegible]lity	Gairan-6	Gairan-21	Debris is processed into an inappropriate shape by dripping water (poor visibility), and the debris approaches a critical state.	
10	ii	Sam[illegible]	[illegible]lity	Gairan-18	Gairan-21	Debris is processed into an inappropriate shape due to dust scattering (poor visibility), and the debris approaches a critical state .	

③ Extract the error generating mechanisms related to the function of interest in the form of an object tree. Use the "Table of disturbances to operational equipment" for extraction.

■ Risk assessment procedures specific to operational equipment

- The procedure for executing STEP 4 shown on page 1/59 of this Appendix is described.

○ STEP3 error analysis table (reprint of previous page)

ID	Action group sheet I D	Error mode that causes stoppage of work	Functions of interest	Disturbances of interest	Disturbances of interest	Error generating mechanisms	Supplementary information
1	i	It takes time to determine the method of processing debris	Work	Gairan-22		The properties of debris are incompatible with the processing method selected,and it takes time to determine the processing method.	
2	ii	Debris processing takes time	Gas phase	Gairan-1	Gairan-20	Excessive heatup of debris in the dark (poor visibility) and volatilization of radioactive materials	
3	ii	Same as above	Gas phase	Gairan-2	Gairan-20	Excessive heatup of debris due to fog (poor visibility) causing volatilization of radioactive materials	
13	ii	Same as above	Gas phase	Gairan-23		The dust dispersed by processing approaches the allowable dust concentration inside the PCV	
14	ii	Same as above	Work	Gairan-13		It takes time to allow the processing jig to access the area where application of external force is desired	
15	ii	Same as above	Work	Gairan-16		Processing jigs wear out quickly, and frequent replacement make processing time-consuming	
16	ii	Same as above	Work	Gairan-15		Hot spots appear and it takes time to assess the impact on equipment	
17	ii	Same as above	Work	Gairan-7		No external mechanical/thermal forces are transferred to the debris due to obstruction caused by water flow	

○ SETP4 risk assessment table

Important monitoring items							Weighted evaluation of important monitoring items								
Item 1	Item 2	Item 3 (Extracted from the error extraction table)		Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
Target equipment	The function that the target is responsible for	Analysis ID	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Impact on function	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Debris processing mechanism	Fuel debris processing function	15	Processing jigs wear out quickly, and frequent replacement make processing time-consuming	Excessive wear and tear of processing jigs	Fuel debris	[Item 4] (a) Degree of wear and tear of processing jigs	3	Work	Technology for remotely exchanging processing jigs on site, such as a tool changer, is under development in the fuel debris retrieval project.	3	・ It is difficult to directly determine the wear and tear of processing jigs. For visual verification, training for operators in sensory inspection is required. For cases other than visual verification, multiple data, such as jig vibration and motor output, must be obtained to make a determination. ・ General industrial technology can be utilized for all of the above.	2	The task is assumed to be temporarily restricted due to the measures in Item 7-1.	18	18
			Same as above	Same as above	Same as above	[Item 5] (b) Compressive strength of fuel debris	3	Work	Same as above	3	・ It is difficult to directly determine the compressive strength, as it is necessary to collect a sample and conduct a tensile test, etc. ・ Since the existing technology requires sample collection + hot lab testing, not being performed at the processing site, there is a problem when measurement is required on site.	2	Same as above	18	

① Enter the equipment and the function of interest entered in the error analysis table (task detail sheet)

② Enter the error generating mechanisms set in the error analysis table

③ Break down the mechanisms in Item 3 into straightforward physical phenomena

④ Implement risk assessment based on the information inherited from the error analysis table

■ Risk assessment table

■ Score table for Item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development [2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for Item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but the throughput decreases due to task load limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-2**	**: Verification of the overall situation and operational/safety equipment inside the PCV**

Daily workflow

Risk assessment table analysis number	Important monitoring items							Weighted evaluation of important monitoring items								
	Item 1	Item 2	Item 3 (excerpt from error extraction table)		Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
	Target equipment	The function that the target is responsible for	Analysis ID	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
No environmental changes inside the PCV																

No task disturbing

*1

*4

*2

*3

(*1) The name of item 2 is omitted for layout reasons. Formal name: Safety functions or operational functions the target equipment is responsible for
(*2) The name of item 7-1 is omitted for layout reasons. Formal name: presence or absence of countermeasures for disturbing safety or operational functions
(*3) The name of item 7-3 is omitted for layout reasons. Formal name: Impact on throughput by countermeasures in item 7-1
(*4) For layout reasons, analysis IDs are abbreviated from this page onward.

■ Risk assessment table

No.195

Model ID

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly and there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-2**	**: Approaching the object to be processed**

Risk assessment table analysis number		Important monitoring items: Item 1	Item 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	Item 6	Weighted evaluation of important monitoring items: Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku-A-	1	Moving mechanism inside the PCV	Moving function inside the PCV	Presence or absence of interfering objects cannot be determined due to darkness, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Darkness	[Items 4/5] (a) Presence of interfering objects unaffected by darkness	1	Safety	Investigation inside the Fukushima Daiichi-2 PCV shows the effectiveness of the method that confirms the presence or absence of interfering objects on the task route in advance using dedicated equipment, and application of a similar method is assumed.	1	・ Direct determination is possible if 3D scans or other dimensional acquisitions are made ・ Detailed investigation inside the Fukushima Daiichi-2 PCV shows the application of laser scanning technology to obtain maintenance information on interfering objects.	1	Because item 7-1 is 1 point	1	1
Saku-A-	2	Moving mechanism inside the PCV	Moving function inside the PCV	Presence or absence of interfering objects cannot be determined due to fog, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Fog	[Items 4/5] (a) Presence of interfering objects unaffected by fog	1	Safety	Same as above	1	Same as above	1	Same as above	1	1
Saku-A-	3	Moving mechanism inside the PCV	Moving function inside the PCV	Presence or absence of interfering objects cannot be determined due to dripping water, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Dripping water	[Item 4/5] (a) Presence of interfering objects unaffected by dripping water	1	Safety	Same as above	1	Same as above	1	Same as above	1	1

The analysis number is defined by the combination of these two character strings

[The numbering rules for analysis ID]
Safety function related: Saku-A-Arabic numerals
Operational function related: Saku-B-Arabic numerals

■ Risk assessment table

No.196

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly and there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-2**	**: Approaching the object to be processed**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku-A-	4	Moving mechanism inside the PCV	Moving function inside the PCV	Presence or absence of interfering objects cannot be determined due to high background noise, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Noise	[Items 4/5] (a) Presence of interfering objects unaffected by noise	1	Safety	Investigation inside the Fukushima Daiichi-2 PCV shows the effectiveness of the method that confirms the presence or absence of interfering objects on the task route in advance using dedicated equipment, and application of a similar method is assumed.	1	・ Direct determination is possible if 3D scans or other dimensional acquisitions are made ・ Detailed investigation inside the Fukushima Daiichi-2 PCV shows the application of laser scanning technology to obtain maintenance information on interfering objects.	1	Because Item 7-1 is 1 point	1	1
Saku-B-	1	Moving mechanism inside the PCV	Moving function inside the PCV	Transfer takes time due to water flow	Low transferring speed	Water flow	[Item 4] (a) Time to reach destination	1	Work	・ Records from underwater ROV injection exist in the investigation inside thethe Fukushima Daiichi-3 PCV, and since the flow of water is taken into consideration in the designed measures, similar response will be necessary. ・ Heavy machinery with underwater specifications exists for general work, and it is assumed that it is possible to formulate countermeasures that resist the flow of water.	1	・ Can be determined directly by acquiring the actual transfer time ・ Can be executed through control, and there are no issues with introduction	1	Because Item 7-1 is 1 point	1	2
							[Item 5] (b) Velocity of water flow on the transfer route	1	Work	Same as above	2	When using a Price current meter, it is possible to directly determine the flow velocity, but there are problems because it requires assessing the radiation resistance of the flow meter in a high-dose radiation environment	1	Same as above	2	2

■ Risk assessment table

No.197

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for Item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly, but can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly, and can expect introduction to be feasible

■ Score table for Item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[Point 2] Countermeasures exist, but the throughput decreases due to task load limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-2**	**: Approaching the object to be processed**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku -B-	2	Moving mechanism inside the PCV	Moving function inside the PCV	Transfer takes time due to assessment of impact on equipment caused by appearance of hot spots	Delay in ascertaining effects on radiation	Hot spot	[Item 4] (a) Degree of effects on equipment against hot spots (radiation resistance)	1	Work	The operational procedure of temporary evacuation from the area when a hot spot is verified has been incorporated in the investigation inside the Fukushima Daiichi-2 PCV, so a similar response will be necessary.	1	・ When using a dosimeter, a direct determination can be made by setting the threshold dose based on the cumulative exposure dose of the operational equipment. ・ The dosimeter has been introduced in the on-site demonstration testing of the project of investigation inside the PCV.	3	Throughput is assumed to be significantly reduced due to the unknown duration of temporary evacuation due to measures taken for Item 7-1.	3	9
							[Item 5] (b) Location of hot spots on the transfer route	1	Work	Same as above	3	・ When using a dosimeter, the specific location of the source cannot be determined directly due to the surrounding background. ・ Development of technology to identify hot spots in a high-dose radiation environment is required.	3	Same as above	9	9

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly, and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-2**	**: Approaching the object to be processed**

Risk assessment table analysis number		Important monitoring items						**Weighted evaluation of important monitoring items**								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		**Item 7-4 (Evaluation Results)**	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Corresponding function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	3	Moving mechanism inside the PCV	Moving function inside the PCV	Cannot detect the transfer route due to sediment soaring during transfer, and transfer takes time	Delay in ascertaining the transfer route	Soaring sediment	[Items 4/5] (a) Transfer route detection unaffected by soaring sediment	3	Work	The detailed investigation inside the Fukushima Daiichi-2 PCV is currently developing a technology that enables equipment to be moved even in the PCV environment by obtaining information on the maintenance of interfering objects in advance through laser scanning.	3	Sampling equipment to be deployed during the experimental fuel debris retrieval phase will be equipped with technology for acquiring information on the layout of structures using laser scanning, and the on-site demonstration testing is scheduled.	1	There is no impact on throughput with the introduction of the technology shown in Item 7-1	9	9
Saku-B-	4	Moving mechanism inside the PCV	Moving mechanism inside the PCV	Verification of current location takes time due to darkness	Delay in ascertaining the current location of the moving mechanism inside the PCV	Darkness	[Items 4/5] (a) Current location detection unaffected by darkness	3	Work	・In the investigation inside the Fukushima Daiichi-2 PCV, self-location was estimated based on the amount of equipment movement and information from the drawings. ・In the Fukushima Daiichi-3 underwater ROV investigation, self-location was estimated based on surrounding structures and information from the drawings. ・During debris retrieval, the layout of surrounding structures will change due to removal of interfering objects, etc., so additional measures are necessary.	2	・ Workers can directly determine their self-location by the method applied in the past investigation inside the PCV shown in Item 7-1. ・ However, as the construction progresses, there is a high possibility that the landmarks will change, so task is necessary to update the information on the layout of structures inside the PCV, which presents problems.	1	Same as above	6	6

IRID

■ Risk assessment table

Model ID

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	Ko-3	: Debris retrieval
Work	Sa-2	: Approaching the object to be processed

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Corresponding function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	5	Moving mechanism inside the PCV	Moving function inside the PCV	Verification of current location takes time due to fog	Delay in ascertaining the current location of the moving mechanism inside the PCV	Fog	[Items 4/5] (a) Current location detection unaffected by fog	3	Work	・ In the investigation inside the Fukushima Daiichi-2 PCV, self-location was estimated based on the amount of equipment movement and information from the drawings. ・ In the Fukushima Daiichi-3 underwater ROV investigation, self-location was estimated based on surrounding structures and information from the drawings. ・ During debris retrieval, the layout of surrounding structures will change due to removal of interfering objects, etc., so additional measures are necessary.	2	・ Workers can directly determine their self-location by the method applied in the past investigation inside the PCV shown in Item 7-1. ・ However, as the construction progresses, there is a high possibility that the landmarks will change, so task is necessary to update the information on the layout of structures inside the PCV, which presents problems.	1	There is no impact on throughput with the introduction of the technology shown in Item 7-1	6	6
Saku-B-	6	Moving mechanism inside the PCV	Moving function inside the PCV	Verification of current location takes time due to dripping water	Delay in ascertaining the current location of the moving mechanism inside the PCV	Dripping water	[Items 4/5] (a) Current location detection unaffected by dripping water	3	Work	Same as above	2	Same as above	1	Same as above	6	6
Saku-B-	7	Moving mechanism inside the PCV	Moving function inside the PCV	Verification of current location takes time due to the high background noise	Delay in ascertaining the current location of the moving mechanism inside the PCV	Noise	[Items 4/5] (a) Current location detection unaffected by noise	3	Work	Same as above	2	Same as above	1	Same as above	6	6

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly, and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	Ko-3	: Debris retrieval
Work	Sa-3	: Work Prior to processing

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	Functions that target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku-A-	1	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to the darkness, it takes time to verify if the debris is submerged or not	Delay in ascertaining whether the debris is submerged or not	Darkness	[Item4/5] (a) Submerged debris detection un affected by darkness	3	Safety	It is necessary to take countermeasures against the risk of making the wrong decision not to apply the neutron absorbent in spite of being submerged in water. It is necessary to utilize the neutron detector under development in the 1 F subsidized project, and to have an action policy for immediately spraying neutron material when criticality is approached.	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Addressing Item 7-1 limits the workload.	18	18
Saku-A-	2	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to fog, it takes time to verify if the debris is submerged or not	Delay in ascertaining whether the debris is submerged or not	Fog	[Item4/5] (a) Submerged debris detection unaffected by fog	3	Safety	Same as above	3	Same as above	2	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-3**	**: Work Prior to processing**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	3	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to dripping water, it takes time to verify if the debris is submerged or not	Delay in ascertaining whether the debris is submerged or not	Dripping water	[Items 4/5] (a) Submerged debris detection unaffected by dripping water	3	Safety	It is necessary to take countermeasures against the risk of making the wrong decision not to apply the neutron absorbent in spite of being submerged in water. It is necessary to utilize the neutron detector under development in the Fukushima Daiichi subsidized project, and to have an action policy for immediately spraying neutron material when criticality is approached.	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Addressing Item 7-1 limits the workload.	18	18
Saku -A-	4	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to high background noise, it takes time to verify if the debris is submerged or not	Delay in ascertaining whether the debris is submerged or not	Noise	[Items 4/5] (a) Submerged debris detection unaffected by noise	3	Safety	Same as above	3	Same as above	2	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-3**	**: Work Prior to processing**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	5	Debris processing mechanism	[Criticality] Neutron absorbent application function	The flow of cooling water disperses the neutron absorbent, and application takes time	Insufficient application of neutron absorbent	Water flow	[Item 4] (a) Application time for neutron absorbent	3	Safety	- The density of the neutron absorbent developed in the debris retrieval project is high, and it is thought that it will overcome the Marangoni convection and sink.	2	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	2	- Based on the evaluation of Item 7-1, the impact on throughput is considered to be limited.	12	12
							[Item 5] (b) Water flow velocity at the neutron absorbent application area	3	Safety	Same as above	2	When using a Price current meter, it is possible to directly determine the flow velocity, but there are problems because it requires assessing the radiation resistance of the flow meter in a high-dose radiation environment	2	Same as above	12	12

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-3**	**: Work Prior to processing**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	6	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to darkness, verification of the results of neutron absorbent application takes time	Delay in ascertaining the neutron absorbent application status	Darkness	[Items 4/5] (a) Detection of neutron absorbent application status unaffected by darkness	3	Safety	It is necessary to take countermeasures against the risk of making the wrong decision not to start processing work despite inadequate application of neutron absorbent. By utilizing the neutron detector being developed in the Fukushima Daiichi subsidized project, the project is advocating an operational procedure to verify the effectiveness after spraying.	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Addressing Item 7-1 limits the workload.	18	18
Saku -A-	7	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to fog, verification of the results of neutron absorbent application takes time	Delay in ascertaining the neutron absorbent application status	Fog	[Items 4/5] (a) Detection of neutron absorbent application status unaffected by fog	3	Safety	Same as above	3	Same as above	2	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-3**	**: Work Prior to processing**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	8	Debris processing mechanism	[Criticality] Neutron absorbent application function	Due to dripping water, verification of the results of neutron absorbent application takes time	Delay in ascertaining the neutron absorbent application status	Dripping water	[Items 4/5] (a) Detection of neutron absorbent application status unaffected by dripping water	3	Safety	It is necessary to take countermeasures against the risk of making the wrong decision not to start processing work despite inadequate application of neutron absorbent. By utilizing the neutron detector being developed in the Fukushima Daiichi subsidized project, the project is advocating an operational procedure to verify the effectiveness after spraying.	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Addressing Item 7-1 limits the workload.	18	18
Saku -A-	9	Debris processing mechanism	[Criticality] Neutron absorbent application function	There are many blind spots in the spraying area and verification of the results of neutron absorbent application takes time	Delay in ascertaining the neutron absorbent application status	Surrounding structures	[Items 4/5] (a) Detection of neutron absorbent application status unaffected by blind spots due to surrounding structures	3	Safety	Same as above	3	Same as above	2	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	1	Debris processing mechanism	Fuel debris processing function	The properties of the debris are incompatible with the processing method selected, and time is required to determine the processing method.	Delay in determining the optimum processing method	Fuel debris with various properties	[Items 4/5] (a) Fuel debris properties (compressive strength) in the processing area	3	Work	The debris retrieval project is studying debris processing methods based on the properties of debris (mainly compressive strength), and is also considering operational procedures where multiple processing methods are sequentially tried on a single piece of debris.	4	There is a problem in that the property data necessary for determining the optimum processing method for debris is not specified except for the compressive strength.	2	The workload is limited during sequential testing of the processing methods in item 7-1.	24	24
Saku -A-	1	Debris processing mechanism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris due to darkness (poor visibility) causes volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to darkness (poor visibility)	[Item 4] (a) Dust concentration at the processing site unaffected by darkness	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology to measure dust concentration at the debris processing site in a dark and high-dose radiation environment is required.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by darkness	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there is a problem with radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-A-	2	Debris processing mechanism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris due to fog (poor visibility) causes volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to fog (poor visibility)	[Item 4] (a) Dust concentration at the processing site unaffected by fog	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology is required to measure dust concentration at the debris processing site in a foggy, high-dose radiation environment.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by fog	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there is a problem with radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

IRID

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	3	Debris processing mechanism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris due to dripping water (poor visibility) causes volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to dripping water (poor visibility)	[Item 4] (a) Dust concentration at the processing site unaffected by dripping water	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology is required to measure dust concentration at the debris processing site in a dripping water and high-dose radiation environment.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by dripping water	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there are problems with interference from dripping water and radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	4	Debris processing mechanism	[Gas phase] Prevention function of excessive heatup of fuel debris	Excessive heatup of debris due to high background (noise) causes volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to high background (noise)	[Item 4] (a) Dust concentration at the processing site unaffected by noise	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology is required to measure dust concentration at the debris processing site where radioactive noise is generated in a high-dose radiation environment.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by noise	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there are problems with interference from dripping water and radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	5	Debris processing mechanism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris due to dust dispersion (poor visibility) causes volatilization of radioactive materials	Volatilization of radioactive materials due to excessive heatup	Excessive heatup due to dust dispersion (poor visibility)	[Item 4] (a) Dust concentration at the processing site unaffected by dripping water	3	Safety	The following methods of general measures will maintain safety functions, but feasibility has not yet been evaluated. - Suspension of work - Injection of cooling water	2	- Direct judgment is possible by setting the threshold for dust concentration. - Technology is required to measure dust concentration at the debris processing site in a high-dose radiation environment.	3	The throughput will be significantly reduced because of the unknown duration of suspension of work caused by the countermeasures for Item 7-1.	18	18
							[Item 5] (b) Debris temperature unaffected by dust dispersion	3	Safety	Same as above	2	- Direct judgment is possible by setting the threshold for debris temperature. - When measuring with a thermal camera, there are problems with interference from dust and radiation resistance in a high-dose radiation environment.	3	Same as above	18	18

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	6	Debris processing mechanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to darkness (poor visibility), and the debris approaches the state of criticality	Debris approaching to criticality due to shape change	Inappropriate processing due to darkness (poor visibility)	[Item 4] (a) Neutron flux unaffected by darkness	3	Safety	Recriticality prevention technology based on neutron absorbent application (temporary suspension of task) is being developed in the Fukushima Daiichi subsidized project.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	12	24
							[Item 5] (b) Debris dimensions unaffected by darkness	3	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	7	Debris processing mechanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to fog (poor visibility), and the debris approaches the state of criticality	Debris approaching to criticality due to shape change	Inappropriate processing due to fog (poor visibility)	[Item 4] (a) Neutron flux unaffected by fog	3	Safety	Recriticality prevention technology based on neutron absorbent application (temporary suspension of task) is being developed in the Fukushima Daiichi subsidized project.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	12	24
							[Item 5] (b) Debris dimensions unaffected by fog	3	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - Image processing for countermeasures against fog and halation suppression with lighting are required. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	8	Debris processing mechanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to dripping water (poor visibility), and the debris approaches the state of criticality	Debris approaching to criticality due to shape change	Inappropriate processing due to dripping water (poor visibility)	[Item 4] (a) Neutron flux unaffected by dripping water	3	Safety	Recriticality prevention technology based on neutron absorbent application (temporary suspension of task) is being developed in the Fukushima Daiichi subsidized project.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	12	24
							[Item 5] (b) Debris dimensions unaffected by dripping water	3	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - Droplets adhering to the camera lens need to be blown off by gas or other means (being developed in the project of investigation inside the RPV) or be treated to prevent fogging. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	9	Debris processing mechanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to dust dispersion (poor visibility), and the debris approaches the state of criticality	Debris approaching to criticality due to shape change	Inappropriate processing due to dust dispersion (poor visibility)	[Item 4] (a) Neutron flux unaffected by dust dispersion	3	Safety	Recriticality prevention technology based on neutron absorbent application (temporary suspension of task) is being developed in the Fukushima Daiichi subsidized project.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	12	24
							[Item 5] (b) Debris dimensions unaffected by dust dispersion	3	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - Visibility evaluation of debris processing status for dust dispersion has been studied in the dust collection project for the disc cutter, but other processing methods have not been evaluated. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

IRID

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	Sa-4	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku-A-	10	Debris processing mechanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to high background (noise), and the debris approaches the state of criticality	Debris approaching to criticality due to shape change	Inappropriate processing due to noise (poor visibility)	[Item 4] (a) Neutron flux unaffected by background (noise)	3	Safety	Recriticality prevention technology based on neutron absorbent application(temporary suspension of task) is being developed in the Fukushima Daiichi subsidized project.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, according to the measures in Item 7-1.	12	24
							[Item 5] (b) Debris dimensions unaffected by background	3	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the shape and dimension of debris, and image processing is required. - Although camera noise caused by radiation from the PCV environment has also occurred in the project of investigation inside the PCV, no major adverse effects have been reported in the visual survey. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items: Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Weighted evaluation of important monitoring items: Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-A-	11	Debris processing mechanism	[Criticality] Debris processing shape control function	Structures fall from the processing site and collide with the debris, causing the debris to approach the state of criticality	Debris approaching to criticality due to shape change	Fall of structure	[Item 4] (a) Neutron flux around the location of the fall	3	Safety	- A technology to prevent re-criticality by spraying neutron absorbent (temporary suspension of work) is under development in the debris retrieval project. - In the debris retrieval project, concepts such as a support arm that supports the processed materials and a tray that catches falling objects are being considered to prevent the processing area from becoming brittle and falling by gravity.	2	- When using a neutron detector, a direct determination can be made by setting the neutron flux threshold. - The neutron detector is under development in the Fukushima Daiichi subsidized project.	2	During the application of the neutron absorbent, workload is limited according to the countermeasure in item 7-1.	12	24
							[Item 5] (b) Structural strength of structure leading to fall mode	3	Safety	Same as above	4	- The structural strength of structures must be evaluated based on various parameters such as defects, strain, stress, and cracks, making direct determination difficult. - In general industry, there are non-destructive inspection equipment (ultrasonic wave counter, etc.) for evaluating the structural strength of bridges and concrete tunnels, but there are technological issues such as radiation resistance in high-dose radiation environment and methods of application to complex shapes.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-A-	12	Debris processing mechanism	[Gas phase] Dust dispersion prevention function	The dust dispersed by processing approaches the allowable dust concentration inside the PCV	Excessive dust dispersion	Debris processing beyond dust dispersion prevention function	[Item 4] (a) Dust concentration at the processing site	1	Safety	Temporary suspension of processing work eliminates excessive dust dispersion. Example measures exist for similar events in the construction of the access route for the investigation inside the Fukushima Daiichi-1 PCV.	2	*If it is difficult to use the monitoring data of the safety equipment in gas phase, the following measures are required. - When using a dust sampler, dust concentration can be determined directly. - Technology is required to measure dust concentration at the debris processing site in a high-dose radiation environment.	3	- Addressing Item 7-1 will not be given 1 point since it is contingent on a temporary suspension of task. - Throughput is assumed to be significantly reduced due to the unknown duration of temporary suspension of task caused by addressing Item 7-1.	6	12
							[Item 5] (b) Amount of anti-dispersion agent (mist) reaching the processing area	1	Safety	Same as above	4	- When using camera images, it is difficult to directly determine the amount of mist reaching the processing area. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	3	Same as above	12	12

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku -B-	2	Debris processing mechanism	Fuel debris processing function	It takes time to allow the processing jig to access the area where application of external force is desired	Poor accessibility to the processing area	Structures at the processing site	[Item 4] (a) Time to reach the processing site	3	Work	Technology to improve the accessibility of the robot arm to the complexly arranged structures inside the PCV is under development in the fuel debris retrieval project.	3	In the debris retrieval project "Support method for remote operation of articulated MNP," technology is being developed to support and evaluate the accessibility improvements to the processing area by acquiring information on the layout of structures in advance and mechanically treating the information.	1	Addressing Item 7-1 is assumed to have low impact on throughput.	9	9
							[Item 5] (b) Three-dimensional shape (dimensions) of the structure at the processing site	3	Work	Same as above	3	Sampling equipment to be deployed during the experimental fuel debris retrieval phase will be equipped with technology for acquiring information on the layout of structures using laser scanning, and the on-site demonstration testing is scheduled.	1	Same as above	9	9

■ Risk assessment table

No.218

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	3	Debris processing mechanism	Fuel debris processing function	Processing jigs wear out quickly, and frequent replacement make processing time-consuming	Excessive wear and tear of processing jigs	Fuel debris	[Item 4] (a) Degree of wear and tear of processing jigs	3	Work	Technology for remotely exchange processing jigs such as a tool changer on site, is under development in the fuel debris retrieval project.	3	- It is difficult to directly determine the wear and tear of processing jigs. For visual verification, training for operators in sensory inspection is required. For cases other than visual verification, multiple data, such as jig vibration and motor output, must be obtained to make a determination. - General industrial technology can be utilized for all of the above.	2	Addressing Item 7-1 is assumed to restrict work temporarily.	18	18
							[Item 5] (b) Compressive strength of fuel debris to be processed	3	Work	Same as above	3	- It is difficult to directly determine the compressive strength, as it is necessary to collect a sample and conduct a tensile test, etc. - Since the existing technology requires sample collection + hot lab testing, not being performed at the processing site, there is a problem when measurement is required on-site.	2	Same as above	18	18

IRID

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Sak u-B-	4	Debris processing mechanism	Fuel debris processing function	Hot spots appear and it takes time to assess the impact on equipment	Delayed determination of effects on radiation	Hot spot	[Item 4] (a) Degree of effects on equipment against hot spots (radiation resistance)	1	Work	The operational procedure of temporary evacuation from the area when a hot spot is verified has been incorporated in the investigation inside the Fukushima Daiichi-2 PCV.	1	- When using a dosimeter, a direct determination can be made by setting the threshold dose based on the cumulative exposure dose of the operational equipment. - The dosimeter has been introduced in the field demonstration testing of the project of investigation inside the PCV.	3	Throughput is assumed to be significantly reduced due to the unknown duration of temporary evacuation due to measures taken for Item 7-1.	3	9
							[Item 5] (b) Source location of hot spots at the processing site	1	Work	Same as above	3	- When using a dosimeter, the specific location of the source cannot be determined directly due to the surrounding background. - Development of technology to identify hot spots in a high-dose radiation environment is required.	3	Same as above	9	9
Sak u-B-	5	Debris processing mechanism	Fuel debris processing function	Mechanical/thermal external forces are not transmitted to debris due to obstruction by water flow	Insufficient transmission of external force to debris	Water flow	[Item 4] (a) Amount of debris filling the inner container	4	Work	The condition of water flow inside the RPV, where cooling water is directly injected, is unknown. In addition, no countermeasures have been considered.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	4	Impact on throughput is unknown due to inability to determine countermeasures for Item 7-1	16	32
							[Item 5] (b) Cooling water velocity and flow rate at the fuel debris processing site	4	Work	Same as above	2	When using a Price current meter, it is possible to directly determine the flow velocity, but there are problems because it requires assessing the radiation resistance of the flow meter in a high-dose radiation environment	4	Same as above	32	32

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	6	Debris processing mechanism	Fuel debris processing function	Processing results (completion of debris shredding) cannot be obtained due to darkness, and having to re-process takes time	Change in shape of processed debris is unknown	Darkness	[Items 4/5] (a) Dimensions of processed debris unaffected by darkness	4	Work	In the debris retrieval project, debris processing technology is being studied, but countermeasures against this error have not been studied in detail.	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	4	Impact on throughput is unknown because no countermeasures have been determined for Item 7-1	64	64
Saku -B-	7	Debris processing mechanism	Fuel debris processing function	Processing results (completion of debris shredding) cannot be obtained due to fog, and having to re-process takes time	Change in shape of processed debris is unknown	Fog	[Items 4/5] (a) Dimensions of processed debris unaffected by fog	4	Function	In the debris retrieval project, debris processing technology is being studied, but countermeasures against this error have not been studied in detail.	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - Image processing for countermeasures against fog and halation suppression with lighting are required. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	4	Impact on throughput is unknown because no countermeasures have been determined for Item 7-1	64	64

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	8	Debris processing mechanism	Fuel debris processing function	Processing results (completion of debris shredding) cannot be obtained due to dripping water, and having to re-process takes time	Change in shape of processed debris is unknown	Dripping water	[Items 4/5] (a) Dimensions of processed debris unaffected by dripping water	4	Work	In the debris retrieval project, debris processing technology is being studied, but countermeasures against this error have not been studied in detail.	4	- When using camera images, it is difficult to directly determine the dimension of debris, and image processing is required. - Droplets adhering to the camera lens need to be blown off by gas or other means (being developed in the project of investigation inside the RPV) or be treated to prevent fogging. - General cameras have low radiation resistance in a high-dose radiation environment, and there are development problems.	4	Impact on throughput is unknown because no countermeasures have been determined for Item 7-1	64	64
Saku -B-	9	Debris processing mechanism	Fuel debris processing function	Processing results (completion of debris shredding) cannot be obtained due to sediments, powder from cutting (dust), and neutron absorbent floating in water, and having to re-process takes time.	Change in shape of processed debris is unknown	Floating neutron absorbent	[Items 4/5] (a) Dimensions of processed debris unaffected by sediments, powders from cutting (dust), or neutron absorbents floating in water	4	Work	In the debris retrieval project, debris processing technology is being studied, but countermeasures against this error have not been studied in detail.	4	- When using camera images, it is difficult to directly determine the shape and dimension of debris, and image processing is required. - Because the floating neutron absorbent has fluidity, it is possible to ensure visibility with artificial water flow. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	4	Impact on throughput is unknown because no countermeasures have been determined for Item 7-1	64	64

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	10	Radiation source collection mechanism	Fuel debris collection function	Debris does not fit in the inner container due to obstruction by the water flow. (Flows away	Low fuel collection rate	Water flow	[Item 4] (a) Amount of debris filling the inner container	4	Work	The condition of water flow inside the RPV, where cooling water is directly injected, is unknown. In addition, no countermeasures have been considered.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	4	Impact on throughput is unknown due to inability to determine countermeasures for Item 7-1	16	32
							[Item 5] (b) Cooling water velocity and flow rate at the fuel debris collection area	4	Work	Same as above	2	When using a Price current meter, it is possible to directly determine the flow velocity, but there are problems because it requires assessing the radiation resistance of the flow meter in a high-dose radiation environment	4	Same as above	32	32

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items: Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Weighted evaluation of important monitoring items: Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	11	Radiation source collection mechanism	Fuel debris collection function	Due to darkness (poor visibility), collection of debris in the inner container takes time	Low fuel collection rate	Darkness	[Item 4] (a) Amount of debris filling the inner container	4	Work	- In the case of debris pick-up operation for collecting debris into the inner container, semi-automated repetitive operations that do not rely on environmental measurements on site are present in general industrial technology and are expected to reduce disturbing work from the environment (poor visibility) inside the PCV. - Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	2	Among the measures for Item 7-1, there is a possibility that operator intervention may reduce the task speed.	8	24
							[Item 5] (b) Relative position of debris and inner container unaffected by darkness	3	Work	Same as above	4	- The operator's trajectory correction measures (e.g., minute misalignment between debris and inner container) for semi-automated operations shown in Item 7-1 cannot be determined directly when using camera images, as it requires discernment based on proficiency. - When detecting with camera + lighting, impact assessment of radiation resistance in a high-dose radiation environment is required.	2	Same as above	24	24

No.224

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	12	Radiation source collection mechanism	Fuel debris collection function	Due to fog (poor visibility), collection of debris in the inner container takes time	Low fuel collection rate	Fog	[Item 4] (a) Amount of debris filling the inner container	4	Work	- In the case of debris pick-up operation for collecting debris into the inner container, semi-automated repetitive operations that do not rely on environmental measurements on site are present in general industrial technology and are expected to reduce disturbing work from the environment (poor visibility) inside the PCV. - Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	2	Among the measures for Item 7-1, there is a possibility that operator intervention may reduce the task speed.	8	24
							[Item 5] (b) Relative position of debris and inner container unaffected by fog	3	Work	Same as above	4	- The operator's trajectory correction measures (e.g., minute misalignment between debris and inner container) for semi-automated operations shown in Item 7-1 cannot be determined directly when using camera images, as it requires discernment based on proficiency. - Cameras generally have image processing and lighting adjustment (halation suppression) technologies for dealing with fog. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items: Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Weighted evaluation of important monitoring items: Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku-B-	13	Radiation source collection mechanism	Fuel debris collection function	Due to dripping water (poor visibility), collection of debris in the inner container takes time	Low fuel collection rate	Dripping water	[Item 4] (a) Amount of debris filling the inner container	4	Work	- In the case of debris pick-up operation for collecting debris into the inner container, semi-automated repetitive operations that do not rely on environmental measurements on site are present in general industrial technology and are expected to reduce disturbing work from the environment (poor visibility) inside the PCV. - Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	2	Among the measures for Item 7-1, there is a possibility that operator intervention may reduce the task speed.	8	24
							[Item 5] (b) Relative position of debris and inner container unaffected by dripping water	3	Work	Same as above	4	- The operator's trajectory correction measures (e.g., minute misalignment between debris and inner container) for semi-automated operations shown in Item 7-1 cannot be determined directly when using camera images, as it requires discernment based on proficiency. - In general, there are technologies such as blowing off droplets adhering to the camera lens with gas, etc., and hydrophilic coating. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	14	Radiation source collection mechanism	Fuel debris collection function	Due to sediments, powder from cutting (dust), and neutron absorbent floating in the water (poor visibility), collection of debris in the inner container takes time	Low fuel collection rate	Floating neutron absorbent	[Item 4] (a) Amount of debris filling the inner container	4	Work	- In the case of debris pick-up operation for collecting debris into the inner container, semi-automated repetitive operations that do not rely on environmental measurements on site are present in general industrial technology and are expected to reduce disturbing work from the environment (poor visibility) inside the PCV. - Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	2	Among the measures for Item 7-1, there is a possibility that operator intervention may reduce the task speed.	8	24
							[Item 5] (b) Relative position of debris and inner container unaffected by sediments, powder from cutting (dust), or neutron absorbent floating in water	3	Work	Same as above	4	- The operator's trajectory correction measures (e.g., minute misalignment between debris and inner container) for semi-automated operations shown in Item 7-1 cannot be determined directly when using camera images, as it requires discernment based on proficiency. - Because the floating neutron absorbent has fluidity, it is possible to ensure visibility with artificial water flow. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

No.227

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	Ko-3	: Debris retrieval
Work	Sa-4	: Processing of debris

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	15	Radiation source collection mechanism	Fuel debris collection function	Due to high background (noise), collection of debris in the inner container takes time	Low fuel collection rate	Noise	[Item 4] (a) Amount of debris filling the inner container	4	Work	- In the case of debris pick-up operation for collecting debris into the inner container, semi-automated repetitive operations that do not rely on environmental measurements on site are present in general industrial technology and are expected to reduce disturbing work from the environment (poor visibility) inside the PCV. - Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems.	1	It is possible to make a direct determination by the amount of debris throughput per day, and introduction is feasible	2	Among the measures for Item 7-1, there is a possibility that operator intervention may reduce the task speed.	8	24
							[Item 5] (b) Relative position of debris and inner container unaffected by noise	3	Work	Same as above	4	- The operator's trajectory correction measures (e.g., minute misalignment between debris and inner container) for semi-automated operations shown in Item 7-1 cannot be determined directly when using camera images, as it requires discernment based on proficiency. - Although camera noise caused by radiation from the PCV environment has also occurred in the project of investigation inside the PCV, no major adverse effects have been reported in the visual survey. - The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.	2	Same as above	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	16	Radiation source collection mechanism	Fuel debris collection function	Cannot verify whether the debris has been collected in the inner container due to darkness (poor visibility)	Unknown amount of fuel debris filling the inner container (overflowing from the inner container, etc.)	Darkness	[Items 4/5] (a) Amount of debris filling the inner container unaffected by darkness	3	Work	- In the project of further increasing the retrieval scale, technology is being developed to collect a small amount of debris - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	2	- In the project of further increasing the retrieval scale, technology to collect a small amount of debris using a camera in a capsule isolated from the PCV environment is being developed, and operational tests are being conducted by the operators. - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	4	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24
Saku-B-	17	Radiation source collection mechanism	Fuel debris collection function	Cannot verify whether the debris has been collected in the inner container due to fog (poor visibility)	Unknown amount of fuel debris filling the inner container (overflowing from the inner container, etc.)	Fog	[Items 4/5] (a) Amount of debris filling the inner container unaffected by fog	3	Work	- In the project of further increasing the retrieval scale, technology is being developed to collect a small amount of debris - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	2	- In the project of further increasing the retrieval scale, technology to collect a small amount of debris using a camera in a capsule isolated from the PCV environment is being developed, and operational tests are being conducted by the operators. - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	4	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	18	Radiation source collection mechanism	Fuel debris collection function	Cannot verify whether the debris has been collected in the inner container due to dripping water (poor visibility)	Unknown amount of fuel debris filling the inner container (overflowing from the inner container, etc.)	Dripping water	[Items 4/5] (a) Amount of debris filling the inner container unaffected by dripping water	3	Work	- In the project of further increasing the retrieval scale, technology is being developed to collect a small amount of debris - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	2	- In the project of further increasing the retrieval scale, technology to collect a small amount of debris using a camera in a capsule isolated from the PCV environment is being developed, and operational tests are being conducted by the operators. - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	4	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24

No.230

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-4**	**: Processing of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	19	Radiation source collection mechanism	Fuel debris collection function	Cannot verify whether the debris has been collected in the inner container due to sediments, powder from cutting (dust), and neutron absorbent floating in water (poor visibility)	Unknown amount of fuel debris filling the inner container (overflowing from the inner container, etc.)	Floating neutron absorbent	[Items 4/5] Amount of debris filling the inner container unaffected by sediments, powder from cutting (dust), or neutron absorbent floating in water	3	Work	- In the project of further increasing the retrieval scale, technology is being developed to collect a small amount of debris - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	2	- In the project of further increasing the retrieval scale, technology to collect a small amount of debris using a camera in a capsule isolated from the PCV environment is being developed, and operational tests are being conducted by the operators. - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	4	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24
Saku-B-	20	Radiation source collection mechanism	Fuel debris collection function	Cannot verify whether the debris has been collected in the inner container due to high background (noise)	Unknown amount of fuel debris filling the inner container (overflowing from the inner container, etc.)	Noise	[Items 4/5] (a) Amount of debris filling the inner container unaffected by noise	3	Work	- In the project of further increasing the retrieval scale, technology is being developed to collect a small amount of debris - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	2	- In the project of further increasing the retrieval scale, technology to collect a small amount of debris using a camera in a capsule isolated from the PCV environment is being developed, and operational tests are being conducted by the operators. - In the large-scale retrieval phase, application of the technology in the above project can be expected, but detailed studies and technological development have not been carried out	4	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24

■ Risk assessment table

No.231

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**													
Work	**Sa-5**	**: Various records following processing work**													
Risk assessment table analysis number	Important monitoring items						Weighted evaluation of important monitoring items								
	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
No environmental changes inside the PCV															

No task disturbing

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-6**	**: Cell transfer of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	1	Cell transfer mechanism	Fuel debris collection function	Presence or absence of interfering objects cannot be determined due to darkness, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Darkness	[Items 4/5] (a) Presence of interfering objects unaffected by darkness	3	Safety	- Investigation inside the Fukushima Daiichi-2 PCV shows the effectiveness of the method that confirms the presence or absence of interfering objects on the task route in advance using dedicated equipment, and application of a similar method is assumed. - Since fuel debris will be transferred during this task, it is assumed that additional safety measures will be required, and 2 points will be given. These countermeasures are being studied for each feature of each method of debris retrieval project.	1	- Direct determination is possible if 3D scans or other dimensional acquisitions are made - Detailed investigation inside the Fukushima Daiichi-2 PCV shows the application of laser scanning technology to obtain maintenance information on interfering objects.	1	The safety measures for each feature of each method shown in Item 7-1 are given 1 point because no element that greatly restrict work are extracted.	3	3
Saku -A-	2	Cell transfer mechanism	Fuel debris collection function	Presence or absence of interfering objects cannot be verified due to fog, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Fog	[Items 4/5] (a) Presence of interfering objects unaffected by fog	3	Safety	Same as above	1	Same as above	1	Same as above	3	3

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-6**	**: Cell transfer of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items							
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	3	Cell transfer mechanism	Fuel debris collection function	Presence or absence of interfering objects cannot be verified due to dripping water, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Dripping water	[Items 4/5] (a) Presence of interfering objects unaffected by dripping water	3	Safety	- Investigation inside the Fukushima Daiichi-2 PCV shows the effectiveness of the method that confirms the presence or absence of interfering objects on the task route in advance using dedicated equipment, and application of a similar method is assumed. - Since fuel debris will be transferred during this task, it is assumed that additional safety measures will be required, and 2 points will be given. These countermeasures are being studied for each feature of each method of debris retrieval project.	1	- Direct determination is possible if 3D scans or other dimensional acquisitions are made - Detailed investigation inside the Fukushima Daiichi-2 PCV shows the application of laser scanning technology to obtain maintenance information on interfering objects.	1	The safety measures for each feature of each method shown in Item 7-1 are given 1 point because no element that greatly restrict work are extracted.	3	3
Saku -A-	4	Cell transfer mechanism	Fuel debris collection function	Presence or absence of interfering objects cannot be determined due to high background noise, and verification of safety on the transfer route takes time	Delay in ascertaining the presence or absence of interfering objects	Noise	[Items 4/5] (a) Presence of interfering objects unaffected by noise	3	Safety	Same as above	1	Same as above	1	Same as above	3	3

■ Risk assessment table

No.234

■ Score table for item 7-1	■ Score table for item 7-2	■ Score table for item 7-3
[4 points] No countermeasures have been determined [3 points] Countermeasures exist, but they are still under development [2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.	[4 points] Cannot be determined directly and there are issues with introduction [3 points] Cannot be determined directly and can expect introduction to be feasible [2 points] Can be determined directly, but there are issues with introduction [1 point] Can be determined directly and can expect introduction to be feasible	[4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task [2 points] Countermeasures exist, but throughput decreases due to workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-6**	**: Cell transfer of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	1	Cell transfer mechanism	Fuel debris collection function	Due to water flow, it takes time to move the inner container	Slow transfer speed	Water flow	[Item 4] (a) Time to reach destination	2	Work	- Heavy machinery with underwater specifications exists in general work technology and water currents can be resisted. - Since fuel debris will be transferred during this task, it is assumed that additional safety measures will be required, and 2 points will be given. It is necessary to study these measures for each feature of each method	1	- Can be determined directly by acquiring the actual transfer time - Can be executed through control, and there are no issues with introduction	1	Although the specific safety measures shown in Item 7-1 have not been studied in depth in the debris retrieval project, in air transfer is expected to be applied, and 1 point is given.	2	4
							[Item 5] (b) Velocity of water flow on the transfer route	2	Work	Same as above	2	When using a Price current meter, it is possible to directly determine the flow velocity, but there are problems because it requires assessing the radiation resistance of the flow meter in a high-dose radiation environment	1	Same as above	4	4

■ Risk assessment table

No.235

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process		**Ko-3**	**: Debris retrieval**													
Work		**Sa-6**	**: Cell transfer of debris**													
Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Items 1	Items 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The functions that target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku -B-	2	Cell transfer mechanism	Fuel debris collection function	Transfer takes time due to evaluation of the impact on the equipment for the inner container that has become a hot spot	Delayed determination of effects on radiation	Inner container radiation	[Item 4] (a) Degree of effects on equipment against hot spots (radiation resistance)	1	Work	- In general, parts with low radiation resistance, such as those used to transfer spent fuel, are designed to be kept away from the radiation source. - In the debris retrieval project, a method has also been proposed in which cranes are used to transfer electric drive components without getting close to the inner container.	1	- When using a dosimeter, a direct determination can be made by setting the threshold dose based on the cumulative exposure dose of the operational equipment. - Dosimeters have been introduced in the on-site validation test of the project of investigation inside the PCV.	1	Because Item 7-1 is 1 point	1	3
							[Item 5] (b) Location of hot spots on the transfer route	1	Work	Same as above	3	- When using a dosimeter, it is necessary to establish a measurement method that is not affected by the surrounding background. - Development of technology to identify hot spots in a high-dose radiation environment is required.	1	Same as above	3	3

■ Risk assessment table

No.236

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-6**	**: Cell transfer of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	3	Cell transfer mechanism	Fuel debris collection function	Cannot detect the transfer route due to sediment soaring during transfer, and transfer takes time	Delay in ascertaining the transfer route	Soaring sediment	[Items 4/5] (a) Transfer route detection unaffected by soaring sediment	3	Work	The detailed investigation inside the Fukushima Daiichi-2 PCV is currently developing a technology that enables equipment to be moved even in the PCV environment by obtaining information on the maintenance of interfering objects in advance through laser scanning. Although this technology is based on the assumption that the scanner will be used in air, it can be adapted by retrofitting the scanner with underwater specifications.	3	Underwater laser scanning technology exists in general industry, and the air dose rate in water is low, so applicability is high.	1	There is no impact on throughput with the introduction of the technology shown in Item 7-1	9	9
Saku-B-	4	Cell transfer mechanism	Fuel debris collection function	Due to inner container radiation, verification of current location takes time	Delay in ascertaining the current location of the inner container	Inner container radiation	[Items 4/5] (a) The current location of the inner container unaffected by the inner container radiation	3	Work	Same as above	3	Same as above	1	Same as above	9	9
Saku-B-	5	Cell transfer mechanism	Fuel debris collection function	Due to soaring dust in cell (R), verification of current location takes time	Delay in ascertaining the current location of the inner container	Dust	[Items 4/5] (a) Transfer route detection unaffected by dust	3	Work	Same as above	3	Same as above	1	Same as above	9	9
Saku-B-	6	Cell transfer mechanism	Fuel debris collection function	Due to high background noise, verification of current location takes time	Delay in ascertaining the current location of the inner container	Noise	[Items 4/5] (a) Current location of the inner container unaffected by noise	3	Work	Same as above	3	Same as above	1	Same as above	9	9

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-7**	**: Transfer of debris ①**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	1	Intra-cell transfer mechanism ①	Fuel debris canister sealing function	Due to inner container radiation, verification of the presence of flow line interference on the transfer route takes time	Delay in ascertaining the presence or absence of flow line interference with other work	Inner container radiation	[Items 4/5] (a) Detection of flow line interference unaffected by the inner container radiation	2	Work	Monitoring for interference between parallel operations in an unmanned environment and operations based on such monitoring is widespread in general industry (e.g., manufacturing plants), so it is assumed that this technology will be introduced.	3	- The more parallel work there are, the more control parameters there are, making it impossible for workers to make direct decisions. - Mechanical monitoring needs to be specially designed according to the characteristics of the work line.	1	Addressing Item 7-1 is assumed to have no impact on throughput.	6	6
Saku -B-	2	Intra-cell transfer mechanism ①	Fuel debris canister sealing function	Due to soaring dust in cell (R), verification of flow line interference on the transfer route takes time	Delay in ascertaining the presence or absence of flow line interference with other work	Dust in cell (R)	[Items 4/5] (a) Detection of flow line interference unaffected by dust	2	Work	Same as above	3	Same as above	1	Same as above	6	6

No.238

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-7**	**: Transfer of debris ①**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	1	Cell (Y)	Static boundary function	It takes time to assess the impact of dust from the inner container on the environmental maintenance of cell (Y)	Delay in ascertaining whether there is an increase in contamination in cell (Y)	Dust in cell (R)	[Item 4] (a) Dust concentration in cell (Y)	1	Safety	- Even if the dust concentration in cell (Y) increases temporarily, the concentration will decrease over time due to ventilation and air conditioning equipment. - The current PCV also responds by temporarily suspending work when dust concentrations rise.	1	Direct determination is possible by setting the dust concentration threshold.	2	Addressing item 7-1 limits the workload (temporary suspension of work)	2	2
							[Item 5] (b) Dust concentration in cell (R)	1	Safety	Same as above	1	Same as above	2	Same as above	2	2

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-7**	**: Transfer of debris ①**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku -A-	2	Cell (Y)	Static boundary function	It takes time to assess the impact of hydrogen from the inner container on the environmental maintenance of cell (Y)	Delay in ascertaining the effect of increased hydrogen concentration in cell (Y)	Hydrogen from inner container	[Item 4] (a) Hydrogen concentration/or oxygen concentration in cell (Y)	1	Safety	- Even if the concentration of hydrogen or oxygen in the cell (Y) rises temporarily, the concentration will decrease over time due to ventilation, air conditioning equipment, and nitrogen injection equipment. - The current PCV is also implementing safety measures with nitrogen injection.	1	Direct determination is possible by setting the hydrogen concentration or oxygen concentration thresholds.	2	Addressing item 7-1 limits the workload (temporary suspension of work)	2	2
							[Item 5] (b) Amount of hydrogen generated in the inner container	1	Safety	Same as above	2	- Direct determination is possible by using a hydrogen concentration meter and comparing with the threshold. - Since the inner container has a high radiation dose, there are issues such as providing radiation resistance when the instrument is brought into close proximity.	2	Same as above	2	2

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-7**	**: Transfer of debris ①**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	3	Cell (Y)	Shielding function of the cell	It takes time to assess the impact of inner container radiation on the environmental maintenance of cell (Y)	Delay in ascertaining whether there is an increase in spatial dose rate in cell (Y)	Inner container radiation	[Item 4] Air dose rate of cell (Y)	2	Work	- Since the radiation source (inner container) is small compared to the spatial scale of cell (Y), it is thought that there will be no significant impact. - If there is a problem with cell operation, measures such as temporarily returning the inner container to cell (R) can be considered.	1	- Direct determination is possible by using a dosimeter and comparing with the threshold	2	Addressing item 7-1 limits the workload (temporary suspension of work)	2	2
							[Item 5] (b) Surface dose rate of inner container	2	Work	Same as above	1	- Direct determination is possible by using a dosimeter	2	Same as above	2	2

No.241

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-7**	**: Transfer of debris ①**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	4	Intra-cell transfer mechanism ①	Fuel debris canister sealing function	Cannot detect the transfer route due to soaring dust in cell (R), and transfer takes time	Delay in ascertaining the transfer route	Soaring dust in cell (R)	[Items 4/5] (a) Transfer route detection unaffected by soaring dust	2	Work	Since cell (R) is a newly installed structure, the transfer route can be defined in design stage.	1	Since cell (R) is a newly installed structure, the transfer route can be defined in design stage, and direct determination is possible.	1	Addressing Item 7-1 is assumed to have no impact on throughput.	2	2
Saku-B-	5	Intra-cell transfer mechanism ①	Fuel debris canister sealing function	Due to inner container radiation, verification of the current location of the inner container takes time	Ascertaining the current location of the inner container	Inner container radiation	[Items 4/5] (a) Current location detection of the inner container unaffected by soaring dust	2	Work	Same as above	1	- Direct determination can be made from the ITV and the amount of wheel rotation of the transfer mechanism in the cell. When the accuracy of detection requirements is high, measures such as use of limiter switches also exist.	1	Same as above	2	2

■ Risk assessment table

No.242

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-8**	**: Sealed collection of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-B-	1	Sealed collection mechanism	Fuel debris canister sealing function	Due to inner container radiation, it takes time to verify whether the contents are protruding from the inner container or not	Delay in ascertaining the presence or absence of contents protruding from the inner container	Contents of inner container	[Item 4] (a) Time to verify whether the contents are protruding from the inner container or not	2	Work	If a foreign object is protruding from the inner container, it is expected to be returned to cell (R), and there will be measures such as replacing it with another inner container.	1	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	2	Addressing Item 7-1 limits the workload.	4	12
							[Item 5] (b) Presence or absence of contents protruding from the inner container	2	Work	Same as above	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Same as above	12	12

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-8**	**: Sealed collection of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Items 1	Items 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target Components	The function that the target is responsible for	Work delay factor	Direct cause of error	Indirect cause of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput by addressing errors (indirect causes)	Individual	Point of representation
Saku -B-	2	Sealed collection mechanism	Fuel debris canister sealing function	Due to inner container radiation, it takes time to verify whether the inner container is damaged or not	Delay in ascertaining the presence or absence of damage to the inner container	Damage during transfer of the inner container	[Item 4] (a) Time to verify whether the inner container is damaged or not	2	Work	If the inner container is damaged, it is expected to be returned to cell (R), and there will be measures such as replacing it with another inner container.	1	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	2	Addressing Item 7-1 limits the workload.	4	12
							[Item 5] (b) Presence or absence of damage to the inner container	2	Work	Same as above	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	2	Same as above	12	12
Saku -B-	3	Sealed collection mechanism	Fuel debris canister sealing function	Dust (debris powder) from the inner container adheres to the lid and main body of the transfer container, and removal takes time	Slow foreign matter (debris powder) removal speed	Fuel debris powder inside the transfer container	[Items 4/5] (a) Removal time of foreign matter (debris powder) caught in the transfer container	2	Work	Although the method of removing foreign matter varies depending on the mode of dust adhesion to the container (electrostatic force or surface tension due to droplets), it is assumed that there are no major technological problems with the removal itself.	1	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	1	There is no impact on throughput if a foreign matter removal method is established	2	6
							[Items 4/5] (b) Amount of foreign matter (debris powder) adhering to the transfer container	2	Work	Same as above	3	Although sensory determination (= direct determination) may be possible with camera images, there are cases in which wrong determinations may be made depending on the conditions for photography, and certainty cannot be guaranteed.	1	Same as above	6	6

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-8**	**: Sealed collection of debris**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items									
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	4	Sealed collection mechanism	Fuel debris canister sealing function	Due to noise caused by the inner container radiation, collection into a sealed canister takes time	Slow collection speed	Inner container radiation	[Item 4] (a) Time to complete collection into the inner container	3	Work	If the radiation from the inner container affects the accuracy of equipment operation, this error cannot be ignored, but in the debris retrieval project, debris collection methods in a high-dose radiation environment in line with each method are being studied.	1	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	1	Done by taking measures in line with the characteristics of each method shown in Item 7-1	3	4
							[Item 5] (b) Surface dose rate of inner container	2	Work	Same as above	1	- Direct determination is possible by using a dosimeter	2	Same as above	4	4

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-9**	**: Transfer of debris ②**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items								
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	1	Cell (G)	Static boundary function	It takes time to assess the impact of airborne dust in cell (Y) on the environmental maintenance in cell (G)	Delay in ascertaining whether there is an increase in contamination in cell (G)	Dust in cell (Y)	[Item 4] (a) Dust concentration in cell (G)	1	Safety	- Even if the dust concentration in cell (G) increases temporarily, the concentration will decrease over time due to ventilation and air conditioning equipment. - The current PCV also responds by temporarily suspending work when dust concentrations rise.	1	Direct determination is possible by setting the dust concentration threshold.	2	Addressing item 7-1 limits the workload (temporary suspension of work)	2	2
							[Item 5] (a) Dust concentration in cell (Y)	1	Safety	Same as above	1	Same as above	2	Same as above	2	2

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-9**	**: Transfer of debris ②**

Risk assessment table analysis number		Important monitoring items: Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Weighted evaluation of important monitoring items: Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku-A-	2	Decontamination water drainage mechanism	Decontamination function for transport cask	Reduced drainage capacity due to partial blockage caused by dust accumulation migrating into contaminated water drainage piping.	Reduced drainage capacity	Contaminated water from water decontamination	[Item 4] (a) Flow rate in the system	1	Safety	If there is a significant trend toward blockage, it can be handled by flushing the piping.	1	Direct determination is possible by comparing with the threshold.	1	Because item 7-1 is 1 point	1	4
							[Item 5] (b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into piping	1	Safety	- It is assumed that the amount of dust adhering to the surface of the sealed canister is small, and that the frequency of error occurrence is lower than that of the liquid phase equipment inside the PCV. - Addressed by multiplexing piping as needed. In addition, the effect of short term functional deterioration or shutdown is extremely small	4	Workers cannot make direct determinations when sampling and hot lab analysis are required. Because contaminated water is handled, there are problems with the sampling methods.	1	Same as above	4	4
Saku-A-	3	Decontamination water drainage mechanism	Decontamination function for transport cask	Acceleration of piping deterioration (deterioration of boundary function) due to corrosion resulting from potential difference caused by dust accumulation migrating to contaminated water drainage piping.	Deterioration of piping	Contaminated water from water decontamination	(a) Flow rate in the system + amount of leakage	1	Safety	Although there is impact on safety functions, the frequency of occurrence is expected to be low.	1	Direct determination is possible by comparing with the threshold.	1	Because item 7-1 is 1 point	1	4
							[Item 5] (b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into piping	1	Safety	Same as above	4	Workers cannot make direct determinations when sampling and hot lab analysis are required. Because contaminated water is handled, there are problems with the sampling methods.	1	Same as above	4	4

■ Risk assessment table

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-9**	**: Transfer of debris ②**

Risk assessment table analysis number		Important monitoring items						Weighted evaluation of important monitoring items										
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
		Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -B-	1	Out-of-cell transfer verification mechanism	Fuel debris transfer function	Dispersion of contaminated water contaminates the inspection equipment, and inspection takes time.	Delay in inspection task	Contaminated water from water decontamination	[Item 4] (a) Time to complete decontamination of transfer container	2	Work	It is assumed that the contaminated water will splash out so countermeasures such as dividing the cell (G) into two cells are assumed.	1	- Can be determined directly by obtaining actual task hours - Can be executed in the control room, and there are no issues with introduction	1	Addressing Item 7-1 is assumed to have no impact on throughput.	2	4
							[Item 5] Inspection items (surface dose rate, degree of hermeticity, concentration of surface contamination) unaffected by contaminated water	2	Work	Same as above	2	By addressing item 7-1, detection requirements can be achieved without being affected by contaminated water. Any item can be directly determined by comparing them with their thresholds, but remote operation of the inspection machine poses a problem when detecting by unmanned operation.	1	Same as above	4	4

Appendix 6.2.4.3-3: Risk assessment table for debris retrieval and transfer operation system (Detailed version) (59/59)

■ Risk assessment table

Model ID

■ Score table for item 7-1
[4 points] No countermeasures have been determined
[3 points] Countermeasures exist, but they are still under development
[2 points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

■ Score table for item 7-2
[4 points] Cannot be determined directly and there are issues with introduction
[3 points] Cannot be determined directly and can expect introduction to be feasible
[2 points] Can be determined directly, but there are issues with introduction
[1 point] Can be determined directly and can expect introduction to be feasible

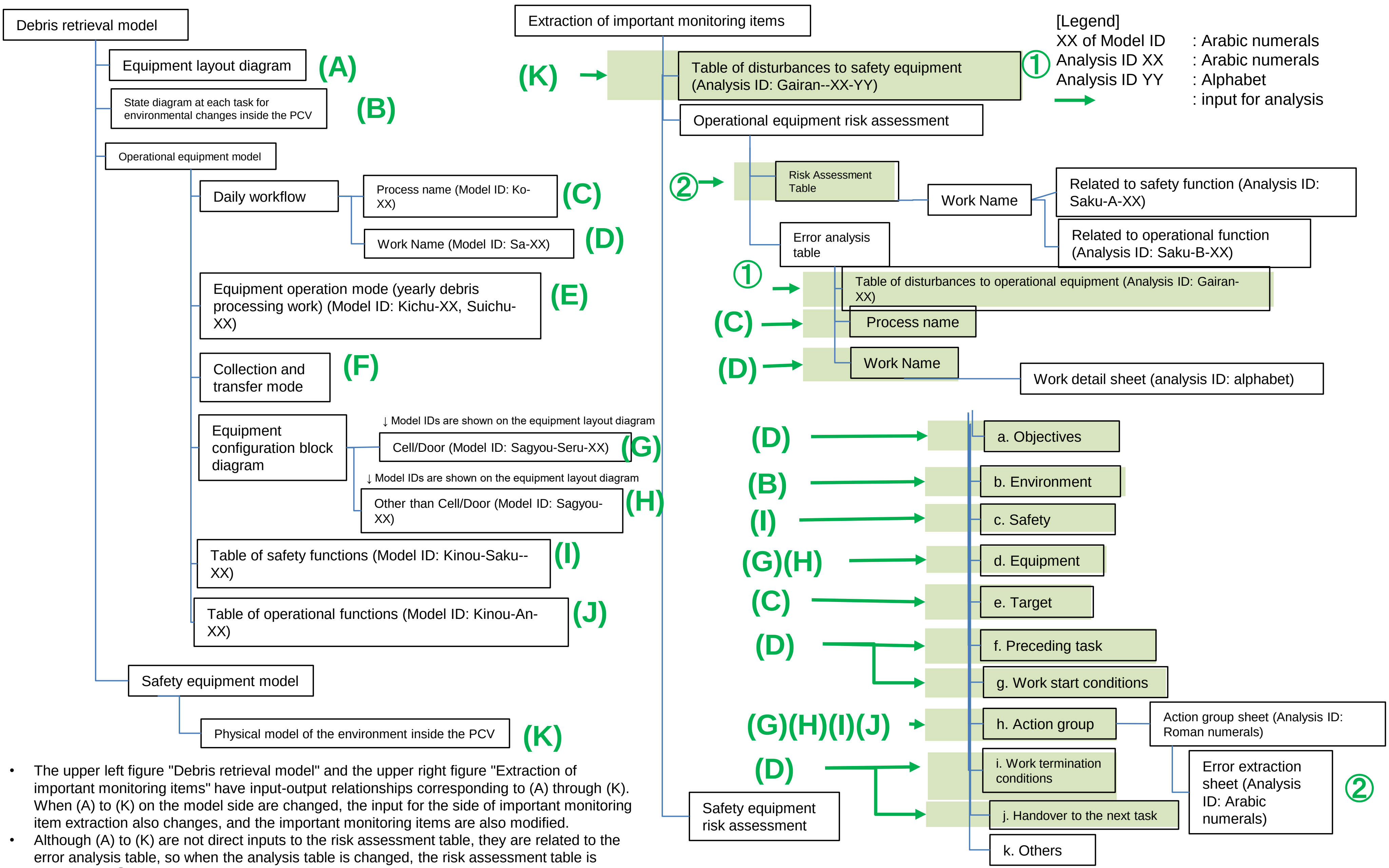
■ Score table for item 7-3
[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
[2 points] Countermeasures exist, but throughput decreases due to workload limitations
[1 point] No impact on throughput, or when 7-1 is 1 point

Process	**Ko-3**	**: Debris retrieval**
Work	**Sa-10**	**: Transfer of debris**

Risk assessment table analysis number	Important monitoring items						Weighted evaluation of important monitoring items								
	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6	Item 7-1			Item 7-2		Item 7-3		Item 7-4 (Evaluation Results)	
	Target equipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	Applicable function	Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (indirect causes)	Individual	Point of representation
No environmental changes inside the PCV															

No task disturbing

Appendix 6.2.4.3-4: Correlation between debris retrieval model and risk assessment table



- The upper left figure "Debris retrieval model" and the upper right figure "Extraction of important monitoring items" have input-output relationships corresponding to (A) through (K). When (A) to (K) on the model side are changed, the input for the side of important monitoring item extraction also changes, and the important monitoring items are also modified.
- Although (A) to (K) are not direct inputs to the risk assessment table, they are related to the error analysis table, so when the analysis table is changed, the risk assessment table is updated via ②.