

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

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International Research Institute for Nuclear Decommissioning (IRID)

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



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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."





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



Power Station of Tokyo Electric Power Company Holdings, Inc.

Appendix 5 Changes in risk over time Figure A5-1

Increased risk level due to deterioration of facility and risk sources

The method must be designed and modeled to be acceptable for the time axis

No.3

 the figure on the left.
 ✓ The method must be capable of monitoring the status of the task and its progress over time.

and risk level axis shown in

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



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

No.4



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

[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



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

No.6

- 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 onsite 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.



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



2. Research goals On-site data usage measures Monitoring data obtained on-site can be used for the three

- 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."



Detailed version: Appendix 2-1

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 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 $N_{0.10}$ 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 $N_{0.11}$ 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

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3. Implementation items, their co-relation, and relations with other projects $N_{0.12}$ 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



3. Implementation items, their co-relation, and relations with other projects 3.2 Relevance between implementation items





Implementation items, their co-relation, and relations with other projects Relevance between implementation items



3. Implementation items, their co-relation, and relations with other projects **No.15** 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 Upgrading project Fundamental project Safety project Canister project		 Development of Technology for Further Increasing the Retrieval Scale of Fuel Debris and Reactor Internals Advancement of Retrieval Method and System for Fuel Debris and Reactor Internals Upgrading of Fundamental Technology for Retrieval of Fuel Debris and Reactor Internals Development of Safety Systems Development of Technologies for Containing, Transfer and Storage of Fuel Debris 		

: 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



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5. Project organization



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 Targeted effects		(Supplemental) TRL definitions
(1) Investigation of monitoring items inside the PCV The items that should be monitored inside the debris retrieval, extracted and organized satisfy safety requirements, such as maintain the confinement function of the PCV during fur debris retrieval, and monitoring the sub-critical 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 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. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV 6.2.1 Prerequisites for the study No.20

- 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.





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

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.

No.21



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.



6.2 Implementation details (1) :Investigation of Monitoring Items Inside the PCV No.23

6.2.1 Prerequisites for the study Prerequisites for each system (2/2)

[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 Implementation details (1) :Investigation of Monitoring Items Inside the PCV No.24 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 No.25

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



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



Daily workflow (target of study for continuous monitoring project)

No.28



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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 (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.

No.29

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
 - \rightarrow 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

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

 Where is fuel debris processed? In air 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 	(4) What is used for collection?(13) Inner containers and transfer casks
(10) Cutting(11) Chipping(12) Picking up	*Inner containers refer to unit cans and canisters



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

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

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 No.33 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.



*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



No.34

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

6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV No.35

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.

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		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	Fuel debris processing function	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		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	Fuel debris collection function	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.

Table. Debris Retrieval Model Launch Equipment: Table of Operational Functions (1/2)
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	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	function	Door mechanism (R/Y)	The inner container must have passage from cell (R) to cell (Y).
12		Intra-cell transfer mechanism $\textcircled{1}$	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 debrie	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	transfer function	Door mechanism (Y/G)	The transfer cask must have passage from cell (Y) to cell (G).
		Intra-cell transfer mechanism (2)	The transfer cask must be transferred from cell (Y) to cell (G).
16		Mechanism for transfer outside the cell	The transfer cask must be transferred from cell (G) to the secondary boundary.
17			
18	Empty container delivery function	Empty container delivery mechanism	Empty inner containers and transfer casks must be supplied into the cell or PCV atmosphere.

- 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
- (f) Table of safety functions

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.



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 No.38 (f) Table of safety functions No.38 No.38

■ Assignment of nuclear safety requirements (1/2)

		General	safety rules	Booio opfoty	Requirements as a safety	function (What should be maintained)	(M/ba) M/biah ayatama will
Nuclea	ar safety	(What accon	should be nplished)	requirements	(When) At what timings do the requests occur?	(How) What are the requirements involving specific measures?	respond?
						Dust concentration reduction function	Gas phase system
					During environmental control inside the	Static boundary function	Gas phase system
					rovj Gas phase confinement	Dynamic boundary function	Gas phase system
						Discharge control function	Gas phase system
					[During environmental control inside the	Static boundary function	Gas phase system
					PCV] Liquid phase confinement	Dynamic boundary function	Liquid phase system
						PCV/cell damage prevention function	Fuel debris retrieval system
Protection of Pro				Confinement of	[During Processing] Gas phase confinement	Dust dispersion prevention function	Fuel debris retrieval system
	Protection of I he public	Prevention		radioactive materials using		Static boundary function	Fuel debris transfer system
people and		of .	Confinement	boundaries	[During Transportation]	Static boundary function	Fuel debris transfer system
tne	and the	discharge	of		Gas phase confinement inside the primary	Dynamic boundary function	Gas phase system
from	from	of radioactive	radioactive substances		boundary (fuel debris collection/transfer area)	PCV/cell damage prevention function	Fuel debris transfer system
risks	risks	materials			[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	[During environmental control inside the PCV] Criticality prevention	Criticality prevention function	Liquid phase system
				reactions (Re-criticality	[During processing] Criticality prevention	Fuel debris shape control function	Fuel debris retrieval system
			(Re du	te-criticality	[During Transportation] Criticality	Fuel debris shape maintenance function	Fuel debris transfer system
			de	deformation) pr	prevention	Debris shape maintenance function of transfer cask	Fuel debris transfer system

IRID

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

No.39 6.2.3 Study of the debris retrieval model 6.2.3.1 Study of the operational equipment model (f) Table of safety functions

■ Assignment of nuclear safety requirements (2/2)

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

		Gener	al safety rules		Requirements as a safety function (What should be maintained)		
Nuc	lear safety	(What shoul	d be accomplished)	requirements	(When) At what timings do the requests occur?	(How) What are the requirements involving specific measures?	(Who) Which systems will respond?
		Prevention	Confinement of	Prevention of abnormal	[During environmental control inside the PCV] Prevention of abnormal heatup	Fuel debris cooling function	Liquid phase system/Re- circulating cooling system
		of excessive	radioactive substances	(Revolatilization of radioactive materials due	[During processing] Prevention of abnormal heatup	Function to prevent excessive heatup of fuel debris	Fuel debris retrieval system
	Protection of the public and	radioactive		to temperature rise)	[During Transportation] Prevention of abnormal heatup	Heat removal function of transfer cask	Fuel debris retrieval system
Protection	the environment from radiation risks	materials	Prevention of excessive radiation 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		Protection against external exposure	[During Transportation] External exposure protection function	Shielding function of transfer cask	Fuel debris transfer system
and the environm ent from radiation risks	Protection of workers from	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
	radiation risks			Operational control for dose reduction of workers	The operation method, maintenance plan, and task manag	ement must be designed for dose reduction.	Entire system
	Protection of people and the			Control of hydrogen	[During environmental control inside the PCV] Prevention of fire and explosion	Oxygen concentration reduction function	Gas phase system
	environment from the Fukushima	nent Prevention of explosions [1]	f fires and] due to retained	concentration or oxygen concentration to maintain the lower limit	[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
	Daiichi-specific risks	hi-specific [1] Hereafter abbreviated as fire and explosion.		of hydrogen explosion	[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 No.40
- 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 Implementation details (1) : Investigation of Monitoring Items Inside the PCV No.41

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 Implementation details (1) : Investigation of Monitoring Items Inside the PCV No.42

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 onsite 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
- (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.



IRID



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

System design

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.

No.46

 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	nctional Configuration irements of components Design value Desi		Design conditions(*)	Control parameters
Reduction of	HEPA filter	Filter efficiency: 99.999%	HEPA filter inlet relative humidity: 99% or less	Dust concentration inside
dust concentration	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	the PCV
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
boundary	Exhaust fan Airflow: 3000 m ³ /h		PCV negative pressure degree: 100 Pa	outside of the PCV
Discharge control	HEPA filter Filter efficiency: 99.999%		HEPA filter inlet relative humidity: 99% or less	Exhaust end dust concentration



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

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.

No.48



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



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. Implementation details **No.50** 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 See Appendix 6.2.4.1-1 for detailed flow of the study (a) Study policies 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 <u>https://www.meti.go.jp/earthquake/nuclear/pdf/120626/120626_01j.pdf</u> (URL validity verification date: 2022.8.3)

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

6. Implementation details 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 N0.51
 equipment
 (b) Settings for environmental changes inside the PCV
 Table of environmental changes inside the PCV

PCV

Assumed properties Assumed processing methods Particle size of dust Fuel Compressive debris Density Localized Processing Equipment Aerial processing (no anti-dispersion agent) Underwater processing Primary component Remarks strength type area mode name [g/cm³] [MPa] [um] լոայ All in range of peak particle [U Rich] size (U, Zr)O2-C, Blade diameter: Craft, on 2 to 3 (mass concentration Pedestal Airborne Airborne Unknown bedrock (upper (Zr, U)O2-T, 200 mm distribution) inside the section): 2000 0.1 to 0.3 (number Mass of PCV 11 Other than [Fe Rich] Cutting Blade thickness: concentration distribution) fuel debris (floor/inside/o UO2, Fe, Zry-2, Disc cutter1 mm above utside) drywell mentioned: α-Zr(O), All in median diameter SUS/Fe, Number of 230 Sedimentation 0.3 (number distribution) Sedimentation Above 50 Fe2(Zr, U), revolutions: 7.9 (sediment distribution) ZrB2, Fe2B, Zr(O), 1000 rpm Peripheral Fe2Zr Either airborne/sedimentation Floating in water 50 or less dispersion

(typical example)

			111833 1	alance and a	amount of dus	st migration 🛛 👎					
gene	rated		Aerial processing		l	Inderwater prodess	sing	Amount of r	processing aid	Amount of anti-	scattering
Aerial processing	Underwater processing	Ma	ss balance	Amount of dust migration	Mas	s balance	Amount of dus migration	inje	ected	agent inje (Only for aerial p	cted processing)
[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
		Sedimentat ion	37	459.6	Bedimentati on	99.5	1235.9		↑ (*)		↑ (*)
		Peripheral dispersion	59	732.9	Floating in water	0.5	6.2				
	Aerial processing [g]	Aerial Underwater processing [g] [g] [g] [2]	Aerial Underwater processing [g] [g] [g] Max [g] [g] [g] Airborne 1242.1 1242 Sedimentat ion Peripheral dispersion	Aerial processing Underwater processing Mass balance [g] [g] [g] [y] [g] [%] 1242.1 1242 Airborne 4 Sedimentation 37 Peripheral dispersion 59	Aerial processing Underwater processing Mass balance Amount of dust migration [g] [g] [g] [%] [g] 1242.1 1242 Airborne 4 49.7 Sedimentation 37 459.6 Peripheral dispersion 59 732.9	Aerial processing Underwater processing Mass balance Arnount of dust migration Mass balance [g] [g] [g] [%] [g] [g] [g] [g] [%] [g] 1242.1 1242 Airborne 4 49.7 Airborne 200 Sedimentation 37 459.6 Bedimentation Peripheral dispersion 59 732.9 Floating in water	Aerial processing Underwater processing Mass balance Arnount of dust migration Mass balance [g] [g] [g] [%] [g] [%] 1242.1 1242 Airborne 4 49.7 Airborne 2E-05 Sedimentation 37 459.6 Bedimentation 99.5 Peripheral dispersion 59 732.9 Floating in water 0.8	Aerial processingUnderwater mocessingMass balanceAmount of dust migrationMass balanceAmount of dust migration[g][g][%][g][%][g][g][g][%][g][%][g]1242.11242Airborne449.7Airborne2E-050.0Sedimentation37459.6Bedimentation99.51235.9Peripheral dispersion59732.9Floating in water0.86.2	genome Arrial processing Amount of processing Amount of dust migration Mass balance Amount of dust migration Mass balance Mass balance Mass balance	generates Annount of dust migration Amount of dust migration [g] [g] [g] [%] [g] [%] [g] Input materials Total amount of input 1242.1 1242 Airborne 4 49.7 Airborne 2E-05 0.0 Aerial processing] 198 L 1242.1 1242 Sedimentat ion 37 459.6 Bedimentati on 99.5 1235.9 (') (') Peripheral dispersion 59 732.9 Floating in water 0.8 6.2	Aerial processing Underwater processing Amount of processing and migration Amount of dust migration Amount of processing and migration Amount of dust migration Amount of dust migration Amount of dust migration Amount of processing and migration Amount of dust migration [g] [g] [g] [%] [g] [%] [g] Input materials Total amount of input Input materials 1242.1 1242 Airborne 4 49.7 Airborne 2 E-05 0.0 Aerial processing] 198 L Mist: 0.05 L/min 1242.1 1242 Sedimentation 37 459.6 Sedimentation 99.5 1235.9 1<

* 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



- 6.2 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.

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



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 No.54

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

safety/operators/throughput as shown in item 7 series. Item H1 on the previous two pages Item H2 on the previous two pages Item 1 Item 2 Item 4 Item 5 Item 6 Item T-1 Item T-2 Item T-3 Item 7-4 Target or operational functions the equipmentlarget function the responsible for item 7-0 Direct causes of error Indirect causes of of error Item 6 Item 7-1 Item 7-3 Item 7-4 HEPA filter Reduction of Acceleration the effective flow Partial blockage Filter on the processing point functions in reduction function	The detection requirements (=important monitoring items) shown in item 6 in the table below are weighted in terms of										
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 Safety functions or operational functions the equipmentiarget functions 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 and prompt on-site operational functions Impact on accurate and prompt on-site responsible for Impact on throughput by countermeasures for disturbing safety or operational functions Impact on accurate and prompt on-site results Impact on throughput by countermeasures for disturbing safety or operational functions Impact on and prompt on-site and prompt on-site results Estimation throughput by countermeasures for disturbing safety or operational functions Impact on throughput by workers Impact on throughput by workers Impact on throughput by countermeasures for disturbing safety or operational functions Impact on throughput by workers Impact on throughput by throughput by (See table below) Impact on throughput by throughput by (See table below) Impact on throughput by throughput by (See table below) Impact on throughput by throughput by (See table below) <t< td=""><td>safety/ope</td><td>erators/throu</td><td>ughput as sl</td><td>hown in item 7</td><td>series.</td><td>(</td><td>Item [H1] on the previous two pages</td><td>] (</td><td>Item [H2] on the previous two pages</td><td>Item [H3] on the previous two pages</td><td></td></t<>	safety/ope	erators/throu	ughput as sl	hown 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	
Safety functions or operational quipmentraget function is responsible for equipmentraget 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 distribuing safety or operational functions Impact on accurate and prompt on-site responsible for Impact on throughput by contermeasures for distribuing safety or operational functions Impact on avoid work workers Impact on throughput by contermeasures in item 7-1 Estimation results HEPA filter Reduction of dust concentration deterioration inside the PCV The effective flow of the item performance cannot be maintained Partial blockage of the filter differential pressure Filter differential pressure Scored from 1 to 4 points (See table below) Product of items 7-1 to 7-3 * The entry details for item 7-1 (4 points] Countermeasures axist, but they are still under development (2 points] Countermeasures exist, but they are still under development (2 points] Requires constant monitoring during task and predictability is good • Score table for item 7-2 (for fuel debris retrieval and transfer gystem) (4 points] Cannot be determined directly and can expect introduction (3 points] Requires regular monitoring and predictability is good • Score table for item 7-2 (for a dety system) (4 points] Cannot be determined directly and can expect introduction (3 points] Cannot be determined directly and can expect introduction (1 point] Can be	Item 1	Item 2	ltem 3	Item 4	Item 5	Item 6	Item 7-1		Item 7-2	Item 7-3	Item 7-4
HEPA Reduction of Acceleration The effective flow path area of the filter optimes are a filter of the filter is concentration deterioration The effective flow path area of the filter optimes are accumulation of reduced and the accumulation of filter performance dust migrating rom the maintained processing point inside the PCV 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) Countermeasures exist, but they are still under development (2 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. Score table for item 7-2 (for fuel debris retrieval and transfer system) (4 points) (Soont armineasures exist, but there are no track records of application at the Fukushima Daiichi. Score table for item 7-2 (for fuel debris retrieval and transfer introduction (2 points) (Soont armineasures exist, and have been application at the Fukushima Daiichi. Score table for item 7-2 (for fuel debris retrieval and there are issues with introduction (2 points) (Soont armineasures exist, and have been application at the Fukushima Daiichi. Score table for item 7-2 (for fuel debris retrieval and there are issues with introduction (1 point) Can be determined directly and there are issues with introduction (1 point) Can be determined directly and there are issues with introduction (1 point) Can be determined directly and can expect introduction (1 point) Can be determined directly and can expect introduction (1 point) Can be determined directly and can expect introduction (1 point) Can be determined directly and can expec	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 abse countermeasure disturbing safet operational func	ence o es for ty or tions	f Impact on accurate and prompt on-site response by workers	Impact on throughput by countermeasures in item 7-1	Estimation results
 *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 5 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. A points] Requires regular monitoring and predictability is poor 1 point] Requires regular monitoring and predictability is good 2 points] Requires regular monitoring and predictability is good 2 points] Requires regular monitoring and predictability is good 2 points] Cannot be determined directly and can expect introduction 3 points] Cannot be determined directly and there are issues with introduction 2 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] Requires regular monitoring and predictability is good 	HEPA filter	Reduction of dust concentration	Acceleration of the deterioration of dust concentratio n 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
 Score table for item 7-1 Score table for item 7-1 points] No countermeasures have been determined points] Countermeasures exist, but they are still under development points] Countermeasures exist, but there are no track records of application at the Fukushima Daiichi point] Countermeasures exist, and have been point] Requires regular monitoring and predictability is good predictability is	*The entry	details for ite	ems 1 to 6 ar	e the same as th	nose on the prev	vious page					
	I and transfer e are issues with expect e issues with ect introduction										

■ 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

 $\left[1 \text{ point}\right]$ 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

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 (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.)



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 (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

* 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.

6. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV 6.2.4 Risk assessment 6.2.4.3 Assessment results (a) Important monitoring items No.57

Actual de	etails d	escrib	ed (ga	s phase s	syster	n)	Score table for Item 7 [4 points] No counterme [3 points] Countermea development [2 points] Countermeasu the Fukushima Daiichi [1 point] Countermeasu	7-1 asures have bee sures exist, bu ures exist, but h res exist and h	n determined ut they are still under vave not been applied at ave been applied to the. (1 points) good (2 points) (2 po	table for i Requires Requires Requires re	tem 7-2 constant monitoring during task and prec constant monitoring during task but prec regular monitoring and predictability is poo gular monitoring and predictability is good	lictability is lictability is	 Score table for item 7 [4 points] No countermeas [3 points] Countermeass suspension of task [2 points] Countermeasuu [1 point] No impact on thr 	-3 isures, and ures exis res exist, t oughput, d	d impact on throughput is unk it, but throughput decrease but throughput decreases due or when 7-1 is 1 point	known es signif e to work	icantly du
Process Work	Ko-3 Sa-9	: Debris ret : Transfer c	rieval of debris (2)	*1	Import	ant monitoring items	Eukushima Daiichi. See Appen details	dix 6.2.4 on this i	1.3-2 for tem		*2 Wei	ghted ev	aluation of important mor	nitoring i	tems	3 Iter	n 7-4
Analysis number e analysis numb the combination aracter strings	Der is define n of these to	Item 2 The function that the ed t is NO isibl	Work delay factor (= error)	Direct causes of	Indirect causes of error	Reasons to be selected	Item 6-1 Detection requirements to avoid work delays	Direct monitoring /Indirect monitoring	Item 6-3 Reason for selection of detection requirements	Point	Item 7-1 Presence or absence of countermeasures for disturbing functions	Point	Item 7-2 Effects on accurate and prompt on-site response by workers	Point	Item 7-3 Impact on throughput due to error handling (indirect causes)	(Eva Re: Indi vidu al	Point of senta tion
An-Ki-1	HEPATIITE	Reduction of dust concentrati on	Acceleratio n of deterioratio n of dust concentrati on reduction function	The effective flow path area of the HEPA filter is reduced and the filter performance cannot be maintained	Ð	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
			inside the PCV				(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	
	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/downstr eam 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	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	
An-Ki-2		or analys	is numbe	ringl	Same as above		(b) Amount of dust and chemical properties at the HEPA filter inlet (pH, chloride ion concentration, chemical composition)	Indirect (item 5)	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	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

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 (*3) The na

(*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



6. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV 6.2.4 Risk assessment 6.2.4.3 Assessment results (a) Important monitoring items

Actual details described (debris retrieval system)

Mode	el ID	I		See *1 on th	е	,	 Score table tor Item 7- [4 points] No countermeasus [3 points] Countermeasure [2 points] Countermeasure Fukushima Daiichi [4] 	ures have s exist, b es exist,	been dete ut they are but have	rmined still under development not been applied at the [1 points] Can be determined [2 points] Can be determined [1 point] Can be determined	ned direct nined dire directly a directly an	y and there are issues with introduction http://www.and can expect introduction to be and there are issues with introduction d can expect introduction to be feasible (4 points) No (3 points) Cou (2 points] Cou (1 point) No ir (1 point)	le for item counterme intermeasu intermeasu npact on th	7-3 easures, and impact on throughput is unknown ures exist, but throughput decreases significantly du ures exist, but throughput decreases due to workloa hroughput, or when 7-1 is 1 point	ie to suspe ad limitatior	nsion of task 15
Proces	ss	Ko- 3 : Debris	s retrieval	previous pag	e		[1 point] Countermeasur Eukushima Daiichi.	es exist	and have	See *2 on the				See *3 on the		
WOIK	_	3a-3 . 11alis		Important mon	itoring items				p	veight weight	nted e	evaluation of important monitoring	na ite	ms previous page	<u> </u>	
Analys	is	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6		٦ 	Item 7-1		Item 7-2	3	Item 7-3	ltem (Eva 0 Res	7-4 Iuati n ults)
numb	ər	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-	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
Sak u-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
0	Sa	[The number afety function rational funct	ing rules for an related: Saku-, numerals ion related: Sak numerals	alysis] A-Arabic su-B-Arabic			[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
1	I											©International Research I	nstitu	ute for Nuclear Decommi	ssion	ing

6. Implementation details 6.2 Implementation details (1) : Investigation of Monitoring Items Inside the PCV 6.2.4 Risk assessment 6.2.4.3 Assessment results (a) Important monitoring items

■ 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)

debris		Equipment name	Work delay factors from which monitoring items are	Important monitoring items for detecting work delays	Weighted evaluation of risk assessment table			
			set		Item 7-1	ltem 7-3		
Cooling water		[Gas phase confinement system]	[Analysis number: Sa- 4 An-Ki-14, 15] As the PCV deteriorates	Differential pressure between inside and outside of the PCV	4	3		
E ,		PCV	and the size of the PCV opening increases, leaks occur inside, and the differential pressure between inside and outside of the PCV decreases	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.



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

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



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.

Moving mechanism inside the PCV Well ででessing mechanism	Equipment name	Work delay factors from which monitoring items are set	Important monitoring items for detecting work delays	Weighted evaluation of risk assessment table		
Nitrogen				Item 7-1	Item 7-3	
	[Debris retrieval system] Debris	[Analysis number: Sa-4 Saku-B-3] Processing jigs wear out quickly, and frequent replacement make	Degree of wear and tear of processing jigs	3	2	
Debras	processing mechanism	processing time-consuming	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	

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

[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 disturbe 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.





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 (2/2)

No.62



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

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

6.2.4 Risk assessment 6.2.4.3 Assessment results (c) Trends in safety equipment

No.63

(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

IRID

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

6.2.4 Risk assessment 6.2.4.3 Assessment results (c) Trends in safety equipment

No.64

(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.

Sofoty requirements	Weighted evaluation results of errors						
Salety requirements	Highest scor	Lowest score					
Gas phase confinement	48						
Liquid phase confinement	4	items s in No	hown .59	3			
Cooling	4			3			
Criticality prevention	4	3					

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



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 (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.

 \rightarrow 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.





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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.

No.66

• 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."

Madal ID	Mork Nama		Evaluation results of error weighting (*1)				
	VVOIK Name		H	lighest score	Lowest score		
So 1	Verification of the overall situation inside the	e PCV,					
Sd-1	operational equipment, and safety equipme	nt					
Sa-2	Approaching the object to be processed	No.60 tab	le	9	1		
Sa-3	Work prior to debris processing	"Dimension	s of	18	12		
Sa-4	Processing of debris	debris unaffe	ected	> 64	9		
Sa-5	Various records following processing work	by fog," et	с.				
	Cell transfer of debris						
Sa-6	(Processing site \rightarrow collection equipment in		9	3			
	area)						
Sa-7	Transfer of debris $\textcircled{1}$			6	2		
	(Red area \rightarrow Yellow area)			0	۷		
Sa-8	Collection of debris			12	4		
S2-0	Transfer of debris ②			Λ	1		
	(Yellow area \rightarrow Green area)		_	4	1		
Sa-10	Transfer of debris						
	$ $ (Green area \rightarrow Secondary boundary)						
1 Quoted sc	*1 Quoted scores for item 7-4 in the risk assessment table						

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 measur ement	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. Implementation details 6.3 Implementation details (2) "Study of the Monitoring Methods" 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.

No.68

Process	Ko-3	: Debris retrie	Debris retrieval												
Work	Sa-4	: Processing	of												
		debris													
		_	Important r	nonitoring item	s	1			M	Veigł	nted evaluation of important monitoring items				
Analysis	Item	Item 3 (excerpt Item 1 Item 2 from error Item 4 Item 5 Item 6 extraction table)			ltem 7-1			Item 7-2	Item 7-3			Item 7-4 (Evaluati on Results)			
number	Targ equi mer	The function that the target is t responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to avoid work delays	Point	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	Debr proce sing mech nism	s [Criticality] bebris processing a shape control function	The dust dispersed by processing approaches the allowable dust concentratio n 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 growth. 	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. Implementation details 6.3 Implementation details (2) "Study of the Monitoring Methods" 6.3.1 Study of diversification of monitoring methods No.69

Process	Ko-3	: Deb	ris retrieval	Г	U Particle size and amount of dispersion of dust generated during processing														
Work	Sa-4	: Pro	cessing of debr	is															
		1	· · · · · · · · · · · · · · · · · · ·	¥	Important monitoring items Weighted evaluation of important monitoring items								1 10 7 4						
	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 7-1		Item 7-2		Item 7-3		n 7-4 luation sults)
Analysis number	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)	Indivi dual	Point of repre senta tion		
An-Ki-1	HEPA filter	Reduction of dust concentrat ion	Increased dust concentration inside the PCV	Dust concentration inside the PCV increases as the HEPA filter deteriorates and the HEPA	1	Partial blockage of the filter element due to accumulation of dust migrating from the processing	 (a) HEPA filter differential pressure (b) Dust amount and particle 	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	1	Functionality is ensured by switching filters through 2 series of filters (already studied) Functionality is ensured by switching filters	1	Filter clogging is due to daily accumulation, so predictability is good Continuous monitoring is required, but	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	1	3		
				filter efficiency does not meet the design value.		point to the HEPA filter	size distribution at the HEPA filter inlet		dust flowing in.	1	through 2 series of filters (already studied)	3	predictability is good.	1		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 resourceintensive predictive detections



6. Implementation Details 6.4 Summary

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 details6.5 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 details6.6 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 details6.7 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

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No.73

6. Implementation details6.8 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

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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

(dolivory)

No.78

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.

No.79



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

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 (1/4) No.80

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) No.81

- 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
Damaged CRD/CRD housing	B4C, Fe	surface contamination)
Damaged core support plate covered with molten debris	Fe	
Unmolten, damaged fuel pins and structures	UO2, Zry-2	Fuel
A portion of the fuel assembly that remains without melting down	UO2, Zry-2, (U, Zr)O2-C, (Zr, U)O2-T, Zr(O), Fe	
Rapidly cooled molten core material that has broken into small pieces	(U, Zr)O2-C, (Zr, U)O2-T	- U-rich mass of fuel
Solidified relatively early near the upper surface of the molten pool	(U, Zr)O2-C, (Zr, U)O2-T, Fe	debris - Fe-rich mass of fuel
Slowly cooled down and turned into lumps near the center of the molten pool	(U, Zr)O2-C, (Zr, U)O2-T, Fe	debris
Solidified relatively early near the lower surface of the molten pool	(U, Zr)O2-C, (Zr, U)O2-T, UO2, Fe	
Molten debris solidified in the lower head	(U, Zr)O2-C, (Zr, U)O2-T, Zr(O), Fe2Zr	
Rapidly cooled molten core material that has broken into small pieces	(U, Zr)O2-C, (Zr, U)O2-T	
Cooled and solidified relatively early on the upper surface of the molten pool during MCCI	(U, Zr)O2-C, (Zr, U)O2-T, Al-Ca-Si-O	MCCI formations
Molten corium slowly cooled down and turned into lumps during MCCI	(U, Zr)O2-C, (Zr, U)O2-T, Al-Ca-Si-O	
Metallic deposit on each part of MCCI	Fe	
Boundary between molten corium pool and concrete	(U, Zr)O2-C, (Zr, U)O2-T, SiO2, (Zr, U)SiO4, 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	Fuel debris powder(**)	
(*) Research report on "Development of Analysis and Estimation Technolo (**) (**) Among fuel debris powders, those that have the potential of migrat	gies for Fuel Debris Characterization" (March, 2019) ing into the gas/liquid phase are referred to as dust	

results of the study of debris processing work (3/4) No.82 Study results ③ "How is it processed?" A precondition is set based on the throughput evaluation In the operational equipment model, that does not depend on the method by the project of "crushing, cutting, and picking up" are Upgrading and Method and Systems (*). The same method treated as a group, but in order to extract disturbing the normal conditions specific is adopted in this project. to the processing method, evaluations are also conducted for items within the (*) Project of Upgrading of Methods and Systems for Retrieval of Fuel dashed lines. **Debris and Reactor Internals** Conditions No. Items Unit 1: 10 years, Unit 2: 10 years, Unit 3: 10 years Fuel debris retrieval timeframe goals 200 days (days other than working days are considered maintenance days) Number of fuel debris retrieval days 2 per year Fuel debris processing hours per day Within 10 hours 3 Crushing Core boring Assuming Unit 3 which has the largest total volume. (CRD instrumentation tube Amount of fuel debris adhesion: 6 tons*, inside the pedestal: maximum 222 tons, outside the pedestal: Chisel maximum 146 tons, total: 374 tons) Fuel debris processing tools 1. MCCI: chisel processing, ultrasonic core boring, etc. 5 Cutting **Disc cutter** 2. CRD with instrumentation tube adhesion: disc cutter, AWJ, laser, etc. 3. Adhesion of metals: Disc cutter, AWJ, laser, etc. AWJ 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 Chipping Laser gouging interfering objects. 3. Core boring: 3.25 kg/h (FY2016 test results) 4. Laser gouging: 4.76 kg/h (FY2016 test results) Proven collection methods such as grabbing and scooping are applied as an Method of collecting fuel debris estimated condition, and the results of elemental tests are also taken into consideration. **Picking up** Fuel debris handling speed Proven handling methods are applied as an estimated condition, and the results of elemental tests are also taken into consideration.

Appendix 6.2.3.1-1: Study of the operational equipment model (equipment operation mode) Details of the



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 (4/4)

No.83

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 $(1) \rightarrow$ Transfer containers

Top-access retrieval method: Plan (2) \rightarrow Unit cans

Side-access retrieval method: Plans A, B, $C \rightarrow$ 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 \div cell spatial volume [9] When there is an upward flow with a velocity of 10 [cm/s] inside the cell



			mechanism	
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): $1.7 E-03 [Bg/cm3] [8]$ Dust particle size [9]: $15 [\mu m]$ or less (UO2) $20[\mu m]$ or less (Fe), $40[\mu m]$ 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 No.86

Configuration of components

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

Safety requirements

Functional requirements

(A) R	equirements during processing								
1		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	Gas phase confinement (inside the PCV)	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) R	equirements during transportation								
7	Gas phase confinement (Inside debris collection and	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	transfer area for cells, etc.)	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					



ID

Design requirements

Appendix 6.2.3.2-1: Study of the safety equipment model/Configuration No.87 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 (Dust concentration inside the PCV) × 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 [m³] (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 [m³/h] ÷ PCV volume [m³])
- λ_{f} : Filter removal rate (= recirculated airflow [m³/h] ÷ PCV volume [m³] × 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)

No.88

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) × $B + F_{cell} = F_{ex}$

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

F_{PSA} : Nitrogen-charged airflow by PSA [m³/h]
 F_{ex} : PCV gas management system exhaust airflow [m³/h]
 F_{cell} : Inflow airflow from adjacent cells [m³/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 [m²]



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/m³)

C (exhaust end dust concentration) = A (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)





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.





No.92

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

No.93

- 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





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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"



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Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (6/10)

ID: Sa-6 "Cell transfer of debris"

No.99



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Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (7/10)

ID: Sa-7 "Transfer of Debris ①"



IRID

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No.100

Appendix 6.2.3.3-3: Debris retrieval model (roadmap of environmental changes in the PCV) (8/10)

ID: Sa-8 "Collection of debris"





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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"

No.102



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

ID: Sa-10 "Transfer of Debris"



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No.103

Appendix 6.2.4.1-1: Flow of study of environmental changes inside the PCV due to operational equipment activities No.104

- 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/cm³] (=11)

V_fd: Deficit volume during processing of hypothetical debris [cm³] (=112.8) -



No.105

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

No.106

- 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



Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (3/11) No.107

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

_	А	В	С		DE	F	G	н	. 1	J K		L	М	Ν	O P		Q	R	S	Т	U	V	W	ХҮ	<u>(Z</u>	AA AB	AC	AD AE																																
			Assumed p	roperties		Assu	Assumed processing methods		Assumed process methods		Assumed processing methods			Dust particle size,				Dust particle size,				Dust particle size,				T Dust particle size,				l amount f dust		Mas	s bala	nce and a	mour	t of dus	tor pro																							
	Fuel debris type	Density	Compressive strength	Primary compon	Localized area	Processing mode	Equipment name	Remarks	Ae ant	rial processing (no ti-dispersion agent)	Underwater si. processing g		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		Underwater processing		erwater sing		erwater sing		Mass	s ba	lance	Amount of dust migration	M	ass bal	ance	Amount of dust migration	Amour processir inject	nt of ng aid ed	Amount scattering injec (Only for proces	of anti- g agent ed aerial sing)	Oth	ers
		[g/cm ³]	[MPa]	ent						[µm]		[µm]	[g]	[g]			[%]	[9]			[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input	Input materials	Total amount of input																																
1	Fuel	11	[Characterizatio n] Stump fuel: 230 Unmolten fuel: 280	[Characte rization] UO2,Zry- 2,(U,Zr)O 2-C, (Zr,U)O2- T,Zr(O), Fe	Inside the RPV	Cutting	Disc cutter	Blade diameter : 200 mm Blade thicknes s: 1 mm	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								of revolutio ns: 1000 rpm	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 dispe	[Monitoring]	47	307.9	Floating in water	[Monitoring]	0.5	3.3																																						
															sion.			No	data	a																																								
4						Cutting	AWJ											No	data	a																																								
5						Chipping	Laser gougin g																																																					
			RID																			©Internat	ional Rese	arch Ins	stitute for N	uclear D	ecommissio	ning																																
Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (4/11) No.108 Table of environmental changes inside the PCV due to operational equipment activities (during fuel debris processing) (2/9) Of the 10 hours of work hours during the day, the net processing time is deemed to be 3.3 hours А В С D Е F G н J Κ М Ν O P Q R S T U V W X Y Ζ AA AB AC AD AE Mass balance and amount of dust migration Assumed processing Total amount of Assumed properties Dust particle size, dust generated Amount of antimethods Aerial processing Underwater processing Fuel debris type scattering agent Underwater processing Aerial processing Density Compressive strength Primary component Amount of processing Processing mode Remarks Equipment name _ocalized area injected Others Aerial processing Amount aid injected Amount of (Only for aerial Underwater (no anti-dispersion Mass balance dust Mass balance of dust processina) processing agent) migration migration Total Total amount Input Total amour [g/cm³] [MPa] [µm] [g] [%] [%] Input materials amount of Input materials [µm] [g] [g] ----[g] -----of input materials of input input [Central Research I Power Industry] Mass Cutting Pedestal inside the Disc Airborne All in range of Airborne 1242.1 Airborne [Dust collection] 2.00E-05 11 Craft and [U-rich] Unknown 1242.1 4 49.7 0.0 [Aerial 198 [Dust Blade L ---on the (U,Zr)02peak particle processing] collection (*) diameter: cutter bedrock Water: 1 Mist: 0.05 오 C,(Zr,U)O size (upper 200 mm L/min L/min fuel debris 2-T, [Fe-[Dust section):2 collection] 2 to rich] 000 Other than UO2, Blade 3 (mass above Fe,Zry-2, thickness: 1 concentration Airborne Institute mentioned α -Zr(O), distribution) 6 PCV (floor/inside/outside) drywell lmm 230 SUS/Fe, [Dust Fe2(Zr,U) collection] 0.1 Number of ç ZrB2. to 0.3 (number Electric revolutions: Fe2B. concentration Zr(O), and 1000 rpm Fe2Zr distribution) Sedimentation Sedimentation Sedimentation [Dust collection] 37 459.6 [Monitoring] All in median [Dust 99.5 1235.9 Sedimentation diameter collection [Dust collection] theory] 0.3 (number Above 50 distribution) [Dust collection] 7.9 sediment distribution) [Central Research Institute of Electric Power Industry] Peripheral dispersion dispersion Either Floating in wate [Dust Periphera [Monitoring] 59 732.9 Floating in wate 0.5 6.2 airborne/sedim collection entation theory] 8 50 or less Cutting No data AW ----9 J Airborne Airborne Airborne Airborne Chipping 8938.6 8938.6 [Investigation 0.00 0.8 0.2 [Base] L kJ Laser gouging Processing [Base] 0.096 Unknown [Investigation 2.00E-03 712 396 -------[Base] --speed: 2 m/min Both in air (*) 8 (*) [Both in air to 3.3 9 0 rradiation beam and and lunderwater diameter underwater approx. Φ5 mm processing] processing] Processing pitch Water: 36 20 kW ç of dust collection] 2.5 mm L/min dust collection] 10 Distance between workpieces: 40 IRID ©International Research Institute for Nuclear Decommissioning

Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (5/11) No.109

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

	А	в	С	D	Е	F	G	н	I	J	к	L	М	N	0	Ρ	Q	R	s	т	U	V	W	ХҮ	Z	AA AB	AC	AD E
		^	coursed	proportion		Assu	med	processing		Duct partic		170	Total a	amount		Ма	ss bal	ance and am	noun	nt of	dust m	igration						
	\neg		SSUMEU				met	thods		Dust partic		126,	gene	rated		Aer	ial pro	cessing	Ur	nder	water	processing	A		Amount	t of anti-		
	uel debris type	Density	Compressive strength	Primary compo	Localized area	Processing mode	Equipment nam	Remarks	Ae (no	rial processing anti-dispersion agent)	U p	nderwater rocessing	Aerial processing	Underwater processing	Ł	Mas balar	s ice	Amount of dust migration	b	Ma: balar	ss ice	Amount of dust migration	process	sing aid	inje (Only fo proce	cted or aerial ssing)	Oth	hers
		[g/cm ³]	[MPa]	nent			le			[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 mention ed: 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),	Pedestal inside the PCV (floor/in	Cutting	Laser gouging	Processing speed: 2 m/min Irradiation beam diameter: approx. Φ5 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				Fe2Źr	iside/outside) drywell			Processing pitch: 2.5 mm Distance between workpieces: 40 mm	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						

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Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (6/11) No.110

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

	<u> </u>	В	C	D	E	F	G	Н		J	Κ	L	M	Ν	0	Р	Q	R	S	Т	U	V	W	XY	Z	AA AB	AC	AD A
			Assumed	properties		Assi	umed p meth	orocessing ods		Dust partie	cle si	ze,	Total an dust ge	nount of		N	lass bala	nce and an	noun	t of d	ust migrati	on						
ruel debiis type	Filel debris type	Density	Compressive strength	Primary compon	Localized area	Processing mode	Equipment name	Remarks	Aer (no :	ial processing anti-dispersion agent)	U p	nderwater rocessing	Aerial processing	Underwater processing	Ma	ass b	alance	Amount of dust migration	N	Mass	valer prod	Amount of dust migration	Amount of aid inj	processing ected	Amount scatterir inje (Only fo proce	t of anti- ng agent cted or aerial ssing)	Othe	ərs
		[g/cm ³]	[MPa]	lent			æ			[µm]		[µm]	[g]	[g]			[%]	[g]			[%]	[g]	Input materials	Total amount of input	Input materials	Total amount of input	Input materials	Total amou of input
14	Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than above mentione d: 230	[U Rich] (U,Zr)O2- C,(Zr,U)O 2-T, [Fe- rich] UO2, Fe,Zry-2, a-Zr(O), SUS/Fe, Fe2(Zr,U) Z-P2	Pedestal inside the PCV (floo	Crushing	Core boring	Jig type: Impregn ated bits Number of revolutio ns: 150 to 300 rpm Drilling	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	138 L 6 ^(*)	Unknown			
15				, 2162, Fe2B, Zr(O), Fe2Zr	or/inside/outside) drywell			speed. 2.86 mm/min Diameter : Φ66 mm Feed pressure : 15 kN	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						
						Crush	Chise												No	o da	ta							
17						ing	_																					

Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (7/11) No.111

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

-	А	В	С	D	Е	F	G	н	1	J K		L	М	Ν	<u>0 P</u>	0	ג	R	s	Т	U	V	W	ХҮ	Z	AA AB	AC	AD AE
		A	Assumed	properties	6	proc	Assu essing	med methods		Dust partic	le size,		T amc d	otal ount of ust		Mass	bala	ance and a	amou U	int of nder	dust migr	cessing			Amount	of anti-		
	Fuel debris type	Density	Compressive strength	Primary compor	Localized area	Processing mode	Equipment nam	Remarks	Aeri anti-	al processing (no dispersion agent)	Underv proces	vater sing	g Aerial processing	erated Underwater processing	Mas	s bala	ance	Amount of dust migration	M	lass l	balance	Amount of dust migratio n	Amou process injec	int of ing aid ted	scatterir inje (Only fo proce	ng agent cted or aerial ssing)	Othe	ers
		[g/cm ³]	[MPa]	lent			Φ			[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	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	[Monitorin g] 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 collectio n] [Aerial processi ng] Mist: 0.05 L/min	9.9 L		
19					/outside)				Sedimentation	All in median diameter [Dust collection] 0.5 (number distribution) [Dust collection] 41.5 (sediment distribution)	Sedimentation	[Monitorin g] Above 45			Sedimentation	[Dust collection]	43	695.1	Sedimentation	[Monitoring]	99.5	1608.4						
20									Peripheral dispersion	Either airborne/sediment ation					Peripheral dispersion	[Monitoring]	50	808.2	Floating in water	[Central Research Institute of Electric Power Industry]	0.5	8.1						

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Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (8/11) No.112

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

	23	22	21				Г
			MCCI formations		uel debris type	п	A
			8	[g/cm³]	Density	A	В
			1300 Core support plate	[MPa]	Compressive strength	ssumed	U
			Fe,B4C	ent	Primary compon	properties	
	3)	(floor/inside/outside	Pedestal inside the PCV		Localized area	6	
			Cutting		Processing mode		<u> </u>
			AWJ	•	Equipment name	Assu proce meth	
		workpiec es: approx. 2 mm Nozzle angle: 0 deg	Jet pressure : 343 MPa Cutting speed: 50 mm/min Distance between		Remarks	med ssing ods	
	Floating in water	Sedimentation	Airborne		Aer disp		
	Unknown	[Dust collection theory] Above 20	[Monitoring] 20 or less	[µm]	ial processing (no anti- persion agent)	Dust part	-
		Sedimentation	Floating in water		Ĺ	icle	
		[Monitoring] Above 45	[Monitoring] 45 or less	[µm]	Inderwater processing	size,	
			2950	[g]	Aerial processing	Total of gen	
			2950	[g]	Underwater processing	amount dust erated	
	Floating in water	Sedimentation	Airborne		M		Ľ
0 of	[Central Research Institute Electric Power Industry]	[Monitoring]	[Central Research Institute of Electric Power Industry]		ass I	Aei	Ma
	3	97	2.E-05	[%]	balance	rial proce	
	88.5	2861.5	0.0	[g]	Amount of dust migration	ssing	
N	Floating in water	Sedimentation	Airborne		М	U	
o da	[Central Research Institule Electric Power Industry]	[Monitoring]	[Central Research Institute of Electric Power Industry]		ass t	nderv	tofo
ata	3	97	2.00E-05	[%]	balance	water pro	luct migro
	88.5	2861.5	0.0	[g]	Amount of dust migration	cessing	tion
			[Internal investigati on] [Underwat er processing] Water: 3.7 L/min	Input materials	Amoi process inje		
			733 L (')	Total amount of input	unt of sing aid cted		
				Input materials	scatterir injec (Only fo proce	Amount	
				Total amount of input	ng agent cted or aerial ssing)	of anti-	701 710
	Mesh width 0.18 mm (nominal), less than 0.45 mm	Particle size [mm]:	Internal investigatio n] [Underwat er processing] Garnet: 500 g/min	Input materials	Othe		
			99 k	Total amount c input	ers		
_			3	ſ			Ĩ

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

	А	В	С	D	Е	F	G	н	I	J	к	L	М	Ν	0	Р	Q	R	s	т	U	V	W	ХҮ	Z	AA AB	AC	AD AE
							Assu	imed					Total a	amount		Ma	ss balan	ce and an	nour	nt of	dust migi	ation						
	-	As	ssumed	propertie	S		proce	ssing		Dust partie	cle s	size,	of o	dust		۵er	ial proce	ssina	1.11	nder	water pro	cessing			Amount	of anti-		
	⁻ uel debris type	Density	Compressiv e strength	Primary com	Localized are	Processing mo	Equipment n	Remarks	pro an	Aerial ocessing (no ti-dispersion agent)	Ur pr	nderwater ocessing	Processing	Underwater	Ma	ass t	palance	Amount of dust migration	м	ass	balance	Amount of dust migration	Amou process injec	int of ing aid ted	scatterir inje (Only fo proce	ng agent cted or aerial ssing)	Othe	ers
	Û	[g/cm³]	[MPa]	ponent	ä	de	ame			[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)O 2- C,(Zr,U) O2-T, AI-Ca- Si- O,Fe,Si O2,(Zr, U)SiO4	Pedestal floor drywell	Cutting	Disc cutter	Cutter size, number of revoluti ons	Airborne	All in range of peak particle size [Dust collection] 2 to 3 (mass concentratio n distribution) [Dust collection] 0.1 to 0.3 (number concentratio n and distribution)	Floating in water	[Dust collection] : 0.5 (number distributio n) [Dust collection] : 5.2 (volume distributio n)	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 processin g] Water: 1 L/min	198 L (*)	[Dust collectio n] [Aerial process ing] 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 ←	99.5	3390.8						
27									Peripheral dispersion	Either airborne/sedi mentation					Peripheral dispersion	[Monitoring]	57	1942.5	Floating in water	[Monitoring] Note 1	0.50	17.0						

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Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (10/11) No.114

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

Image: Properties Assumed properties Assumed processing methods Dust particle size. Total amount of dust generated Mass balance methods Mass balance migration Annual of dust migration (dust migration) Annual of dust migration 1	Α	В	С	D	E	F	G	н	1	J	к	L	М	Ν	0	Ρ	Q	R	S	Т	U	V	W	ХҮ	Z	AA AB	AC	AD AE
No. Construct processing Underwater processing Amount of mining agent injected Amount of mini	Fuel	Δοσ	sumed n	ronarti	<u>0</u> 0	A	ssumed pr	ocessing		Dust par	ticla	sizo	Total a	imount		Ma	ss balan	ce and an	nour	nt of o	dust migr	ation						
IS OD (m) Store (m) Store	deb		sumed p	openti			metho	ods		Dustpar		3126,	gene	rated		Aeri	ial proce	ssing	U	nder	water pro	cessing			Amoun	t of anti-		
Image: Normal biology of the state	ris type	Density	Compressive strength	Primary compor	Localized area	Processing mode	Equipment nam	Remarks	ہ proce anti-c a	Aerial essing (no dispersion agent)	b Ui pi	nderwater rocessing	Aerial processing	Underwater processing	Ma	ass b	palance	Amount of dust migration	м	lass	balance	Amount of dust migration	Amou process injec	int of sing aid cted	scatterii inje (Only fo proce	ng agent cted or aerial ssing)	Oth	ers
28 1 300 bit Fe B bit 20 bit	1	[g/cm³]	[MPa]	lent			œ			[µm]		[µm]	[g]	[g]			[%]	[g]			[%]	[g]	Input materials	Total amount of	Input materials	Total amount	Input materials	Total amount of
20 and plate Cuppont plate a <t< td=""><td>Exig</td><td>8</td><td>1300</td><td>Fe,B</td><td>Ped</td><td>Cut</td><td>AWJ</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>1</td><td>No</td><td>data</td><td>a</td><td></td><td></td><td>nput</td><td></td><td>orinput</td><td></td><td></td></t<>	Exig	8	1300	Fe,B	Ped	Cut	AWJ											1	No	data	a			nput		orinput		
29 Image: plate plate plate plate image:	sting		support	40	lesta	ting																						
23 1	struc		plate		floor	Chip	Laser gouging											1	No (data	a							
30 31 31 31 32 32 32 32 32 34 34 34 34 34 34 34 34 36289 361.7 36327.7	tures				. dryv	bing																						
30 31 1					ell	Cru	Core											1	No	data	a							
31 Image: Constraint of the constraint						shing	boring																					
32 32 32 32 32 32 32 32 32 32 32 32 32 3						Crushing	Chisel	Jig type: Air drive system Blows per minute: 1250 bpm Total Length:	Airborne	[Dust collectio n 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			
©International Research Institute for Nuclear D								480 mm Jig arrangem ent: 2 chisels in parallel operation	Sedimentation	[Monitori ng] 10 mm Less than	Sedimentation	[Monitoring] Less than 10 mm			Sedimentation	[Monitoring]	97.35	35327.7	Sedimentation	[Monitoring]	98.93	35901.1						
		5 6						-					_									©Inte	rnational R	esearch li	nstitute f	or Nuclea	ar Decomm	issioning

Appendix 6.2.4.1-2: Table of dynamic environmental changes inside the PCV due to operational equipment activities (11/11) No.115

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

	А	В	С	D	Е	F	G	н	<u> </u>	J	Κ	L	М	Ν	0	Ρ	Q	R	S	Т	U	V	W	ΧY	Z	AA AB	AC	AD AE
	Fuel de	A	ssum	ed propertie	s	A	ssumeo me	d processing ethods	0	Dust par	ticle	size,	Total a of c	amount Just		Ma	iss ba	lance and an	noun	t of o	dust m	igration			Amount	t of opti		
	ebris type	Density	Compressive strength	Primary compor	Localized area	Processing mode	Equipment name	Remarks	Ae proce (no dispe ag	erial essing anti- ersion ent)	Ur pr	nderwater	processing	Underwater	t	Mas	ss nce	Amount of dust migration	Mas	ss ba	alance	Amount of dust migration	Amou process injec	unt of sing aid cted	scatterin inje (Only fo proce	or anti- ng agent cted or aerial ssing)	Othe	ers
		[g/cm ³]	[MPa]	lent			CD			[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- 2) 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

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

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Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the No.116 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)

No.117

- (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 $^{\circ}$ 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.



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

No.118

- (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⁾



(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," *Zairyoto-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.



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (4/14)

- (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



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



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 336h⁷)

(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.



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (5/14)

- (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



No.120

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

(5 to 20.8%). ⁸⁾⁹⁾

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.



(Source)

Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (6/14) No.121

- (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.



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV(7/14)

- (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.

Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (8/14)

- (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
 - **D** 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)
 - **D** External appearance of test equipment: See Figure 6

Type of	C	Si	Mn	P	S
steel 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

Table 1 Chemical composition of test material (wt %)

*: "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.





Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV(9/14)

(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







Figure 8 Sea salt particle adhesion procedure

Table 2 Measured values of various salts at a fixed point of humidity in the test matrix¹⁰

Table 1 Relative humidity values of the humidity fixed point at 22.3°C

	MgCl ₂	NaBr	NaC1	KC1
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

Fig. 7 Evaluation results of liquid film thickness when sea salt particle adhesion and relative humidity are varied²⁾

(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.



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (10/14)

- (ii) Status of studies related to corrosion evaluation of structures
 - (a) Corrosion test
 - ➤ Test matrix

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



No.125



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

Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (11/14) No.126

- (ii) Status of studies related to corrosion evaluation of structures
 - (a) Corrosion test
 - Corrosion test results under non-irradiated conditions



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (12/14)

- (ii) Status of studies related to corrosion evaluation of structures
 - (a) Corrosion test



2 times larger, verifying that corrosion accelerates as

the dose rate increases (Figure 13)



Appendix 6.2.4.1-3: Impact study on methods due to static environment inside the PCV (13/14)

- (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 findings²⁾.

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.





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

- (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 above¹)).
 - 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 above⁷).
 - > 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

					Impo	ortant monitoring items			
Analyzi	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3
number	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	Û	Partial blockage of the filter element due to accumulation of dust migration	(a) HEPA filter differential pressure	Direct (item 4)	Selected because accumulation of dust in the HEPA filter increases differential pressure,
	Same as above	Same as above	Same as above	Same as above		from the processing point to the HEPA filter	(b) Dust amount and particle size distribution at the HEPA filter inlet	Indirect (item 5)	and this tendency is affected by the amount and particle size distribution of the dust flowing in.

Safety equipment (gas phase confinement equipment)

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

This number is linked to Appendix <u>6.2.4.3</u>-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) **No.131** This number is Table. Important monitoring items for gas phase confinement equipment in "Model ID Sa-4: Processing of debris" (2/2) linked to Appendix 6.2.4.3-2 Analysis number Important monitoring items Temperature differential before and after the electric heater An-Ki-10,11,12,13,57,58,59,60 Amount of mist at electric heater inlet An-Ki-11,12,58,59 Differential pressure between inside and outside of the PCV An-Ki-14,15 Amount and chemical properties (pH, chloride ion concentration) of mist flying to the PCV wall near the D/W water surface Differential pressure between inside and outside of the PCV + pressure inside the system An-Ki-16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at filter An-Ki-16 casing inlet Amount and nuclide composition of dust at filter casing inlet An-Ki-17 An-Ki-18,19 Amount of mist at filter casing inlet Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at An-Ki-20, 24 exhaust line inlet Amount and nuclide composition of dust at exhaust line inlet An-Ki-21,25 An-Ki-22.23.26.27 Amount of mist at exhaust line inlet HEPA filter differential pressure + differential pressure between inside and outside of the PCV An-Ki-28 An-Ki-35,36,37 Airflow rate of exhauster Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at An-Ki-35 exhauster inlet Amount and nuclide composition of dust at exhauster inlet An-Ki-36 An-Ki-38,39,40,41,42 Demister differential pressure + differential pressure between inside and outside of the PCV Amount and particle size distribution of dust at demister inlet An-Ki-38 Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at An-Ki-39 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 Amount and particle size distribution of dust at dry backwash filter inlet An-Ki-43 Amount and chemical properties of dust (pH, chloride ion concentration, chemical composition) at dry An-Ki-44 backwash filter inlet An-Ki-45 Amount and nuclide composition of dust at dry backwash filter inlet Amount of mist at dry backwash filter inlet An-Ki-46,47 Amount of processing aid (mist) sprayed at processing point An-Ki-52 An-Ki-54 Amount of anti-dispersion agent (mist) sprayed at processing point Amount and nuclide composition of dust at electric heater inlet An-Ki-57



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
Ap Eki 6 13	Water temperature inside the PCV
AII-EKI-0,13	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
Ap Eki 15	D/W water level
AII-EKI-15	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)

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"

ppendix	Analysis number	Important monitoring items
.2.4.3-2	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
		Water temperature inside the PCV
	An-Rei-5, 11	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. Import	ant 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)

No.135

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"

luipment		
	Analysis number	Important monitoring items
		No important monitoring items due to the environment inside the PCV
-		
This num	ber is	

dix	
Table. Important mor	nitoring 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
	Degree of influence of equipment on hot spots (radiation resistance)
Saku-B-2	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
	dix <u>Table. Important mor</u> <u>Analysis number</u> Saku-A-1 Saku-A-2 Saku-A-3 Saku-A-3 Saku-B-1 Saku-B-1 Saku-B-2 Saku-B-3 Saku-B-3 Saku-B-3 Saku-B-5 Saku-B-6 Saku-B-7

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 \$		tant 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
		Application time for neutron absorbent
	Saku-A-S	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 linked to	^{is}	t monitoring items for operational equipment in "Model ID Sa-4:
6.2.4.3-3	Analysis number	Important monitoring items
	Saku-B-1	Fuel debris properties (compressive strength) in the processing area
		Dust concentration at the processing site unaffected by darkness
	Saku-A-T	Debris temperature unaffected by darkness
		Dust concentration at the processing site unaffected by fog
	Saku-A-2	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 1	Dust concentration at the processing site unaffected by noise
	Saku-A-4	Debris temperature unaffected by noise
	Saku-A-5	Debris temperature unaffected by dust dispersion
	Saku-A-6	Neutron flux unaffected by darkness
	Gard-A-0	Debris dimensions unaffected by darkness
	Saku-A-7	Neutron flux unaffected by fog
	Saku-A-1	Debris dimensions unaffected by fog
	Soku A 9	Neutron flux unaffected by dripping water
	Saku-A-o	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)
	Jaku-A-To	Debris dimensions unaffected by background
	Saku-A-11	Neutron flux around the location of the fall
	Jaku-A-TT	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
	Gara-D-5	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 i linked to Appendix	^s <u>Table. Important</u>	monitoring items for operational equipment in "Model ID Sa-4:
6.2.4.3-3	Analysis number	Important monitoring items
	Soku P 4	Degree of influence of equipment on hot spots (radiation resistance)
	Saku-D-4	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
F	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)

No.139

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 linked to Appendix	Table. Important mo	nitoring items for operational equipment in "Model ID Sa-6: Cell
6.2.4.3-3	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 P 1	Time to reach destination
	Saku-B-1	Velocity of water flow on the transfer route
	Saku B 2	Degree of influence of equipment on hot spots (radiation resistance)
	Saku-B-2	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

ſ	This number	Table Important manitaring i	tame for operational equipment in "Model ID So 7: Transfer of debrie $\widehat{(1)}$ (Call D). Call V	/\"
IS linked to Appendix			terms for operational equipment in Model ID Sa-7. Transier of debits () (Cell $R \rightarrow$ Cell f	
l	6.2.4.3-3	Analysis number	Important monitoring items	

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
	Dust concentration at cell (Y)
Saku-A-T	Dust concentration at cell (R)
	Hydrogen concentration/or oxygen concentration in cell (Y)
Saku-A-2	Amount of hydrogen generated in the inner container
Solu P 2	Air dose rate of cell (Y)
Saku-D-3	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 monitor	oring items for operational equipment in "Model ID Sa-9: Transfer of debris (2) (Cell Y \rightarrow 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)

<u>Table. Important monitoring items for operational equipment in "Model ID Sa-10: Transfer of debris (Cell G \rightarrow Secondary boundary)"</u>

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



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (1/48)

■ 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)

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed Version) (2/48) No.143

- 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 equipmentspecific 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.


Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (3/48)

■ 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

No.144

Fuel		Assı	umed properties		Assumed	processing	nethods		Particle size of	dust		١
debris	Density	Compressive strength	Primary	Localized area	Processing	Equipment	Remarks	Aeri (no anti-	al processing dispersion agent)	Underwater	processing	
iypo	[g/cm ³]	[MPa]	component		mode	name			[µm]		[µm]	
Mass of fuel debris	11	Craft, on bedrock (upper section): 2000 Other than	[U Rich] (U, Zr)O2-C, (Zr, U)O2-T, [Fe Rich] UO2, Fe, Zry-2,	Pedestal inside the PCV (Floor/Interior/ outside) drywell	Cutting	Disc cutter	Blade diameter: 200 mm Blade thickness:	Airborne	All in range of peak particle size 2 to 3 (mass concentration distribution) 0.1 to 0.3 (number concentration distribution)	Airborne	Unknown	
JEDITS		above mentioned: 230	α-2r(O), SUS/Fe, Fe2(Zr, U), ZrB2, Fe2B, Zr(O), 5-07-				1 mm Number of revolutions:	Sedimentation	All in median diameter 0.3 (number distribution) 7.9 (sediment distribution)	Sedimentation	Above 50	
			∠r(O), Fe2Zr				1000 rpm	Peripheral dispersion	Either airborne/sedimentation	Floating in water	50 or less	

	Total amo	unt of dust		Mass ba	alance and amo	ount of dust migr	ation				American	
	gene	erated	Aerial	process	sing	Underwa	ater proc	essing	Amount of p	rocessing aid	Amount o	ranti-scattering
\setminus	Aerial processing	Underwater processing	Mass balan	се	Amount of dust migration	Mass balar	nce	Amount of dust migratior	inje	cted	(Only for a	erial processing)
	[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	∕list: 0.05 .∕min	9.9 L
			Sedimentation	37	459.6	Sedimentation	99.5	1235.9		↑ (*)		(*)
			Peripheral dispersion	59	732.9	6.2	Dioturb	 	Dietuwk			
1									Distuit		Disturt	bance (3)



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (4/48)

Procedure for entering the information on disturbances into the risk assessment table (2/2) No. Disturbance Particle size and amount of dispersion of dust 1 generated during processing 2 Use of processing aid injected onto processing jigs 3 Use of anti-dispersion agent for dust (1) to (4) on the Others Important monitoring previous page **(4)** Heat input during processing items extracted Abrasive input during processing 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 Analysis The function number Indirect that the Direct Target Work delay factor Detection requirements to avoid work Reason for selection of detection target is causes monitoring/Indire Direct causes of error Reasons to be selected (= error) equipment delays requirements of error ct monitoring responsible for Dust concentration inside the PCV Reduction of Increased dust increases because the HEPA filter **HEPA** filter dust concentration inside deteriorates and the design value of Partial blockage of the filter (a) HEPA filter differential pressure Direct (item 4) Selected because accumulation of concentration the PCV the exhaust filter efficiency is not element due to dust in the HEPA filter increases ensured accumulation of dust An-Ki-1 1 differential pressure, and this tendency migrating from the Predict loss of safety is affected by the amount and particle processing point to the functions due to debris Same as Same as (b) Dust amount and particle size size distribution of the dust flowing in. Same Same as above Indirect (item 5) **HEPA** filter retrieval operations by above above distribution at the HEPA filter inlet extracting (a) direct/(b) indirect monitoring As the PCV deteriorates and the size Selected because increase in the size Decrease in PCV of the opening increases, inleakage of the opening caused by the corrosion Static (a) Differential pressure between differential pressure (Primary occurs and decreases the differential Direct (item 4) Partial damage caused by of the PCV wall surface decreases the boundary between inside and inside and outside of the PCV Boundary) pressure between inside and outside corrosion of PCV wall differential pressure between inside outside of the PCV 2 An-Ki-14 of the PCV. surface due to accumulation and outside of the PCV, and because (b) Amount and chemical properties of processing aid (mist) this trend is affected by the liquid Same as Same as (pH, chloride ion concentration) of Same as abov Organize the causal Same as above Indirect (item 5) phase chemical properties on the PCV above mist flying to PCV wall surface near above relationship between the wall surface. direct cause of the error D/W water surface 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



No.145

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (5/48) No.146

Risk assessment table(gas phase confinement equipment)

Debris retrieval

Model ID Process

Ko-3

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

Work	Sa-4	: Processing	of debris														
					Impo	rtant monitoring items						Weigh	ted evaluation of important mo	onitoring	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 (Evaluation	'-4 Results)
Analysis number	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 represent ation
An-Ki-1	HEPA filter	Reduction of dust concentration	Increased dust concentration inside the PCV	Dust concentrati on inside the PCV increases as the HEPA filter deteriorate s and the HEPA filter efficiency does not meet the design yalue.	0	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 (b) Dust amount and particle size distribution at the HEPA filter inlet	Direct (item 4) Indirect (item 5)	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) Functionality is ensured by switching filters through 2 series of filters (already studied)	3	Filter clogging is due to daily accumulation, so predictability is good Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	1	• 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/downstre am dust concentration ratio (b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at HEPA filter inlet 	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) 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 Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point 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



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (6/48)

Model ID Process Work	isk as phas ко-з sa-4	SSESSM CONF Debris retrieval Processing of c	inem 1 inem Jebris	table ent eq	uipr	nent)	Score table fr [4 points] No cou [3 points] Counte development [2 points] Counte records of applica [1 point] Counter at the Fukushima Item 6-1	or item 7-1 ntermeasures ha rmeasures exist, ermeasures exist ation at the Fukus measures exist, Dalichi.	ve been determined but they are still under , but there are no track shima Daiichi and have been applied Item 6-3	■ Score [4 points] predictab [3 points] predictab [2 points] is poor [1 point] is good	table for item 7-2 Requires constant monitorin lity is poor Requires constant monitorin lity is good Requires regular monitoring Requires regular monitoring	g during task g during task and predictat and predictat Weighted d	Score table for it [4 points] No count unknown [3 points] Countern ignificantly due to s [2 points] Counterm to workload limitation [1 point] No impact of evaluation of important models	tern 7-3 termeasures uspensior easures e ns on through ponitoring i	es, and impar exist, but thr of task xist, but throug put, or when 7- items em 7-3	t on throughp oughput decreases 1 is 1 point	0.1 4' put is pases s due
Analysis number	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/Ind irect monitoring	Reason for selection of detection requirements	f Poi	Presence or absence o countermeasures for disturbing functions	f Point	Effects on accurate and prompt on-site response by workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of represent ation
An-Ki-3	HEPA filter	Reduction of dust concentration	Increased dust concentrat ion 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.	0	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downs tream 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 inflowin dust	n 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)	5 4	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
	Same as above	Same as above	Same as above	Same as above		Partial blockage of filter elements due to adhesion of	(a) HEPA filter differential pressure	Direct (item 4)	Selected because the differential pressure increases due to partia blockage caused by m that accumulates in the HEPA filter, and	al 1 ist e	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	
An-Ki-4					(2)	processing aid migrating from the processing point to the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	because this trend is affected by the amount of inflowing mist due to the processing aid.	t D 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	3



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (7/48) Risk assessment table

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 [4 points] No counter unknown [3 points] Counterme significantly due to sus; [2 points] Countermeas to workload limitations [1 point] No impact on t

and 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

rocess	Ko-3	: Debris retriev	al				Fukushima Daiic	:hi.			good	moning at	[1 poir	t] No im	npact on throughput, o	r when 7-1 is 1	point
Vork	Sa-4	: Processing o	fdebris														
					Important	monitoring items						We	ighted evaluation of important	monitori	ng items		
Analysis	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	Iter (Evaluatio	n 7-4 on Results)
number	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/l ndirect 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	٢	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	(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)	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
				the design value.		result of debris retrieval operations	(b) Amount of mist sprayed at processing point	Indirect (item 5)	sprayed at the processing point.	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	
	Same as above	Same as above	Same as above	Same as above		Partial blockage due to adhesion of anti- dispersion agent migrating from the processing point to	(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	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	
AU-KI-P					٩	the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
	Same as above	Same as above	Same as above	Same as above	Same as	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design	(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	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	
An-Ki-7					above	condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of mist sprayed at processing point	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4

IRID

Model ID

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Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (8/48) No.149

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID

Process

Ko-3

 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 and predictability is poor [2 points] Countermeasures exist, and have been applied at the Fukushima Daiichi. [1 point] Requires regular monitoring and predictability [2 points] Countermeasures exist, but throughput decreases due to workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point 				
)	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	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

Work	Sa-4	: Processing	of debris			L			is god	a							
		•			Impor	tant monitoring items						Weigh	ted evaluation of important monitor	ng item	S		
Analysis	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	lte (Eva Re	m 7-4 aluation sults)
number	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)	Indiv idual	Point of repres entatio n
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	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	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
				efficiency does not meet the design value.			(b) Amount and particle size distribution of abrasives at HEPA filter inlet	Indirect (item 5)	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)	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		Performance degradation of the HEPA filter caused by the design condition of relative humidity at the	(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	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied) $\rightarrow 2$ 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	
					Same as above	HEPA filter inlet exceeding the assumed design condition with evaporation of D/W stagnant water as a result of heat input during processing	(b) Amount of heat input at processing point	Indirect (item 5)	processing point.	1	Functionality is ensured by installing a demister and an electric heater at the first-stage filter (already studied) \rightarrow 2 series only	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4
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	0	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 degradation of the electric heater, and because this trend is affected by the amount and nuclide composition of inflowing 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	
				ensured.			(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)	dust.	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	

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (9/48) <u>No.15</u>0

Risk assessment table (g

1113	n a33	503311					bla fan ita ar 7 d		Score	table for	item 7-2						
as	ohase	e confi	inem	ent equip	ment)	Score ta [4 points] No [3 points] Co developmen	countermeasures have pountermeasures exist, b t	e been deter ut they are	mined still under [4 points] predictab [3 points]	Requires ity is poo Requires	s constant monitoring during tas or s constant monitoring during tas	k and k but	 Score table for item 7-3 [4 points] No countermeasures [3 points] Countermeasures et 	, and im xist, but	npact on throug t throughput de	hput is unknow ecreases signif	n icantly due
odel ID				1		[2 points] Co	ountermeasures exist, b	out there are	no track [2 points]	Requires	od s regular monitoring and predict	ability	[2 points] Countermeasures et	xist, but	t throughput de	ecreases due te	o workload
Process	Ko-3	: Debris retriev	val			[1 point] Cou	untermeasures exist, ar	nd have bee	n applied is poor	equires	regular monitoring and predictab	litv is	limitations [1 point] No impact on through	out. or w	/hen 7-1 is 1 p	pint	
Nork	Sa-4	: Processing o	fdebris			at the Fukus	hima Daiichi.		good			,	[· · · · · · · · · · · · · · · · · · ·				
					Important mor	nitoring items	•					Weig	hted evaluation of important monitori	ng items			
Analysis	Item 1	Item 2	Item 3	Item 4	ltem 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 (Evaluation	-4 Results)
number	Target equipment	The function that the target is responsible for	Work delay fa (= error)	actor 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 requirement	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 represent ation
	Electric	Reduction of	Increased due	st The dust		Performance	(a) Temperature	Direct	Selected because the		Functionality is ensured by		Post-detection is possible by		Because		
	heater	dust	concentration	concentration inside		degradation of the	differential before and	(item 4)	temperature differentia		switching between heaters using		constant monitoring of the		item 7-1 is 1		
	(Pretreatmen	concentration	inside the PC	V the PCV increases		electric heater	after the electric		before and after the	1	2 series of electric heaters		temperature differential before		point	4	
	t equipment)			because the electric		caused by adhesion	heater		electric heater	1	(already studied)	4	and after the electric heater, but	'		4	
				heater deteriorates		of processing aid			decreases due to				predictability is poor.				
An-Ki-11				and the design	2	migrating from the			performance								4
				value of the filter is		processing point to	(b) Amount of mist at	Indirect	degradation of the		Functionality is ensured by		Continuous monitoring is		Because		
				not ensured.		the electric heater	electric heater inlet	(item 5)	electric heater, and		switching between heaters using		required, but predictability is		Item 7-1 IS 1		
									offected by the amount	1	2 series of electric neaters	3	gooa.	1	point	3	
									of mist inflow due to th		(alleady studied)						
									processing aid.								
									Selected because the		Functionality is ensured by		Post-detection is possible by		Because		
							(a) Temperature		temperature differentia		switching between heaters using		constant monitoring of the		item 7-1 is 1		
	Same as	Same as	Same as abo	ve Same as above		Performance	differential before and	Direct	before and after the	1	2 series of electric heaters	4	temperature differential before	1	point	4	
	above	above				degradation of the	after the electric	(item 4)	electric heater		(already studied)		and after the electric heater, but				
						electric heater	neater		decreases due to				predictability is poor.				
An-Ki-12					3	caused by adhesion			performance		Functionality is ensured by				Because		4
						of anti-dispersion			degradation of the		switching between heaters using				item 7-1 is 1		
						agent migrating from	(b) Amount of mist at	Indirect	electric heater, and		2 series of electric heaters		Continuous monitoring is		point		
						the processing point	electric heater inlet	(item 5)	because this trend is	1	(already studied)	3	required, but predictability is	1		3	
						to the electric heater			of mist inflow due to th				good.				
									anti-dispersion agent								
						Performance	(a) Temperature	Direct	Selected because the		It is assumed that the		Post-detection is possible by		Because		
						degradation of the	differential before and	(item 4)	temperature differentia		processing work will proceed		constant monitoring of the		item 7-1 is 1		
	Same as	Same as	0	0		electric heater	after the electric		before and after the		without exceeding the PCV		temperature differential before		point		
	above	above	Same as abo	ve Same as above		caused by the rise in	heater		electric heater	1	design temperature	4	and after the electric heater, but	1		4	
						PCV temperature			decreases due to				predictability is poor.				
						due to heat input			performance								
An-Ki-13					4	during processing	(b) Amount of heat	Indirect	degradation of the		It is assumed that the		Advance detection is possible by		Because		4
							input at processing	(item 5)	electric heater, and		processing work will proceed		constant monitoring of the		item 7-1 is 1		
							point		affected by the amount		without exceeding the PCV		temperature on the upstream side		point		
									of heat input at the	1	design temperature	3	or the electric heater, and	1		3	
									processing point which				predictability is good				
									raises the temperature								
									of inflowing gas.								

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (10/48) **No.151**

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID Process

Ko-3

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	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	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 [4 points] No impact on throughput, or whom 7.1 is 1 point.
at the Fukushima Daiichi.	[1 point] Requires regular monitoring and predictability is	[1 point] No impact on throughput, or when 7-1 is 1 point

Work	Sa-4 : F	Processing of d	ebris														
				Impo	ortant mor	nitoring items						Weight	ed evaluation of importa	int monit	oring items		
Anaturia	Item 1	Item 2	Item 3	Item 4	Item 5- 1	ltem 5-2	Item 6-1	Item 6-2	Item 6-3		Item 7-1		Item 7-2		Item 7-3	(Eva	Item 7-4 luation Results)
number	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/I ndirect 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)	Indivi dual	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	0	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	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	- 18
				pressure between inside and outside of the PCV.			(b) Amount and chemical properties (pH, chloride ion concentration) of mist flying to PCV wall surface near D/W water surface	Indirect (item 5)	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	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	- 40
An-Ki-15	Same as above	Same as above	Same as above	Same as above		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	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	10
					3		(b) Amount and chemical properties (pH, chloride ion concentration) of mist flying to PCV wall surface near D/W water surface	Indirect (item 5)	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	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	48

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (11/48) No.152

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID Process

Ko-3

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 d to suspension of task [2 points] Countermeasures exist, but throughput decreases due to worklow limitations [1 point] No impact on throughput, or when 7-1 is 1 point

Work	Sa-4	: Process	ing of debris			L			good								
					Important	monitoring items						Weighteo	levaluation of importan	it monitor	ingitems		
Analysis	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	(E	tem 7-4 valuation Results)
number	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/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)	Indiv idual	Point of representati on
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.	0	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 (b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at filter casing inlet 	Direct (item 4) Indirect (item 5)	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. Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	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 (b) Amount and nuclide composition of dust at filter casing inlet 	Direct (item 4) Indirect (item 5)	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. 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. Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	4

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (12/48)

	lick	accaceme	nt tahla			N0.153
	s pha	ase confin	ement 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 anolication 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 	■ 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
Process	Ko-3	: Debris retrieval		[1 point] Countermeasures exist, and have been applied at	predictability is poor [1 point] Requires regular monitoring and	workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point
Work	Sa-4	: Processing of debris		the Fukushima Daiichi.	predictability is good	
			Important monitoring items		Weighted evalua	tion of important monitoring items

					Impo	rtant monitoring items						Weig	nted evaluation of important mor	itoring	items		
Analysis	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	(Eva	Item 7-4 luation Results)
number	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)	Indivi dual	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	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	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
				between inside and outside of the PCV.			(b) Amount of mist at filter casing inlet	Indirect (item 5)	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)	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	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)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	
	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		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	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	
An-Ki-20				between inside and outside of the PCV.	U		(b)(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at exhaust line inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (13/48)

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

: Processing of debris

Model ID Process

Work

Ko-3

Sa-4

			No.154
)	■ 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

					Impor	tant monitoring items						Weigl	nted evaluation of important monitoring iter	ms			
Analysis	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	lte (Eva Re	m 7-4 aluation sults)
number	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/l ndirect 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)	Indiv idual	Point of represent ation
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	0	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	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
				outside of the PCV.			(b) Amount and nuclide composition of dust at exhaust line inlet	Indirect (item 5)	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	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	Q	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	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)	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.	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	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)	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.	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (14/48) Risk assessment table Score table for item 7-1 (gas phase confinement equipment) ■ Score table for item 7-2 Score table for item 7-3 [4 points] No countermeasures have been determined [4 points] Requires constant monitoring during task and [4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but they are still under predictability is poor [3 points] Countermeasures exist, but throughput decreases significantly due to Model ID development [3 points] Requires constant monitoring during task but suspension of task [2 points] Countermeasures exist, but there are no track predictability is good [2 points] Countermeasures exist, but throughput decreases due to workload Ko-3 Debris retrieval Process records of application at the Fukushima Daiichi [2 points] Requires regular monitoring and predictability is poor limitations 1 point] Countermeasures exist, and have been applied at the Sa-4 Work Processing of debris [1 point] Requires regular monitoring and predictability is good [1 point] No impact on throughput, or when 7-1 is 1 point kuchima Daiich Important monitoring items Weighted evaluation of important monitoring items Item 7-4 Item 6-3 Item 1 Item 2 Item 3 Item 4 Item 5-1 Item 5-2 Item 6-1 Item 6-2 Item 7-1 Item 7-2 Item 7-3 (Evaluation Analysis Results) number The function Direct Indirect Presence or absence of Impact on throughput due Point of that the target Work delay Reasons to be etection requirements nonitoring/I Reason for selection of detection Effects on accurate and prompt on Target Direct causes of error causes of Point countermeasures for disturbing Point Point to error handling (Indirect enresen equipment is responsible factor (= error) selected to avoid work delays direct requirements site response by workers dual error functions causes) ation for monitoring Isolation Static Decrease in As the isolation Partial damage due (a) Differential Selected because partial damage Although there is an impact on Post-detection is possible by Because item 7-1 is 1 valve boundary differential valve deteriorates to corrosion of dust pressure between to the isolation valve causes an safety functions, the frequency of constant monitoring of the noint (Integration pressure and the size of the migrating from the inside and outside of increase in the primary boundary occurrence is expected to be low differential pressure between of valves between opening increases. processing point to the PCV + pressure opening which decreases the compared to other boundary inside and outside of the PCV, but Direct 4 4 present in inside and inleakage occurs the isolation valve inside the system differential pressure between sections predictability is poor. It may be (item 4) the system) outside of and decreases the inside and outside of the PCV. difficult to identify the area of damage. the PCV differential pressure and because this trend is affected between inside and by the amount and chemical An-Ki-24 1outside of the PCV properties (pH, chloride ion Because item 7-1 is 1 (b)(b) Amount and Although there is an impact on Continuous monitoring is concentration, and chemical chemical properties safety functions, the frequency of required, but predictability is poor. point composition) of dust flowing into occurrence is expected to be low (pH, chloride ion the exhaust line Indirect concentration compared to other boundary 4 4 (item 5) chemical sections composition) of dust at exhaust line inlet Partial damage due Selected because partial damage Because item 7-1 is 1 (a) Differential Although there is an impact on Post-detection is possible by to irradiation of dust to the isolation valve causes an safety functions, the frequency of pressure between constant monitoring of the poin migrating from the inside and outside of increase in the primary boundary occurrence is expected to be low differential pressure between Same as Direct Same as Same as the PCV + pressure compared to other boundary inside and outside of the PCV, but 4 Same as above processing point to opening which decreases the above above (item 4) above the isolation valve differential pressure between inside the system sections predictability is poor. It may be Same as inside and outside of the PCV, difficult to identify the area of An-Ki-25 and because this trend is affected above damage (b) Amount and Although there is an impact on Continuous monitoring is Because item 7-1 is 1 by the amount and nuclide nuclide composition safety functions, the frequency of required, but predictability is poor point composition of dust flowing into Indirect of dust at exhaust occurrence is expected to be low 1 4 the exhaust line (item 5) line inlet compared to other boundary sections. Because item 7-1 is 1 Partial damage due (a) Differential Selected because partial damage Although there is an impact on Post-detection is possible by to adhesion of pressure between to the isolation valve causes an safety functions, the frequency of constant monitoring of the point processing aid inside and outside of increase in the primary boundary occurrence is expected to be low differential pressure between Direct Same as Same as Same as Same as above migrating from the the PCV + pressure opening which decreases the compared to other boundary 4 inside and outside of the PCV, but above above above (item 4) processing point to inside the system differential pressure between the sections predictability is poor. It may be inside and outside of the PCV, the isolation valve difficult to identify the area of An-Ki-26 2 1 and because this trend is affected damage (b) Amount of mist at Although there is an impact on Continuous monitoring is Because item 7-1 is 1 by the amount of mist flowing into exhaust line inlet safety functions, the frequency of required, but predictability is point the exhaust line Indirect 1 occurrence is expected to be low 3 good. 3 1 (item 5) compared to other boundary sections.



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (15/48) No.156

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID

Process

Ko-3

1	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	[4 points] Boguiros constant manitoring during task and	14	Decire table for item 7.5
	[3 points] Countermeasures exist, but they are still under	[4 points] Requires constant monitoring during task and	[4	points into countermeasures, and impact on throughput is unknown
		predictability is poor	[3	B points] Countermeasures exist, but throughput decreases significantly due to
	development	[3 points] Requires constant monitoring during task but	SU	uspension of task
	[2 points] Countermeasures exist, but there are no track	predictobility is good	12	pointal Countermonouros oviet but throughout decreases due to workload
	records of application at the Fukushima Daiichi	predictability is good	۱z	points countermeasures exist, but throughput decreases due to workload
	[1 point] Countermonoures evict, and have been applied at the	[2 points] Requires regular monitoring and predictability is poor	lim	mitations
	[1 point] countermeasures exist, and have been applied at the	[1 point] Requires regular monitoring and predictability is good	[1	point No impact on throughout or when 7-1 is 1 point
	Eukushima Dajichi	[1 point] requires regular memoring and predictability is good		point in part of an edgipat, of an of a point

Work	Sa-4	: Processing	of debris				-										
		-	-	-	Impoi	tant monitoring items	•					Weig	hted evaluation of important monitori	ng items			
Analysis	Item 1	Item 2	Item 3	Item 4	ltem 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3		Item 7-1		Item 7-2		Item 7-3	lte (Ev Re	em 7-4 aluation esults)
number	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/I ndirect 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)	Individ ual	Point of represent ation
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	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	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
				outside of the PCV.			(b) Amount of mist at exhaust line inlet	Indirect (item 5)	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.	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	As filter elements deteriorate and the design value of the exhauster is not ensured, the exhaust airflow rate	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	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
			the PCV	differential pressure between inside and outside of the PCV decreases.			particle size distribution at the HEPA filter inlet	Indirect (item 5)	nera mer.	1	switching filters through 2 series of filters (already studied)	3	required, but predictability is good.	1	is 1 point	3	
	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	(a) HEPA filter upstream/downstrea m 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	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	
An-Ki-29					Same as above	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)	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

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (16/48)

Score table for item 7-1

development

[4 points] No countermeasures have been determined

[3 points] Countermeasures exist, but they are still under

[2 points] Countermeasures exist, but there are no track

Score table for item 7-2

predictability is poor

predictability is good

[4 points] Requires constant monitoring during task and

[3 points] Requires constant monitoring during task but

Score table for item 7-3

to suspension of task

[4 points] No countermeasures, and impact on throughput is unknown

[3 points] Countermeasures exist, but throughput decreases significantly due

No.157

Risk assessment table (gas phase confinement equipment)

Model ID				records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.				aiichi ve been applied [2 points] Requires to track is poor [1 point] Requires to track	quires i uires re	regular monitoring and predicta gular monitoring and predictabil	bility ity is	[2 points] Countermeasures e limitations [1 point] No impact on through	xist, bu put, or v	t throughput decreases /hen 7-1 is 1 point	s due t	o workload	
Process	Ko-3 Sa-4	: Debris retri	eval			atulei	ukusinina Dalicin.		good								
					Impoi	tant monitoring items						Weigh	ted evaluation of important monitori	ng items			
Analysis	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	lte (Ev: Re	m 7-4 aluation esults)
number	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)	Indiv idual	Point of represe ntation
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	0	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstrea m 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	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
				the differential pressure between inside and outside of the PCV decreases.			(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	
	Same as above	Same as above	Same as above	Same as above		Partial blockage due to adhesion of processing aid migrating from the processing point to	(a) HEPA filter differential pressure	Direct (item 4)	Selected because dust accumulation in the HEPA filter increases the HEPA filter differential pressure, and	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	
An-Ki-31					Q	the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
	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,	(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	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	
An-Ki-32					Same as above	which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of mist sprayed at processing point	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (17/48)

Risk assessment table(gas phase confinement equipment)

: Debris retrieval

: Processing of debris

Model ID Process

Work

Ko-3

Sa-4

■ 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

					Impoi	tant monitoring items						Weigł	nted evaluation of important monitorir	ng items			
Analysis	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 (Evaluation	7-4 n Results)
number	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 represen tation
	HEPA filter	Dynamic boundary	Decrease in differential pressure between inside and	As filter elements deteriorate and the design value of the exhauster is not ensured, the		Partial blockage due to dispersion of anti- dispersion agent migrating from the processing point to	(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	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	
An-Ki-33			outside of the PCV	exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	3	the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
	Same as above	Same as above	Same as above	Same as above	Same as	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design	(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	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	
An-Ki-34					above	condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of mist sprayed at processing point	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4
	Exhauster	Dynamic boundary	Decrease in differential pressure between inside and outside of	As the exhauster deteriorates and the design value of the exhauster is not ensured, the exhaust airflow rate		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	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	
An-Ki-35			the PCV	decreases and the differential pressure between inside and outside of the PCV decreases.	1		(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at exhauster inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (18/48)

Risk assessment table(gas phase confinement equipment)

Model ID Process

Work

Ko-3

Sa-4

: Debris retrieval

: Processing of debris

		No.159
■ 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

					Impoi	rtant monitoring items						Weigl	hted evaluation of important monitorin	ıg items			
Analysis	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	ltem 6-2	Item 6-3		Item 7-1		Item 7-2		Item 7-3	lte (Evaluat	em 7-4 ion Results)
number	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/I ndirect 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)	Individ ual	Point of represent ation
	Exhauster	Dynamic boundary	Decrease in differential pressure between inside and	As the exhauster deteriorates and the design value of the exhauster is not ensured, the	Same as	Partial damage to the exhauster due to irradiation of dust migrating from the processing point to	(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	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	
An-Ki-36			outside of the PCV	exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases.	above	the exhauster	(b) Amount and nuclide composition of dust at exhauster inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
A . 1/ 07	Same as above	Same as above	Same as above	Same as above		Performance degradation of the exhauster caused by	(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	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	
An-Ki-37					(4)	the rise in PCV temperature due to heat input during processing	(b) Amount of heat input at processing point	Indirect (Item 4)	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	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	3
An-Ki-38	Demister (Pretreatmen t 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.	Ð	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 (b) Amount and particle size distribution of dust at distribution relat	Direct (item 4) Indirect (item 5)	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) Functionality is ensured by switching between demisters using 2 series of demisters	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. Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	3	3

IRID

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (19/48)

■ Score table for item 7-2

Score table for item 7-3

Score table for item 7-1

[4 points] No countermeasures have been det

■ Risk assessment table (gas phase confinement equipment)

•						[3 point	nts] Countermeasures	exist, but th	ey are still under	equires	constant monitoring during task	and	[4 points] No countermeasures, an	d impac	t on throughput is unknow	/n :::::	
Model ID						develo	pment	oviet but th	[3 points] R	equires	constant monitoring during task	but	suspension of task	a, Dui	inougriput decreases si	grincarii	iy due to
Process	Ko-3	: Debris retrie	eval			record	s of application at the F	ukushima Daii	chi [2 points] Reg	s good uires ree	gular monitoring and predictability is	poor	[2 points] Countermeasures exi limitations	st, but	throughput decreases	due to	workload
Work	Sa-4	: Processing	of debris			[1 poin Fukusl	nt] Countermeasures ex hima Daiichi.	ist, and have b	been applied at the [1 point] Requ	ires reg	ular monitoring and predictability is (good	[1 point] No impact on throughput,	or when	7-1 is 1 point		
					Impor	tant monitoring items						Weigh	ted evaluation of important monitorir	ng items			
Analysis	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	lte (Eva Re	m 7-4 Iluation sults)
number	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)	Indiv idual	Point of represen tation
An-Ki-39	Demister (Pretreatmen t 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	Same as	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 (b) (b) Amount and	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	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
				differential pressure between inside and outside of the PCV decreases.	above		(b) (b) Announcian chemical properties (pH, chloride ion concentration, chemical composition) of dust at demister inlet	Indirect (item 5)	chemical properties (pH, chloride ion concentration, chemical composition) of dust flowing into the filter.	1	switching filters through 2 series of filters (already studied)	4	required, but predictability is poor.	1	point	4	
An-Ki-40	Same as above	Same as above	Same as above	Same as above	Same as	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	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
					above		(b) Amount and nuclide composition of dust at demister inlet	Indirect (item 5)	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	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	



No.160

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (20/48)

Risk assessment table(gas phase confinement equipment)

: Debris retrieval

: Processing of debris

Model ID

Process

Work

Ko-3

Sa-4

			110.1
nt)	■ 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

					Impoi	tant monitoring	items					Weig	hted evaluation of important monitoring items				
Applysis	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	ltem 6-2	Item 6-3		Item 7-1		Item 7-2	1	tem 7-3	Iter (Eva Re:	n 7-4 luation sults)
number	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/l ndirect 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)	Indivi dual	Point of repres entatio n
An-Ki-42	Demister (Pretreatmen t 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	3	Partial blockage due to adhesion of anti- dispersion agent migrating	(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	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
				outside of the PCV decreases.		from the processing point to the demister	(b) Amount of mist at demister inlet	Indirect (item 5)	into the demister.	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	
	Dry backwash	Dynamic	Decrease in differential pressure	As the dry backwash filter deteriorates and the design value of the exhauster is not ensured, the		Partial blockage due to accumulatio n of dust migrating	(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	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	
An-Ki-43	filter (Pretreatmen t equipment)	boundary	between inside and outside of the PCV	exhaust airflow rate decreases and the differential pressure between inside and outside of the PCV decreases	1	from the processing point to the dry backwash filter	(b) Amount and particle size distribution of dust at dry backwash filter inlet	Indirect (item 5)	backwash filter.	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
	Same as above	Same as above	Same as above	Same as above		Partial damage due to corrosion of dust migrating from the	(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	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	
An-Ki-44					Same as above	processing point to the dry backwash filter	(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at dry backwash filter inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (21/48) Risk assessment table

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID Process

Ko-3

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 trace records of application at the Fukushima Dalichi [1 point] Countermeasures exist, and have been applied at the Fukushima Dalichi.	 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

Work	Sa-4	: Processing	of debris														
		•			Impoi	tant monitoring items		_				Weigh	ted evaluation of important monitori	ngitems			
Analysis	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 ⁻ (Evaluation	7-4 Results)
number	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 represen tation
Δn.Ki.45	Dry backwash filter (Pretreatme nt 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	Ð	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 trand is affected by	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	A
				decreases and the differential pressure between inside and outside of the PCV decreases.	U		(b) Amount and nuclide composition of dust at dry backwash filter inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	7
An-Ki-46	Same as above	Same as above	Same as above	Same as above	Q	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 (b) Amount of mist 	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	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (already studied) Functionality is ensured by	1	Filter clogging is due to daily accumulation, and predictability is good.	1	Because item 7-1 is 1 point Because item	1	3
							at dry backwash filter inlet	Indirect (item 5)	backwash filter.	1	installing a demister and electric heater at the first-stage filter (already studied)	3	required, but predictability is good.	1	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	(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	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
						filter	(b) Amount of mist at dry backwash filter inlet	Indirect (item 5)	inflowing mist.	1	Functionality is ensured by installing a demister and electric heater at the first-stage filter (cleaned ustudied)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (22/48)

Risk assessment table(gas phase confinement equipment)

: Debris retrieval

Model ID

Process

Ko-3

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	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
at the Fuldorinina Dalieni.	good	

Work	Sa-4	: Processing	of debris														
					Impo	rtant monitoring items						Weigł	nted evaluation of important monitorin	ng items			
Analysis	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	lter (Eva Re	n 7-4 Iuation sults)
number	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)	Individ ual	Point of represent ation
An-Ki-48	HEPA filter	Discharge control	Increase in dust concentratio n 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 (b) Dust amount and particle size distribution at the HEPA filter inlet	Direct (item 4) Indirect (item 5)	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) 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 Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	1	3
	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	(a) HEPA filter upstream/downstrea m 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	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	
An-Ki-49					above	the HEPA filter	(b) Amount and chemical properties (pH, chloride ion concentration, chemical composition) of dust at HEPA filter inlet	Indirect (item 5)	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
A- 16 50	Same as above	Same as above	Same as above	Same as above	Same as	Partial damage to filter elements due to irradiation of dust migrating from the processing point to the HEPA filter	(a) HEPA filter upstream/downstrea m 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 unstream and downstream sides	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	
и АП-КІ-50					above		(b) Amount and nuclide composition of dust at HEPA filter inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (23/48) ■ Risk assessment table

Risk assessment table(gas phase confinement equipment)

Model ID

Process

Ko-3

: Debris retrieval

■ 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 apod	 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

Work	Sa-4	: Processing	of debris														
					Impo	rtant monitoring items		-				Weig	nted evaluation of important monitori	ng items			
	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	ltem 6-2	Item 6-3		Item 7-1		Item 7-2		Item 7-3	lte (Ev R	m 7-4 aluation esults)
Analysis number	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)	Indiv idual	Point of represen tation
	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		Partial blockage due to adhesion of processing aid migrating from the processing point to	(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	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	
An-Ki-51				filter efficiency is not ensured, the dust concentration inside the PCV increases.	2	the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
	Same as above	Same as above	Same as above	Same as above	Same as	Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet, which is a design	(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	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	
An-Ki-52					above	condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of processing aid (mist) sprayed at processing point	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4
	Same as above	Same as above	Same as above	Same as above		Partial blockage due to adhesion of anti- dispersion agent migrating from the	(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	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	
An-Ki-53					3	processing point to the HEPA filter	(b) Amount of mist at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (24/48)

Risk assessment table(gas phase confinement equipment)

: Debris retrieval

Model ID
Process

Ko-3

0.4

		No.1
 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

					Impor	tant monitoring items						Weigh	ted evaluation of important monitori	na items			
	Itom 1	Itom 2	Itom 3	Itom 4	Itom 5-1	Itom 5-2	Itom 6-1	Itom 6-2	Itom 6-3		Itom 7-1	rro.g.	Itom 7-2		Itom 7-3	lte (Ev	em 7-4
Analysis			item 5	item 4	item 5-1	nem 3-2	item o- i	nem 0-2	nem 0-5				1		item 7-5	R	esults)
number	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)	Individ ual	Point of represent ation
	HEPA filter	Discharge control	Increase in dust concentration on downstream side of HEPA filter	As the HEPA filter deteriorates and the design value		Performance degradation of the HEPA filter caused by relative humidity at HEPA filter inlet,	(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	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	
An-Ki-54				of the filter efficiency is not ensured, the dust concentration inside the PCV increases.	3	which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of anti- dispersion agent (mist) sprayed at processing point	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4
	Same as above	Same as	Same as above	Same as		Partial blockage of 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	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	
An-Ki-55					¢	accumulation of abrasives migrating from the processing point to the HEPA filter	(b) Amount and particle size distribution of abrasives at HEPA filter inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	3
	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	(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	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	
An-Ki-56					Same as above	HEPA filter inlet exceeding the assumed design condition with evaporation of D/W stagnant water as a result of heat input during processing	(b) Amount of heat input at processing point	Indirect (item 5)	processing point.	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	4

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (25/48) **No.166**

[2 points] Requires regular monitoring and

Risk assessment table Score table for item 7-2 Score table for item 7-1 (gas phase confinement equipment) [4 points] Requires constant monitoring during task Score table for item 7-3 [4 points] No countermeasures have been determined [4 points] No countermeasures, and impact on throughput is unknown and predictability is poor [3 points] Countermeasures exist, but they are still under [3 points] Countermeasures exist, but throughput decreases significantly [3 points] Requires constant monitoring during task development but predictability is good due to suspension of task [2 points] Countermeasures exist, but there are no track

records of application at the Fukushima Daiichi

Model ID)	records of application at the Fukusnima Dalichi [1 point] Countermeasures exist, and have been a									s poor		workload limitations				
Process	Ko-3	: Debris retri	eval			Fukushima D	mermeasures exist, Jaiichi.	and have be	[1 p	oint] F	Requires regular monitoring	and	[1 point] No impact on throug	ghput, c	or when 7-1 is 1 point		
Work	Sa-4	: Processing	of debris			Landoninia E			predic	tability is	s good						
					Important m	nonitoring items						Weigh	ted evaluation of important monitori	ng item	s		
Analysis	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	lte (Ev: Re	em 7-4 aluation esults)
number	Target equipment	The function that the target is responsible for	Work delay facto (= error)	or 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)	Indiv idual	Point of represe ntation
	Electric heater (Pretreatme nt equipment)	Discharge control	Increase in dust concentration or 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		Performance degradation of the electric heater caused by irradiation of dust migrating from the processing point to the electric	(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	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	
An-Ki-57				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.	0	heater	(b) Amount and nuclide composition of dust at electric heater inlet	Indirect (item 5)	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	Continuous monitoring is required, but predictability is poor.	1	Because item 7-1 is 1 point	4	4
	Same as above	Same as above	Same as above	Same as above		Performance degradation of the electric heater caused by adhesion of processing aid	(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	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	
An-Ki-58					2	migrating from the processing point to the electric heater	(b) Amount of mist at electric heater inlet	Indirect (item 5)	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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4
	Same as above	Same as above	Same as above	Same as above		Performance degradation of the electric heater caused by adhesion of anti-dispersion	(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	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	
An-Ki-59					3	agent migrating from the processing point to the electric heater	(b) Amount of mist at electric heater inlet	Indirect (item 5)	uegradation 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)	3	Continuous monitoring is required, but predictability is good.	1	Because item 7-1 is 1 point	3	4

Model ID

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[2 points] Countermeasures exist, but throughput decreases due to

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (26/48) No.167

Risk assessment table (gas phase confinement equipment)

: Debris retrieval

Model ID

Process

Ko-3

Score table for item 7-1 A points] No countermeasures have been determined Soints] Countermeasures exist, but they are still under development Soints] Countermeasures exist, but there are no tract 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
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Work	Sa-4	: Processi	ng of debris							3							
					Important n	nonitoring item	S					Weighted	evaluation of important mo	onitoring it	ems		
	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	Iten (Evaluatio	n 7-4 on Results)
number	Target equipme nt	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)	Individu al	Point of represent ation
An-Ki-60	Electric heater (Pretre atment equipm ent)	Discharge control	Increase in dust concentra tion on downstre am 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	¢	Performanc e 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 (b) Amount of heat input at processing point	Direct (item 4) Indirect (item 5)	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) 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 Continuous monitoring is required, but predictability is good.	1	Because item 7- 1 is 1 point Because item 7- 1 is 1 point	4	4
				side of the filter.													

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (27/48)

No.168

Risk assessment table (liquid phase confinement equipment)

: Debris retrieval

Model ID Process

Ko-3

Score table for itom 7.1	Score table for item 7-2	
	[4 points] Requires constant monitoring during task and	Score table for item 7-3
[4 points] No countermeasures have been determined	predictability is poor	[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still under	[3 points] Requires constant monitoring during task but	[3 points] Countermeasures exist, but throughout decreases significantly du
development	redistability is good	to avanancian of teak
[2 points] Countermeasures exist, but there are no track		
records of application at the Fukushima Daiichi	[2 points] Requires regular monitoring and predictability	[2 points] Countermeasures exist, but throughput decreases due to workloa
[1 point] Countermeasures exist and have been applied	is poor	limitations
at the Eulershime Dejichi	[1 point] Requires regular monitoring and predictability is	[1 point] No impact on throughput, or when 7-1 is 1 point
at the Fukushima Dalichi.	hoop	

Work	Sa-4	: Processing	of debris														
					Import	ant monitoring items						Weig	nted evaluation of important me	onitoring	items		
Analysis	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	ltem 7-4 (E resu	valuation lts)
number	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/l ndirect 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 representat ion
	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		Partial blockage of the pump due to dust contamination migrating from the processing point to the D/W stagnant water transfer	(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	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	
An-Eki-1				design value for the pump flow rate is not ensured, resulting in the D/W water level to increase	Ð	pump	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	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	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	4
	Same as above	Same as above	Same as above	Same as above		Partial damage due to corrosion caused by potential difference	(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	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	
An-Eki-2					Same as above	resulting from accumulation of dust migrating from the processing point to the D/W stagnant water transfer	(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	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	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	4

IRID

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (28/48)

Risk assessment table (liquid phase confinement equipment)

Debris retrieval

: Processing of debris

Model ID Process

Work

Ko-3

Sa-4

		No.169
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

		1			Impor	tant monitoring items						Weig	nted evaluation of important monitor	ng items	:		
Analysis	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	lte (Eva	em 7-4 aluation
number	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)	Indivi dual	Point of repres entatio n
	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,		Partial damage due to corrosion of metal components such as impellers caused by the chemical	(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	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	
An-Eki-3				the design value for the pump flow rate is not ensured, resulting in the D/W water level to increase	0	properties of transferring liquid migrating from the processing point to the D/W stagnant water transfer pump	(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	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	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	4
	Same as above	Same as above	Same as above	Same as above		Partial blockage of the pump due to abrasive contamination migrating from the	(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,	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	
An-Eki-4					4	processing point to the D/W stagnant water transfer pump	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	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	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	4
	Same as above	Same as above	Same as above	Same as above		Partial damage due to corrosion caused by potential difference resulting from accumulation	(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	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	
An-Eki-5					Same as above	of abrasives migrating from the processing point to the D/W stagnant water transfer pump	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	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	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	4

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (29/48) No.170

	phas	e cor	nfinen	nent equ	uipm	nent) Sco [4 points [3 points develop [2 points	re table for item 7-1 S] No countermeasures S] Countermeasures ement S] Countermeasures e for antication of the second	es have been exist, but the exist, but the	determined y are still under ere are no track	Score table [4 points] Req predictability is [3 points] Req predictability is [2 points] Req	e for ite uires c poor uires c good uires re	m 7-2 onstant monitoring during task onstant monitoring during task agular monitoring and predictab	and but	Score table for item 7-3 [4 points] No countermeasures, [3 points] Countermeasures exi to suspension of task [2 points] Countermeasures exi	and im ist, but ist, but	pact on throughput throughput decrea throughput decrea	tis unkno ases sign ases due	own nificantly di e to workloa
Process	Ko-3	· Debris retrieva	1	1		[1 point]	Of application at the F Countermeasures e	xist, and hav	aiicni /e been applied	is poor [1 point] Requi	res rec	ular monitoring and predictabilit	y is	limitations	ut or w	hen 7-1 is 1 noint		
Work	Sa-4	: Processing of	debris	-		at the Fu	ukushima Daiichi.			good		and monitoring and prodictability	<i>y</i> 10	[Point] to inpact on anoughp	ut, 01 11			
					Imp	ortant monitoring items							W	veighted evaluation of important monitoring it	ems			
Analysis	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Iten	1 6-3		Item 7-1		Item 7-2		Item 7-3	Item 7	-4 (Evaluation results)
number	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 sele require	ction of detection ements	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)	Individu al	Point of representatio
	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		Performance degradation of the pump caused by the temperature of the transferring liquid, which is a design condition, exceeding the design	(a) Water temperature inside PCV	Direct (item 4)	Selected because the transferring liquid floc stagnant water trans- verified to deviate fin condition, and becau- affected by the amount the processing point	e temperature of wing into the D/W fer pump was om the design use this trend is unt of heat input at	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Athough constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	
An-Eki-6				increase	4	assumption, as a result of debris retrieval operations	(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	3
	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	(a) D/W stagnant water transfer pump flow rate	Direct (item 4)	Selected because the decreases due to participate and participation of the by abrasive contamination of the stagnant water trans- because this trend is amount, particle size	e pump flow rate intial damage caused nation in the D/W fer pump, and s affected by the e distribution, and	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small	3	Atthough constant monitoring is required, detectability is good.	1	Because item 7-1 is 1 point	3	
An-Eki-7					Same as above	into contact with the impeller and causing the impeller to wear out	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into D/W stagnant water transfer pump	Indirect (item 5)	particle density of at transferring liquid flo room stagnant water	vrasives in the wing into the torus transfer pump.	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	4
	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		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 th decreases due to pa caused by dust cont PCV stagnant water and because this tre amount and particle	e pump flow rate intial blockage amination in the discharge pump, nd is affected by the size distribution of	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shuldown is extremely small	1	Monitoring is required during operation, but detectability is good.	1	Because item 7-1 is 1 point	1	
An-Eki-8				the water level in the PCV buffer tank to increase	D		(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)	dust in the transferri the torus room stage pump.	ng liquid flowing into aant water transfer	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	2



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (30/48)

isk a id p	asses hase	ssmei confi	nt tab ineme	ole ent equ	ipme	■ Score [4 points] [3 points] developm [2 points]	e table for item 7-1 No countermeasures Countermeasures ex ent	s have been o xist, but they	determined are still under a ste no track	le for it quires o s poor quires s good	em 7-2 xonstant monitoring during task constant monitoring during task	and	Score table for item 7-3 [4 points] No countermeasure [3 points] Countermeasures of to suspension of task	s, and i exist, b	mpact on through ut throughput dec	out is un reases s	known significantly
loael ID	i	1		1		records o	f application at the Fu	ukushima Da	iichi [2 points] Re	quires	egular monitoring and predicta	bility	[2 points] Countermeasures e	exist, b	ut throughput dec	reases o	lue to work
Process	Ko-3	: Debris retrie	eval	-		[1 point]	Countermeasures exi	ist, and have	been applied [1 point] Requ	iires re	gular monitoring and predictabil	ity is	[1 point] No impact on through	nput, or	when 7-1 is 1 poir	nt	
Work	Sa-4	: Processing	of debris			at the Fur	Cushina Dalichi.		good								
					Impor	tant monitoring items						Weig	hted evaluation of important monitor	ring item	S	-	
Analysis	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	ltem 7-	4 (Evaluatio esults)
number	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)	Indivi dual	Point of representa on
	PCV stagnant water discharge pump	Dynamic boundary	Abnormal drainage of PCV stagnant water buffer	Due to deterioration of the PCV stagnant water discharge pump, the design		Partial damage due to corrosion caused by potential difference resulting from accumulation	(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	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	
An-Eki-9			tank	value for the pump flow rate is not ensured, resulting in the water level in the PCV buffer tank to increase	1	of dust migrating from the processing point to the PCV stagnant water discharge pump	(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)	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	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	4
	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	(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	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	
An-Eki- 10					Same as above	chemical properties of transferring liquid migrating from the processing point to the PCV stagnant water discharge pump	(b) Amount, particle size distribution, and particle density of dust in transferring liquid flowing into PCV stagnant water discharge pump	Indirect (item 5)	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	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	2
	Same as above	Same as above	Same as above	Same as above		Partial blockage of the pump due to abrasive contamination migrating from the	(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	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	
An-Eki- 11					4	processing point to the PCV stagnant water discharge pump	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water	Indirect (item 5)	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	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	2

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (31/48)

Score table for item 7-1

development

[4 points] No countermeasures have been determined

[3 points] Countermeasures exist, but they are still under

[2 points] Countermeasures exist, but there are no track

Score table for item 7-2

predictability is poor

predictability is good

.

[4 points] Requires constant monitoring during task and

[3 points] Requires constant monitoring during task but

Score table for item 7-3

to suspension of task

to a statel Oswate and

[4 points] No countermeasures, and impact on throughput is unknown

[3 points] Countermeasures exist, but throughput decreases significantly due

Risk assessment table (liquid phase confinement equipment)

Model ID

						records	of application at the F	ukushima Da	iichi	is poor	uies ie	gular mornioning and predictat	inty	limitations	101, DUI	inoughput decreases	s due t	5 WOI KIDAU
Process	Ko-3	: Debris retrie	eval			[1 point] at the Fu	Countermeasures ex kushima Daiichi.	tist, and hav	e been applied	[1 point] Requir	res reg	ular monitoring and predictabilit	y is	[1 point] No impact on throughp	ut, or wi	hen 7-1 is 1 point		
Work	Sa-4	: Processing	of debris							good								
					Impor	tant monitoring items							Weigh	ted evaluation of important monitor	ing items	5		
Analysis	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item	16-3		Item 7-1		Item 7-2		Item 7-3	lte (Ev re	em 7-4 aluation esults)
number	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 selec require	ction of detection ements	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)	Indivi dual	Point of represent ation
	PCV stagnant water discharge pump	Dynamic boundary	Abnormal drainage of PCV stagnant water buffer	Due to deterioration of the PCV stagnant water discharge pump, the design		Partial damage due to corrosion caused by potential difference resulting from accumulation	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because rate decreases d damage to the PC water discharge p because this trem	e the pump flow lue to partial CV stagnant pump, and nd is affected by	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	
An-Eki- 12			tank	value for the pump flow rate is not ensured, resulting in the water level in the PCV buffer tank to increase	٩	of abrasives migrating from the processing point to the PCV stagnant water discharge pump	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water discharee pump	Indirect (item 5)	the amount, parti distribution, and p of abrasives in th liquid flowing into stagnant water di	icle size particle density he transferring o the PCV lischarge pump.	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	4
	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,	(a) Water temperature inside PCV	Direct (item 4)	Selected because temperature of tra flowing into the P water discharge p verified to deviate	e the ansferring liquid PCV stagnant pump was e from the	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	
An-Eki- 13					Same as above	which is a design condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of heat input at processing point	Indirect (item 5)	design condition, this trend is affect amount of heat in processing point.	, and because cted by the nput at the	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	2
	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	(a) PCV stagnant water discharge pump flow rate	Direct (item 4)	Selected because rate decreases d damage caused l contamination in stagnant water di	te the pump flow lue to partial by abrasive the PCV ischarge 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	
An-Eki- 14					Same as above	stagnant water discharge pump coming into contact with the impeller and causing the impeller to wear out	(b) Amount, particle size distribution, and particle density of abrasives in transferring liquid flowing into PCV stagnant water discharce pump	Indirect (item 5)	and because this affected by the au size distribution, density of abrasiv transferring liquic torus room stagn transfer pump.	a trend is mount, particle and particle ves in the d flowing into the eant water	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	2



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No.1

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (32/48)

No.173

■ Risk assessment table (liquid phase confinement equipn

: Debris retrieval

Model ID	
Process	

Work

Ko-3

 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. 	ints] Requires constant monitoring during task and ctability is poor ints] Requires constant monitoring during task but ctability is good ints] Requires regular monitoring and predictability or int] Requires regular monitoring and predictability is	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
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Work	Sa-4	: Processing	of debris														
					Importar	t monitoring items						Weighte	d evaluation of important monit	oring items			
Analysis	Item 1	ltem 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 re	(Evaluation sults)
number	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)	Individ ual	Point of represent ation
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.	Ū	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 (b) Chemical properties (pH, chloride ion concentration, chemical composition) of D/W wall surface in liquid phase	Indirect (Item 4) Indirect (Item 5)	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.) 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. Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	3	- 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 transfering liquid in the system is not ensured, resulting in the water level in the connected boundary or tank to increase or decrease.	0	Partial blockage due to accumulation of dust migrating from the processing point to the piping	 (a) Flow rate in the system (b) Amount, particle size distribution, and particle density of dust in the transferring liquid 	Direct (item 4) Indirect (item 5)	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 Because item 7-1 is 1 point	3	4

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (33/48)

Score table for item 7-2

Score table for item 7-3

N	0	.1	7	4
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Risk assessment table (liquid phase confinement equipment) Score table for item 7-1 Id points No countermeasures have been determined Id points Countermeasures exist, but they are still

Model ID				, , , , , , , , , , , , , , , , , , , ,	P	[3 poin develop [2 poin	ats] Countermeasures oment ats] Countermeasures	exist, but th exist, but th	ey are still under predictability nere are no track predictability	is poor Requires	s constant monitoring during t	ask an ask bu	[3 points] No countermeasures [3 points] Countermeasures [3 points] Countermeasures [2 points] Countermeasures	exist	but throughput decrease	s signi	icantly due
Process Work	Ko-3 Sa-4	: Debris retrieva : Processing of	ıl debris	-		records [1 point Fukush	of application at the Fi Countermeasures exi ima Daiichi.	ukushima Daii ist, and have I	been applied at the [1 point] Req	quires n uires re	egular monitoring and predictabilit gular monitoring and predictability	y is poo is good	I [1 point] No impact on through	hput, or	when 7-1 is 1 point	00 00	. 10 Work
					Impo	ortant monitoring items		1				v	eighted evaluation of important monitoring	items		lte	m 7-4
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/In direct monitoring	Item 6-3 Reason for selection of detection requirements	Point	Item 7-1 Presence or absence of countermeasures for disturbing functions	Point	Item 7-2 Effects on accurate and prompt on-site response by workers	Point	Item 7-3 Impact on throughput due to error handling (Indirect causes)	(Eva re Indivi dual	Point of represe ntation
	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.		Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing point to the	(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	
An-Eki-17					0	piping	(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	4
	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	(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	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	
An-Eki-18					Same as above	piping	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)	ion concentration, and chemical composition) of dust flowing into the piping.	1	Although there is impact on safety functions, the frequency of accurrence 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	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.	¢	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
An-Eki-19							(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	



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (34/48)

Score table for item 7-1

development

[4 points] No countermeasures have been determined

[3 points] Countermeasures exist, but they are still under

[2 points] Countermeasures exist, but there are no track

Score table for item 7-2

predictability is poor

predictability is good

[4 points] Requires constant monitoring during task and

[3 points] Requires constant monitoring during task but

[2 points] Requires regular monitoring and predictability

■ Score table for item 7-3

to suspension of task

[4 points] No countermeasures, and impact on throughput is unknown

[3 points] Countermeasures exist, but throughput decreases significantly due

[2 points] Countermeasures exist, but throughput decreases due to workload

No.175

Risk assessment table (liquid phase confinement equipment)

woder ID	Ko-3 · Debris retrieval			records of application at the Fukushima Daiichi [1 point] Countermeasures exist, and have been applie							Iz points Requires regular monitoring and predictability Iz points Countermeasures exist, but infoughput decreases due lind is poor limitations						
Process	Ko-3	: Debris retrieva	1]			[1 point] Counterme at the Fukushima D	easures exis aiichi.	t, and have been applied	[1 point] F good	Requires regular monitoring and	predic	tability is [1 point] No impac	on thro	oughput, or when 7-1	is 1 point	
Work	Sa-4	: Processing of	debris		Imp	ortant monitoring items						w	eighted evaluation of important monitoring	items			
Analysis	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	ltem 7-4 (I resu	Evaluation ults)
number	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
	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.		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 accurrences of lea resulting from damage to the valve, because this trend is affected by the chemical properties (pH, chloride ior	iks and 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	
An-Eki-20					0		(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)	concentration, chemical composition dust flowing into the liquid-phase system.) of	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	4
	Same as above	Same as above	Same as above	The valve deteriorates and the amount of transferring liquid deviates from the control value.		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 io	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	
An-Eki-21					۹		(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into liquid system	Indirect (item 5)	concentration, chemical compositior dust flowing into the liquid-phase system.) of 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	4
	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		Partial damage due to corrosion caused by accumulation and adhesion of dust migrating from the processing point to the	(a) Water level of PCV stagnant water buffer tank + leak detection	Direct (item 4)	Selected because the water level in buffer tank decreases due to damag to the PCV stagnant water buffer tar and this tendency is affected by the chemical properties (pH, chloride io concentration, chemical composition	the e ik, 1 i	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	
An-Eki-22				exposure dose deviates from the control value.	0	PCV stagnant water buffer tank	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into liquid system	Indirect (item 5)	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.	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	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (35/48)

No.176

Risk assessment table (liquid phase confinement equipment)

: Debris retrieval

Model ID	
Process	

Ko-3

■ 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 [4 points] No co [3 points] Coun to suspension o [2 points] Coun limitations [1 point] No imp
---	---	---

Score table for item 7-3
I points] No countermeasures, and impact on throughput is unknown

3 points] Countermeasures exist, but throughput decreases significantly due o suspension of task

2 points] Countermeasures exist, but throughput decreases due to workload mitations

[1 point] No impact on throughput, or when 7-1 is 1 point

Work	Sa-4	: Processing	of debris														
		•		-1	Impor	tant monitoring items						Weigh	nted evaluation of important monitor	ing item	IS		
Analysis	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	lte (Ev	m 7-4 aluation sults)
number	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	Poin t	Presence or absence of countermeasures for disturbing functions	Poin t	Effects on accurate and prompt on-site response by workers	Poin t	Impact on throughput due to error handling (Indirect causes)	Indiv idual	Point of repres entatio n
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,	0	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
23			Ĩ	resulting in the D/W water level to increase			(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	
	Same as above	Same as above	Same as above	Due to deterioration of the D/W stagnant water coarse particle removal equipment, leakage occur.		Partial damage due to corrosion caused by potential difference resulting from accumulation of dust migrating from the processing	(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.	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	
An-Eki- 24		Ieakage occur, and the site Same as boundary radiation dose/worker from the processing point to the D/W stagnant water coarse particle (b) Amount, partin size distribution, and particle dens of dust in the transferring liquic flowing into D/W dotation dotation from the processing point to the D/W (b) Amount, partin size distribution, and particle dens of dust in the transferring liquic flowing into D/W	(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)	chemical composition) of transferring liquid flowing into the liquid system	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	4				



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (36/48)

No.177

Risk assessment table (liquid phase confinement equipment)

: Debris retrieval

: Processing of debris

Model ID

Process

Work

Ko-3

Sa-4

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 monitorin predictability is poor [3 points] Requires constant monitorin predictability is good [2 points] Requires regular monitoring a poor [1 point] Requires regular monitoring a good

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

		Important monitoring items										Weighted evaluation of important monitoring items						
Analysis	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	lter (Eva	m 7-4 aluation sults)	
number	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)	Indiv idual	Poin of repre entati n	
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.	٩	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 (b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Direct (item 4) Indirect (item 5)	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. Constant monitoring is required because the equipment is related to confinement, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	3	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	٩	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 (b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into liquid system 	Direct (item 4) Indirect (item 5)	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. Same as above	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 Because item 7-1 is 1 point	3	4	

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (37/48)

■ Risk assessment table (cooling equipment)

: Debris retrieval

Score table for item 7-1	Score table for item 7-2 [4 points] Requires constant monitoring during task and	■ Score table for item 7-3
[4 points] No countermeasures have been determined	[4 points] Requires constant monitoring during task and	■ Ocore table for item 7-0
[3 points] Countermeasures exist, but they are still under	predictability is poor	[4 points] No countermeasures, and impact on throughput is unknown
development	[3 points] Requires constant monitoring during task but	[3 points] Countermeasures exist, but throughput decreases significantly due
development	predictability is good	to suspension of task
[2 points] Countermeasures exist, but there are no track	[2 points] Requires regular monitoring and predictability	[2 points] Countermeasures exist, but throughout decreases due to workload
records of application at the Fukushima Daiichi	is near	Imitationa
[1 point] Countermeasures exist, and have been applied	is pool	innitations
at the Eukuchime Dejichi	[1 point] Requires regular monitoring and predictability is	[1 point] No impact on throughput, or when 7-1 is 1 point
at the Fukushima Dalichi.	boop	

Model ID

Ko-3

<u></u>	Vork	Sa-4	a-4 : Processing of debris															
			Important monitoring items								Weighted evaluation of important monitoring items							
	Analysis number	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)	Indivi dual	Point of repres entatio n
	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		Partial damage to the D/W stagnant water transfer pump due to corrosion of metal components such as impellars	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	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		
,				flow rate is not ensured, resulting in the PCV liquid phase temperature to increase.	1	caused by dust contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid at D/W stagnant water transfer pump inlet	Indirect (item 5) 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 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	4		
		Same as Same as above above	Same as s above S	Same as above	Same as above		Partial damage to the D/W stagnant water transfer pump due to contamination and	(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	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	
,	An-Rei-2					Same as above	entrapment of dust contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water transfer nump inlet	Indirect (item 5)	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	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	3	4

No.178

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (38/48)

Risk assessment table									
(cooling equipment)									
Madal ID									

: Debris retrieval

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Model ID

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Ko-3

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Process

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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 Eukushima Daiichi
[1 point] Countermeasures exist, and have been applied at the
Fukushima Dajichi

	Score table for item 7-2													
[4	points]	Requires	constant	monitoring	during	task	and							
pre	edictabili	ty is poor												
[3	points]	Requires	constant	monitoring	during	task	but							
pre	predictability is good													
[2	[2 points] Requires regular monitoring and predictability is poor													
[1	point] Re	equires reg	ular monito	oring and pre	dictabili	ity is g	ood							

[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

No.179

[1 point] No impact on throughput, or when 7-1 is 1 point

Score table for item 7-3

WORK	Sa-4 : Processing or debris																	
		Important monitoring items								Weighted evaluation of important monitoring items								
Analysis	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		lter (Eva Re	m 7-4 aluation asults)	
number	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)	Indivi dual	Point of repres entatio n	
	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	٩	Partial damage to the D/W stagnant water transfer pump due to abrasives discharged during AWJ processing in the coolant migrating	(a) D/W stagnant water transfer pump flow rate (b) Amount of abrasives in the	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	1	Supported by multiplexing. In addition, the effect of short term functional deterioration or shutdown is extremely small Supported by multiplexing. In addition. the effect of short term	4	Continuous monitoring is required, but predictability is poor. Although the equipment is used for securing the PCV cooling	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	_	
An-Rei-3				in the PCV liquid phase temperature to increase.		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	Indirect (item 5)	amount and particle size distribution of abrasives in the transferring liquid flowing into the D/W stagnant water transfer pump.	1	functional deterioration or shutdown is extremely small	3	water and required to operate during retrieval operations, detectability for significant functional deterioration is good	1		3	4		
	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	(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	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		
An-Rei-4					Same as above	abrasives contained in the coolant migrating from the processing point to the D/W stagnant water transfer pump	(b) Amount, particle size distribution, and particle density of abrasives in the coolant flowing into D/W stagnant water transfer pump	Indirect te (item 5) sy	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	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	4	
	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	(a) Water temperature inside l by the erature, sion	Direct (item 4)	Selected because the pump flow rate decreases due to the functional deterioration of the D/W stagnant water transfer	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		
An-Rei-5					Same as above	condition, exceeding the design assumption, as a result of debris retrieval operations	(b) Amount of heat input at processing point	Indirect (item 5)	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	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	4	


Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (39/48)

No.180

■ Risk assessment table (cooling equipment)

: Debris retrieval

■ 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	■ Sc [4 poin [3 poir to susp [2 poir limitati [1 poin
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d Score table for item 7-3
 [4 points] No countermeasures, and impact on throughput is unknown
 it [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
 y [2 points] Countermeasures exist, but throughput decreases due to workload limitations

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1 point] No impact on throughput, or when 7-1 is 1 point

Work	Sa-4	: Processing	of debris														
					Importan	t monitoring items						Wei	ghted evaluation of important monito	ringitem	3		
Analysis	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	(Eval	Item 7-4 Jation Results)
number	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)	Indivi dual	Point of representatio n
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 (b) The chemical properties (pH,	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 When the circulation cooling system shutdown, the external	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 Because item 7-1 is 1 point	3	3
							chloride ion concentration, chemical composition) of transferring liquid flowing into cooler inlet	Indirect (item 5)		1	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	good.	1		3	
An Roi-7	Same as above	Same as above	Same as above	Same as above	Ø	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	(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	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 <u>extremely small</u>	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 Because item 7-1 is	3	
Ап-Кеі-/					(đ.)	with the piping inside the cooler, and causing the piping to wear out	abrasives flowing into cooler inlet	Indirect (item 5)	transterring liquid flowing into the cooler.	1	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	required, and predictability is good.	1	1 point	3	3

Model ID Process

Ko-3

IRID

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (40/48) No.181

Risk assessment table (coolina equipment)

ooli	Model ID					[4	Score table for item 7-1 [4 points] No countermeasures have been determined [3 points] Countermeasures exist, but they are still under development				under Score table for item 7-2 [4 points] Requires constant monitoring during task predictability is poor		sk and	Score table for item 7-3 [4 points] No countermeasures,	and imp	eact on throughput is u	nknown	
Process	Model ID	: Debris retrieval]		de [2 re	evelopment points] Countermeasur cords of application at the	es exist, but es exist, but Fukushima [there are no track Daiichi	[3 points] predictabilit	ty is poo Require ty is goo	r es constant monitoring during ta d	ask but	[3 points] Countermeasures e suspension of task [2 points] Countermeasures	exist, bu exist, b	it throughput decreased throughput decreased throughput decre	ses significa ases due	antly due to to workload
Work	Sa-4	: Processing of d	lebris			[1 Fu	point] Countermeasures Ikushima Daiichi.	exist, and hav	ve been applied at the	[2 points] Re	equires r	egular monitoring and predictability i	is good	[1 point] No impact on throughp	ut, or wh	en 7-1 is 1 point		
					Imp	ortant monitoring items	•						v	eighted evaluation of important monitoring ite	ems			
Analysis	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 (Evaluation	7-4 Results)
number	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 or requirement:	of detection s	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 represen tation
	PCV stagnant water injection pump	Cooldown of debris	Degradation of cooling function due to reduced coolant throughput	Functional deterioration of the pump		Partial damage to the PCV stagnant water injection pump due to corrosion and deformation	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pum decreases due to the funct deterioration of the PCV st	ip flow rate tional taonant water	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	
An-Rei-8					Ð	of metal components such as impellers caused by dust contained in the coolant migrating from the processing point to the PCV stagmant water injection pump	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into PCV stagnant water injection pump inlet	Indirect (item 5)	injection pump, and becaus affected by the chemical pu chloride ion concentration, composition) of transferring into the PCV stagnant wate pump.	se this trend is roperties (pH, chemical g liquid flowing er injection	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 osignificant functional detectability osignificant functional deterioration is good	1	Because item 7-1 is 1 point	3	4
	Same as above	Same as above	Same as above	Same as above		Partial damage to the pump due to contamination and	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pum decreases due to the funct	np flow rate	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	
An-Rei-9					Same as above	entrapment of dust contained in the coolant migrating from the processing point to the PCV stagnant water injection pump	(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)	deterioration of the PCV st injection pump, and becaus affected by the amount and distribution of dust in the tr liquid flowing into the PCV injection pump.	tagnant water se this trend is d particle size ransferring stagnant water	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	4
	Same as above	Same as above	Same as above	Same as above		Partial damage to the pump due to contamination and entrapment of abrasives discharged during AWJ processing in the coolant	(a) PCV stagnant water injection pump flow rate	Direct (item 4)	Selected because the pum decreases due to the funct	ip flow rate	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	
An-Rei-10					¢	migrating from the processing point to the PCV stagnant water injection pump	(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into PCV stagnant water injection pump	Indirect (item 5)	deterioration of the PCV st injection pump, and becaus affected by the amount of the transferring liquid flowi PCV stagnant water injection	tagnant water se this trend is abrasives in ng into the on pump.	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	4



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (41/48)

■ Risk assessment table (cooling equipment)

: Debris retrieval

Model ID Process

Ko-3

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	■ Score table for item 7-3 [4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly d to suspension of task [2 points] Countermeasures exist, but throughput decreases due to worklo limitations [1 point] No impact on throughput, or when 7-1 is 1 point
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				4					9000								
Work	Sa-4	: Processing	of debris														
					Impor	tant monitoring items						Weig	nted evaluation of important monitorin	g items			
Analysis	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	lte (Evaluat	em 7-4 tion Results)
number	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)	Individ ual	Point of representa tion
	PCV stagnant water injection pump	Cooldown of debris	Degradation of cooling function due to reduced coolant throughput	Functional deterioration of the pump		Performance degradation of the pump caused by the coolant temperature, which is a design condition, exceeding	(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	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	
An-Rei- 11					4	the design assumption, as a result of debris retrieval operations	(b) Amount of heat input at processing point	Indirect (item 5)	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	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	4
	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	(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	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	
An-Rei- 12					Same as above	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	(b) Amount of abrasives in the transferring liquid flowing into PCV stagnant water injection pump	Indirect (item 5)	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	3	Attrough 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	4

No.182

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (42/48)

■ Risk assessment table (cooling equipment)

: Debris retrieval

Model ID

Process

Ko-3

■ 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 [3 points] Countermeasures et to suspension of task [2 points] Countermeasures et limitations [1 point] No impact on through
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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

No.183

1	Work	Sa-4	: Processir	ng of debris			L			good								
F						Important r	monitoring items	\$				W	eighted e	valuation of important monit	oring item	าร		
		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	lte	em 7-3	lte (Evalua	em 7-4 tion Results)
	Analysis number	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)	Individ ual	Point of representa tion
		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		Deterioration due to corrosion caused by dust contained in the cooling	(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	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	
An-Rei- 13				the temperature inside the PCV deviates from the control value.	1	water migrating from the processing point to the PCV stagnant water buffer tank	(b) Chemical properties (pH, chloride ion ssing to the chemical composition) of ant coolant flowing buffer into liquid system		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	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	4	
	An-Rei-	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		Partial blockage due to accumulatio n of dust	(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	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
An-Rei- 14				ensured, resulting in the temperature inside the PCV to deviate from the control value.		migrating from the processing point to the piping	(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into piping	Indirect (item 5)	amount and particle size distribution of dust in the coolant flowing into the piping	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	4	

IRID

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (43/48) **No.184**

Risk assessment table (cooling equipment)

Model ID

		_	
Score table for item 7-1	Secretable for item 7.3	ſ	Secretable for item 7.3
[4 points] No countermeasures have been determined			
[2 pointe] Countermodeures quiet but they are still under	[4 points] Requires constant monitoring during task and		[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still under	predictability is poor		[3 points] Countermeasures exist but throughout decreases significantly due to
development	predictability is poor		b points contenned suits exist, but throughput decredees significantly due to
[2 points] Countermonourse evist but there are no track	[3 points] Requires constant monitoring during task but		suspension of task
[2 points] Countermeasures exist, but there are no track	predictability is good		[2 points] Countermeasures exist, but throughput decreases due to workload
records of application at the Fukushima Daiichi			
[1 point] Countermeasures exist, and have been applied at the	[2 points] Requires regular monitoring and predictability is poor		limitations
[1 point] countermeasures exist, and have been applied at the	[1 point] Requires regular monitoring and predictability is good		[1 point] No impact on throughput, or when 7-1 is 1 point
Eukushima Daiichi			

Process	Ko-3	: Debris retrie	eval			[1 point] Fukushi	j Countermeasures exist ima Daiichi.	t, and have be	[1 point] Requir	es regul	ar monitoring and predictabilit	y is goo	[1 point] No impact on through	put, or w	hen 7-1 is 1 point		
Work	Sa-4	: Processing	of debris														
					Impor	tant monitoring items						v	eighted evaluation of important mor	nitoring i	tems		
Analysis	Item 1	Item 2	Item 3	Item 4	ltem 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3		Item 7-1		Item 7-2		Item 7-3	lter (Eva Re	m 7-4 aluation sults)
number	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)	Indivi dual	Point of repres entatio n
An-Rei-	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		Partial damage due to corrosion caused by potential difference resulting	(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	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	
15				temperature inside the PCV deviates from the control value.	1	from accumulation of dust migrating from the processing point to the piping	(b) Amount, particle size distribution, and particle density of dust in the coolant flowing into liquid system	Indirect (item 5)	because this trend is affected by the amount and particle size distribution of dust flowing into the piping.	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	4
	Same as above	Same as above	Same as above	Same as above		Partial damage due to corrosion caused	(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	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	
An-Rei- 16					Same as above	by changes in the water quality of the coolant migrating from the processing point to the piping	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into liquid system	Indirect (item 5)	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	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	4
	Piping	Static boundary	Same as above	Due to deterioration of the piping, the design value for the flow rate of coolant in		Partial blockage due	(a) Flow rate in the system	Direct (item 4)	Selected because the flow rate in the system decreases due to	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	
An-Rei- 17				the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	¢	to accumulation of abrasives migrating from the processing point to the piping	(b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into piping	Indirect (item 5)	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	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	4



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Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (44

Risk assessment table	
cooling equipment)	

Model	п
wouer	JU I

An-Rei-20

particles

removal

equipment

coolant in the

system

coarse particle removal

value for the flow rate of

coolant in the system is

not ensured, resulting in

the PCV to deviate from the control value.

the temperature inside

equipment, the design

migrating from the

D/W stagnant water

equipment

1

processing point to the

coarse particle removal

pressure before and after

coarse particle removal

D/W stagnant water

equipment

Ris	k ass	essm	ent ta	ble												Ν	0.	185
OOlir Model ID Process Work		: Debris retrieval	ent)			[4 [3] (2) (2) (1) (1) (1) (1)	Score table for item 7-1 points] No countermeasure velopment points] Countermeasure cords of application at the point] Countermeasures	res have been es exist, but es exist, but Fukushima Da exist, and have	determined they are still under there are no track aiichi e been applied at the	Score ta [4 points] F predictability [3 points] F predictability [2 points] Re [1 point] Req	ble for it Requires is poor Requires is good quires re uires re	em 7-2 constant monitoring during task s constant monitoring during task egular monitoring and predictability is ular monitoring and predictability is	and but poor good	Score table for item 7-3 [4 points] No countermeasures, an [3 points] Countermeasures exist suspension of task [2 points] Countermeasures ex limitations [1 point] No impact on throughput,	d impac st, but f ist, but or when	t on throughput is unknown throughput decreases sig throughput decreases c 7-1 is 1 point	nificantl Jue to	y due to workload
		•			Imp	ortant monitoring items	Kushima Dalichi.			<u> </u>			v	Veighted evaluation of important monitoring ite	ms			
Analysis	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3			ltern 7-1		Item 7-2		Item 7-3	lte (Ev R	m 7-4 aluation asults)
number	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/Ind irect monitoring	Reason for selection requiremen	of detection ts	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)	Individ ual	Point of represen tation
	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.		Partial damage due to corrosion caused by dust	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because occurre due to damage to the valv flow rate of coolant in the	nces of leaks e reduces the system, and	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	
An-Rei-18					0	migrating from the processing point to the valve	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into liquid system	Indirect (item 5)	because this trend is affec chemical properties (pH, concentration, chemical c dust flowing into the liquid	ted by the shloride ion omposition) of -phase system.	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	4
	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.		Adhesion of the valve due to accumulation of	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because the flow in the system decreases or resulting from adhesion of	rate of coolant lue to blockage the valve, and	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	
An-Rei-19					¢	abrasives migrating from the processing point to the valve	(b) Amount, particle size distribution, and particle density of abrasives in the coolant flowing into liquid system	Indirect (item 5)	because this trend is affec chemical properties (pH, c concentration, chemical c dust flowing into the liquid	ted by the chloride ion pomposition) of phase system.	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	4
	D/W stagnant water coarse	Static boundary	Decrease in the flow rate of	Due to deterioration of the D/W stagnant water		Partial blockage due to accumulation of dust	(a) Flow rate in the system + differential		Select because the flow ra decreases due to blockage	ate in the system e of the D/W		Because the cyclone is structured so that dust does not easily accumulate, the	3	Detection of trends and post-detection are possible through constant monitoring		Because item 7-1 is 1 point		

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

frequency of occurrence is low, and

discharges the contaminants after a

blockage is detected, the impact on

safety functions is considered to be

1

small.

because the auto-strainer automatically

Direct

(item 4)

3

4

4

of the flow rate in the system and the

D/W stagnant water coarse particle

good.

differential pressure before and after the

removal equipment, and detectability is

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (45/48) Risk assessment table No.186

Score table for item 7-2

Score table for item 7-3

Score table for item 7-1

Risk assessment table (cooling equipment)

Iodel ID Process	ко-з	: Debris retrieval	ent)]		[4 po [3 pr deve [2 pr recor [1 po Fuku	Ints] No countermeasures points] Countermeasures lopment points] Countermeasures ds of application at the F int] Countermeasures ex shima Daiichi.	s have been d exist, but th exist, but th ukushima Daii ist, and have	etermined ley are still under here are no track chi been applied at the	[4 points] Red predictability is [3 points] Red predictability is [2 points] Requi [1 point] Requir	quires poor quires good ires regu res regu	constant monitoring during task constant monitoring during task jular monitoring and predictability is g ilar monitoring and predictability is go	and but poor pod	[4 points] No countermeasures, and [3 points] Countermeasures exist, suspension of task [2 points] Countermeasures exist limitations [1 point] No impact on throughput, or	impact o but th , but t when 7	n throughput is unknown roughput decreases signifi nroughput decreases due -1 is 1 point	cantly of to wo	due to rkload
Work	Sa-4	: Processing of d	lebris							i								
			1		Imp	ortant monitoring items	1						W	Veighted evaluation of important monitoring ite	ms	i	ltem	7-4
Analysis number	Item 1	Item 2	Item 3	Item 4	Item 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3	3		Item 7-1		Item 7-2		Item 7-3	(Evalı Res	uation ults)
	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/Ind irect monitoring	Reason for selection requireme	n of detection ints	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)	Individ ual	Point of represen tation
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 DNW stagnant water coarse particle removal equipment, leaks occur, and the temperature inside the PCV deviates from the control value.	Ð	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 of damage to the DW stage coarse particle removal e because this trend is affe chemical properties (pH, concentration, and chem of coolant flowing into the	occur due to nant water squipment, and acted by the chloride ion ical composition) e 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 DW 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	
	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	(a) Flow rate in the system + amount of leakage	Direct (item 4)	Selected because leaks of damage to the D/W stage coarse particle removal e because this trend is affe chemical properties (pH,	occur due to nant water equipment, and acted by the chloride ion	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	
An-Rei-22					Same as above	processing point to the D/W stagnant water coarse particle removal equipment	(b) Chemical properties (pH, chloride ion concentration, chemical composition) of coolant flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)	concentration, and chemi of coolant flowing into the	ical composition) e liquid system	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	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 codart in the system is not ensured, resulting in the temperature inside the PCV to deviate from the control value.	۲	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 flo system decreases due to D/W stagnant water coar removal equipment, and trend is affected by the a particle size distribution of coolant flowing into the li	w rate in the blockage of the se particle because this imount and of dust in the iquid 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 DW 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	



Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (46/48) **No.187**

■ 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	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 [4 points] Decurrent transfer monitoring and predictability is poor	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] Countermeasures exist, and have been applied at the Fukushima Daiichi.	predictability is poor [1 point] Requires regular monitoring and predictability is good	due to workload limitations [1 point] No impact on throughput, or when 7-1 is 1 point

Iodel ID	-	1					a	oplied at the	Fukushima Daiichi.		[1 point] Requires regu	uar m	ionitoring and [1 point] No im	pact on	throughput, or when 7-	1 is 1 p	point
Process	Ko-3	: Debris retri	eval				Ľ				predictability is good				01.		
Work	Sa-4	: Processing	of debris														
		-			Impor	tant monitoring items		_				Weigh	ted evaluation of important monitor	ing item	6	_	
Analysis	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	lter (Eva re:	n 7-4 Juation sults)
number	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	Poin t	Presence or absence of countermeasures for disturbing functions	Poin t	Effects on accurate and prompt on-site response by workers	Poin t	Impact on throughput due to error handling (Indirect causes)	Indiv idual	Point of repres entatio n
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.	Ō	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 (b) Amount of dust in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Direct (item 4) Indirect (item 5)	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. Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	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	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment (b) Amount, particle size distribution, and particle density of dust in the transferring liquid flowing into D/W stagnant water coarse particle coarse particle	Direct (item 4) Indirect (item 5)	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. Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	4

IRID

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (47/48)

■ Risk assessment table (liquid phase/subcriticality maintenance equipment)

Model ID

Process

Work

Ko-3

Sa-4

Debris retrieval

Processing of debris

Score table for item 7-1	
TA STATES AND A ST	destance for a

points] Countermeasures exist, but they are still under development
points] Countermeasures exist, but there are no track records of applicati
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

[4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task workload limitations

[1 point] Requires regular monitoring and predictability is good

[2 points] Countermeasures exist, but throughput decreases due to [1 point] No impact on throughput, or when 7-1 is 1 point

Score table for item 7-3

No.188

					I	mportant monitoring items					Wei	ghted ev	aluation of important monitoring items				
Analysis	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		tem 7-3	lte (Eva re	n 7-4 Juation sults)
number	Target equipment	The function that the target is responsi ble 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)	Individ ual	Point of represen tation
	D/W stagnant water coarse particles removal equipment	Criticali ty prevent ion	Approachin g 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		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	(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	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 DW stagnant water coarse particle removal equipment, but detectability is poor.	1	Because item 7-1 is 1 point	4	
An-Rin-3				accumulation of particles in the PCV stagnant water buffer tank increases, approaching criticality.	1	water migrating from the processing point to the D/W stagnant water coarse particle removal equipment (in the case of an auto-strainer)	(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)	properties (pH, chloride ion concentration, chemical composition) of transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	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	4
	Same as above	Same as above	Same as above	Same as above	Same as	Decrease in the efficiency of centrifugal removal resulting from insufficient flow rate in the equipment caused by increased density of the transferring	(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	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	
An-Rin-4					above	liquid due to dust migrating from the processing point to the D/W stagnant water coarse particle removal equipment	(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)	particle size distribution of dust in the transferring liquid flowing into the D/W stagnant water coarse particle removal equipment	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	4
An-Rin-5	Same as above	Same as above	Same as above	Same as above	٩	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 (b) Amount of abrasives in the transferring liquid 	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. Constant monitoring is required because the equipment is related to criticality prevention, but	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	3	4
							flowing into D/W stagnant water coarse particle removal equipment	Indirect (item 5)		1	Same as above	4	predictability is poor.	1		4	

Appendix 6.2.4.3-2: Risk assessment table for safety equipment (Detailed version) (48/48) ■ Risk assessment table (invidual sectors)

(liquid phase/sub-criticality maintenance equipment)

Model ID						[4 points] A [3 points] developme	No countermeasures hav Countermeasures existent	e been determ t, but they a	ined re still under	Score table [4 points] Req predictability is p [3 points] Req	foritem i uires co oor uires co	-2 nstant monitoring during task and nstant monitoring during task but	[4 [3 su	Score table for item 7-3 points] No countermeasures, and impoints] Countermeasures exist, but spension of task	pact on f ut throu	throughput is unknown Ighput decreases significai	ntly du	ue to
Process Work	Ko-3 Sa-4	: Debris retrie : Processing o	val of debris			[2 points] records of [1 point] C Fukushima	application at the Fukus ountermeasures exist, a a Daiichi.	nima Daiichi nd have been	applied at the	predictability is g [2 points] Require [1 point] Require	ood es regula s regula	r monitoring and predictability is poor monitoring and predictability is good	[2 lin [1	points] Countermeasures exist, I nitations point] No impact on throughput, or wh	out thro nen 7-1	oughput decreases due tr is1point	o worl	kload
		•			Impo	rtant monitoring items							Weig	phted evaluation of important monitori	ng items	6		
Analysis	ltem 1	Item 2	Item 3	Item 4	ltem 5-1	Item 5-2	Item 6-1	Item 6-2	Item 6-3			Item 7-1		Item 7-2		Item 7-3	lte (Ev re	em 7-4 aluation esults)
number	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/I ndirect monitoring	Reason for se requirements	election of detecti	^{on} Poir	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)	Indivio ual	Point of represe ntation
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.	۲	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 (b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment 	Direct (item 4) Indirect (item 5)	Selected beca pass through t water coarse p equipment due equipment, an is affected by t particle size di abrasives in th flowing into the water coarse p equipment	use large particles the D/W stagnant particle removal to damage to the d because this trent the amount and istribution of the transferring liqui to D/W stagnant particle removal	d 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. Constant monitoring is required because the equipment is related to criticality prevention, but predictability is poor.	1	Because item 7-1 is 1 point Because item 7-1 is 1 point	4	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 cause particle removal equipment	(a) Amount and particle size distribution of dust downstream of D/W stagnant water coarse particle removal equipment (b) Amount, particle size distribution, and particle density of abrasives in the transferring liquid flowing into D/W stagnant water coarse particle removal equipment	Direct (item 4) Indirect (item 5)	Selected beca pass through t water coarse p equipment due equipment, an is affected by t particle size di abrasives in th flowing into th water coarse p equipment	use large particles the D/W stagnant particle removal to damage to the d because this tren the amount and istribution of te transferring liqui e D/W stagnant particle removal	d 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 Because item 7-1 is 1 point	4	4



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (1/59)

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

- 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.



Attachment 6.2.4.3-3: Risk assessment table for work equipment (detailed version) (2/59)

No.191

Risk assessment procedures specific to operational equipment

The execution procedure of STEP 1 and 2 shown on the previous page is shown.



IRID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (3/59)

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.

O STEP2 Action group (reprint of previous page)

ID Movement Remarks Analysis Classification Locations (check) Determine the processing method of the <Target > Disturbance candidate ID Processing (cutting/chipping/crushing/picking up) of <Target> PCV Static element Inside the PCV is in a state of darkness ii Gairan-1 (action) by < Equipment: Debris processing mechanism> Gairan-2 Static element PCV Fog is generated inside the PCV by processing iii (check) Verify the processing results of <target> and solidification PCV Gairan-3 Static element Airflow is occurring inside the PCV due to heat generated by the debris <Equipment: Radiation source storage mechanism> stores ysis shee iv Static element PCV Airflow is occurring inside the PCV due to inleakage from existing openings (Action) Gairan-4 <Target> to <Equipment: Inner container> > Gairan-5 Static element PCV Airflow is occurring inside the PCV due to nitrogen injection Verify the safety of the <Target: Debris> stored in the inner Safety of ٧ (check) chipped state Gairan-6 Static element PCV Water is dripping inside the PCV due to the injection of cooling water container each defined actio 2 Enter the functions involved in the action of interest. Candidate entries are those 1) Enter top events that related to either ID c (related to safety function) or d (related to operational function) impede defined actions on the task detail sheet and delay work O STEP3 Error analysis table Ъ Featured Disturbance of Disturbance Action group Supplementary ID Error mode that stagnates work Error generating mechanisms sheet I D features interest of interest information The properties of debris and the selected processing method are incompatible, and it takes 1 i Work Disturbance-22 Deciding how to process debris takes time time to determine the processing method. Excessive heatup of debris in the dark (poor visibility) and volatilization of radioactive 2 ii Debris processing takes time Gas phase Gairan-1 Gairan-20 materials Excessive heatup of debris due to fog (poor visibility) causing volatilization of radioactive ii 3 Same as above Gas phase Gairan-2 Gairan-20 materials Debris is excessively heated by dripping water (poor visibility), and radioactive materials ii 4 Same as above Gas phase Gairan-6 Gairan-20 volatilize Excessive heating of debris with high background (noise) and volatilization of radioactive 5 ii Gas pb Same as above Gairan-24 Gairan-20 materials ii 6 Gairan-19 Same as above hase Gairan-20 Dust scattering (poor visibility) overheats debris and volatilizes radioactive materials Debris is processed into an inappropriate shape in the dark (with poor visibility), and the riticality 7 ii Same as above Gairan-1 Gairan-21 debris approaches a critical state. Debris is processed into an inappropriate shape by fog (poor visibility), and the debris ii 8 Sam lity Gairan-2 Gairan-21 3 Extract the error generating approaches a critical state. Debris is processed into an inappropriate shape by dripping water (poor visibility), and the mechanisms related to the function of 9 ii Sam lity Gairan-6 Gairan-21 debris approaches a critical state. interest in the form of an object tree. Debris is processed into an inappropriate shape due to dust scattering (poor visibility), and ii 10 Sam Use the "Table of disturbances to lity Gairan-18 Gairan-21 the debris approaches a critical state . operational equipment" for extraction.



anal

error

e

Deploy

O STEP3 Table of disturbances to operational equipment

No.192

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (4/59)

Risk assessment procedures specific to operational equipment

The procedure for executing STEP 4 shown on page 1/59 of this Appendix is described.

O 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	Supplement ary 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	ï	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	e Gairan-23	The dust dispersed by processing approaches the allowable dust concentration inside the PCV	
	14	ï	Same as above	₩prk	Gairan-13	It takes time to allow the processing jig to access the area where application of external	
	15	ii	Same as above	Work	Gairan-16	Processing jigs wear out quickly, and frequent replacement make processing time-consuming	
ſ	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	

O SETP4 risk assessment table

	Im	nportant monit	oring items						Wei	ghted evaluation of important monitoring items				
Item 1 Item 2	Item (Extracted fro extraction	n 3 om the error in table)	Item 4	ltem 5	Item 6		Item	7-1		Item 7-2		Item 7-3	lt (E' F	tem 7-4 valuation Results)
Target equipment	t Analysis V 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	Poi nt	Impact on throughput by addressing errors (indirect causes)	Indivi dual	Point of representat on
Debris processing mechanism	g Pro q 15 re	ocessing jigs wear out quickly, and frequent eplacement 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	
① Enter the equipment and the function of interest entered in the error analysis table (task detail sheet)		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	18
2 Enter the generat mechanisms	e error ing	3 Br	eak down th	ne mechar	nisms in Item	3			(4) II	mplement risk assessment ba	ase	d on the		

into straightforward physical phenomena

information inherited from the error analysis table



error analysis table

No.193

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (5/59) No.194

Risk assessment table

	■ S [4 p [3 p dev ther Fuk hav	Score table for oints] No count oints] Counterr elopment [2 e are no tr ushima Daiichi e been applied	Item 7-1 termeasures e points] Co ack record [1 point] C at the Fuki	es have been exist, but the ountermeasu ds of appl countermeas ushima Daii	n determined ey are still under ires exist, but ication at the sures exist, and chi.	Score table [4 points] Cann with introductio [3 points] Can introduction to [2 points] Can with introductio [1 point] Can introduction to	for item 7-2 not be determined directly n not be determined dire be feasible be determined directly, n be determined direct be feasible	and the ctly and but the ly and	re are issues d can expect re are issues can expect	Score table for Itte [4 points] No counter [3 points] Countern suspension of task [2 points] Countern limitations [1 point] No impact of	em 7-3 rmeasu neasur neasur on thro	ures, and impact on t res exist, but throu es exist, but the th pughput, or when 7-1	hroug ghpu rough is 1 p	ghput is unknowr t decreases sign nput decreases o point	n hificantly due to t	due to
Model ID Process	Ko-3 De	bris retrieva	<u></u>				Daily workflow									
Work	Sa-2 : Ve	rification of rational/safe	the overa	all situatio ment insio	on and de the PCV 🥌											
		_		Important	monitoring ite	ms				Weighted evaluat	ion o	f important monit	oring	g items		
Risk	Item 1	Item 2	Item 3 from extracti	(excerpt n error ion table)	Item 4	Item 5	ltem 6		Item	7-1		Item 7-2		Item 7-3	lten (Eval res	n 7-4 uation ults)
table analysis number	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	ence or absence untermeasures isturbing ions	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 environment	al changes in	side the PCV												И		
Not	task distu	bing		*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.



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (6/59) ■ Risk assessment table

isk as	S	se	ssme		e											1	NO.
Moc	del		Score table [4 points] No c [3 points] Cour [2 points] Cour the Fukushima [1 point] Cour Ko-3 : Debri Score : Appr	for item 7-1 countermeasures Intermeasures exist a Daiichi termeasures exist s retrieval oaching the	have been determined st, but they are still und ist, but there are no tra ist, and have been applie object to	er development ack records of appli d at the Fukushima	Cation at [4 with Daiichi. [2 p intr [1 intr	Score table for ite points] Cannot b in introduction points] Cannot oduction to be fer oduction points] Can be de oduction point] Can be oduction to be fer	em 7-2 e detern be det asible etermine e deter asible	nined dir ermined ed directl mined	ectly, and there are issues directly and can expect y and there are issues with directly and can expect	[. [: [: [:	Score table for item 7-3 4 points] No countermeasures, and 3 points] Countermeasures exis uspension of task 2 points] Countermeasures exist, b 1 point] No impact on throughput, c	impact on st, but thi ut through pr when 7-1	throughput is unkn roughput decrease put decreases due t is 1 point	own :s signif o worklo	icantly d ad limitati
WORK	`	\rightarrow	be pro	cessed	Important manit	oring itomo					Woig	btod o	valuation of important manitor	ing itomo			
Risk			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	lter (Eva res	n 7-4 luation sults)
table analys numb	/sis ber		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
combinati se two cter strings	ed tion s)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 Daitchi-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-	u-	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-	^{u-} 3	i	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 numbering rules for analysis ID] Safety function related: Saku-A-Arabic numerals Operational function related: Saku-B-Arabic numerals

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (7/59) ■ Risk assessment table

No.196

				Score table for	r item 7-1			■ Sc	core table for ite	am 7-2		core table for item 7-3				
				[4 points] No cou [3 points] Counte development [2 points] Counte records of applica	ntermeasures l ermeasures ex ermeasures ex ation at the Fuk	have been ist, but the ist, but the cushima Da	determined ey are still under ere are no track aiichi	[4 pc with i [3 p introd [2 po iptrod	pints] Cannot be introduction oints] Cannot duction to be fe ints] Can be de duction	be determined directly, and there are issues be determined directly and can expect asible termined directly and there are issues with	■ 3 [4 p [3 p due [2 worl	oints] No countermeasures, and ir ioints] Countermeasures exist, b to suspension of task points] Countermeasures exist, kload limitations	mpact but thi but	on throughput oughput decre throughput de	is unki ases ecreas	nown significantl <u>y</u> es due to
			1	[1 point] Counter	measures exist aiichi.	, and have	e been applied at	[1 p	oint] Can be	e determined directly and can expect	[1 p	oint] No impact on throughput, or	when	7-1 is 1 point		
Proce	ess	Ko-3 :	Debris retrie	eval				Introd								
Work		Sa-2	Approaching	g the object to												
		Important m	nonitoring item	IS			_	Weig	hted evaluati	on of important monitoring items	-					
Ri asses	isk sment	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		ltem 7-2		Item 7-3	lte (Eva re	m 7-4 aluation sults)
ta ana nun	ble Ilysis nber	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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (8/59) ■ Risk assessment table

No.197

Score	re table for item 7-1	■ Score table for Item 7-2	Score table for item 7-3
[4 poir	ints] No countermeasures have been determined	[4 noints] Cannot be determined directly and there are issues with	4 points] No countermeasures, and impact on throughput is unknown
[3 poi	pints] Countermeasures exist, but they are still	introduction	[3 points] Countermeasures exist, but throughput decreases significantly
under	r development	[3 points] Cannot be determined directly, but can expect introduction to be	due to suspension of task
[2 poi	oints] Countermeasures exist, but there are no	feasible	[Point 2] Countermeasures exist, but the throughput decreases due to
track r	records of application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues with introduction	task load limitations
[1 pc	oint] Countermeasures exist, and have been	[1 point] Can be determined directly, and can expect introduction to be	[1 point] No impact on throughput, or when 7-1 is 1 point
ID applie	ed at the Fukushima Daiichi.	feasible	

Model ID

Proce	rocess Ko-3 : Debris retrieval																
Work Sa-2 : Approaching the object to be processed Important monitoring items																	
			_		mportant monito	ring items	_				Weight	ted ev	aluation of important monitoring	items		_	
Risk		lten	n 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6		lterr	1 7-1		Item 7-2		Item 7-3	lter (Eva res	n 7-4 luation sults)
asses table analy numb	sment sis er	Tarı equip	rget T oment ^{tr}	The function that the arget 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 mechar inside tł PCV	Nism ir	Noving function hside 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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (9/59) ■ Risk assessment table

No.198

	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	[4 points] Cannot be determined directly, and there are issues with	[4 points] No countermeasures, and impact on throughput is unknown
	[3 points] Countermeasures exist, but they are still under development	introduction [3 points] Cannot be determined directly and can expect introduction to be feasible	[3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task
	[2 points] Countermeasures exist, but there are no track records of application at the Eukushima Dajichi	[2 points] Can be determined directly, but there are issues with introduction	[2 points] Countermeasures exist, but throughput decreases due to workload limitations
	[1 point] Countermeasures exist, and have been applied at the	[1 point] Can be determined directly, and can expect introduction to be feasible	[1 point] No impact on throughput, or when 7-1 is 1 point
del ID	Eukushima Dajichi		

Mod

Process	Ko-3	: Debri	Debris retrieval											
Work	Sa-2	: Appr	Approaching the object to be processed											
			-	Important monitorin	g									
	lter	n 1	1 Item 2 Item 3 (excerpt from											

		-		Important monitorin	g items					Weighted evalu	ation o	of important monitoring ite	ms		_	
Risk	ment	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	ltem 7- (Evalua Results	4 ition 5)
table analysi numbe	s r	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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (10/59) Risk assessment table

NT		-	•	0
N	0	.	y	y
÷ 1	-	-	-	-

	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	[4 points] Cannot be determined directly, and there are issues with	
	[3 points] Countermeasures exist, but they are still under	introduction	14 points no countermeasures, and impact on throughput is unknown
	development	[3 points] Cannot be determined directly and can expect introduction to be	[3 points] Countermeasures exist, but throughput decreases significantly due to
	[2 points] Countermeasures exist, but there are no track records of	feasible	suspension of task
	application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues with introduction	[2 points] Countermeasures exist, but throughput decreases due to workload limitations
Model ID	[1 point] Countermeasures exist, and have been applied at the	[1 point] can be determined directly and can expect introduction to be feasible	[1 point] No impact on throughput, or when 7-1 is 1 point
	Fukushima Dalichi.		

Process Ko-3 : Debris retrieval Work Sa-2 : Approaching the object to be																
Woi	'k	Sa-2 : Appi proce	roaching the c ssed	bject to be												
Risk		J		Important me	nitoring items					Weighted evalu	uation	of important monitoring i	tems			
asse table anal	essment e ysis	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	lter (Eva Re	m 7-4 Iluation sults)
nun		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
Sak -B	u 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
Sakı B-	^{J-} 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
Sakı B-	^{J-} 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (11/59) Risk assessment table

No.200

Score table for item 7-1 [4 points] No countermeasures have been determined

application at the Fukushima Daiichi

development

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] Countermeasures exist, but there are no track records of [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

[1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi.

[3 points] Countermeasures exist, but they are still under

[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

Score table for item 7-3

Proces	s Ko-3 : Debr	is retrieval													
Work	Sa-3 : Work	Prior to processi	ng												
Risk assessm table ana number	^{ent} ^{ysis} Item 1	Item 2	Important mo Item 3 (Extracted from the error extraction	nitoring items	Item 5	ltem 6			Weighted eva	aluation	of important monitoring Item 7-2	items	ltem 7-3	ltı (Ev	em 7-4 aluation Results)
	Target equipment	Functions that target is responsible for	table) 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-	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-	Debris 2 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (12/59) Risk assessment table No.201

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	[4 points] Cannot be determined directly and there are issues	[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still	with introduction	[3 points] Countermeasures exist, but throughput decreases significantly
under development	[3 points] Cannot be determined directly and can expect	due to suspension of task
[2 points] Countermeasures exist, but there are no	[2 points] Can be determined directly but there are issues with	[2 points] Countermeasures exist, but throughput decreases due to
track records of application at the Fukushima Daiichi	introduction	workload limitations
[1 point] Countermeasures exist, and have been	[1 point] Can be determined directly and can expect	[1 point] No impact on throughput, or when 7-1 is 1 point
applied at the Fukushima Daiichi.	introduction to be feasible	

Model ID

Proce	ss	Ko-3	: Debris	retrieval													
Work		Sa-3	: Work F	Prior to processi	ng												
					Important monitor	ing items		-			Weighted evalu	ation of	important monitoring items				
Risk		Iten	n 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	lte (Eva R€	m 7-4 aluation esults)
assess nt f analys numbe	ame able is r	Tar equip	get ment	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 process mechar	ing iism	[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 process mechar	ing iism	[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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (13/59)

Risk assessment table

No.202

 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	 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
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Proce	SS	Ko-3	: Deb	ris retrieval													
Work		Sa-3	: Wor	k Prior to proce	essing												
Risk asses table analys numbe	sment is er	Item Targ equipn	1 et nent	Item 2 The function that the target is responsible for	Important mo Item 3 (excerpt fron error extraction table) Work delay factor	Direct causes	Item 5 Indirect causes of error	Item 6 Detection requirements to avoid work delays	Point	Applicable function	Weighted eva Item 7-1 Presence or absence of countermeasures for disturbing functions	Point	Effects on accurate and prompt on-site response by workers	Point	Item 7-3 Impact on throughput due to error handling (Indirect	lte (Eva Re	m 7-4 aluation sults) Point of representatio
Saku -A-	5	Debris processi mechani	ng sm	[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

IRID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (14/59) Risk assessment table

						Score table for [4 points] No cour	item 7-1 termeasure	es have been	Score [4 points]	e tabl s] Cai	e for iten nnot be d	n 7-2 determined directly and there are issu	Jes	Score table for item [4 points] No counterme	7-3 easure	es, and impact on throu	ughput is	s
determined with introduction unknown [3 points] Countermeasures exist, but they are still under development [3 points] Countermeasures exist, but there are issues with [3 points] Countermeasures exist, but there are issues with [3 points] Cannot be determined directly and can expect introduction [3 points] Countermeasures exist, but there are issues with [2 points] Countermeasures exist, but there are issues with [2 points] Can be determined directly, but there are issues with [2 points] Countermeasures exist, but there are issues with [2 points] Can be determined directly and can expect [2 points] Countermeasures Model ID Fukushima Daiichi Fukushima Daiichi Fukushima Daiichi [1 point] Can be determined directly and can expect [1 point] No in									unknown [3 points] Countermeas significantly due to susg [2 points] Countermeas due to workload limitatio [1 point] No impact on t	termeasures exist, but throughput decreases e to suspension of task termeasures exist, but throughput decreases d limitations bact on throughput, or when 7-1 is 1 point								
Proce	ess	Ko-3	: Debris	retrieval		[1 point] Countern been applied at th	neasures ex e Fukushim	kist, and have have ha Daiichi.	Introduct	tion t	o be feas	SIDIE						
Work		Sa-3	: Work P process	Prior to														
					Importa	nt monitoring items						Weighted e	valua	ation of important monitori	ng iter	ms		
Risk	sment	Item	1 Item	n 2	(excerpt from error ltem 4 ltem 5 ltem 6 extraction table)							Item 7-1		Item 7-2		Item 7-3	ltem (Eval Res	1 7-4 uation sults)
table a numb	analysis er	Targ equipn	et ta nent	e function hat the arget is sponsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirements to a work delays	avoid	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 process mechar	[Crit Neu abs app func ism	ticality] utron orbent olication ction	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 absorben application status unaffected by darkness	nt s	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 spraving.	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 process mechar	[Crit Neu abs app func ism	ticality] utron orbent vlication ction	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 absorben application status unaffected by fog	nt s	3	Safety	Same as above	3	Same as above	2	Same as above	18	18

IRID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (15/59)

Risk assessment table

Model ID

Process

Ko-3

: Debris retrieval

₽				
		1		Λ
	U	•4	ίU	4

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

re table for item 7-2 s] Cannot be determined directly and there are issues roduction s] Cannot be determined directly and can expect ction to be feasible s] Can be determined directly, but there are issues with ction Can be determined directly and can expect ction 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

Work		Sa-3 :	Work Prior to	processing													
				Important	monitoring items	_				Weighted ev	aluatio	on of important monitoring it	tems				
Pick		Item 1	Item 2	Item 3 (excerpt from error extraction table	l Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lte (Eva Re	m 7-4 aluation esults)	
assess table analysi numbe	ment s	Target equipmen	The function that the t 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 wate verification of the results of neutron absorbent application takes time	r, 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 tim	 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	

IRID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (16/59) Risk assessment table

Mode	ID		Score table [4 points] No co [3 points] Cour [2 points] Cour application at [1 point] Courn Fukushima Da	for item 7-1 countermeasures have the ntermeasures exist, but ntermeasures exist, but the Fukushima Daiichi termeasures exist, and ilichi.	been determined they are still und there are no trad have been applid	der developmen ck records of ed at the	nt Scorr [4 points introduc [3 points introduc [2 points introduc [1 point]	e table fo b] Cannot tion b] Cannot tion to be b] Can be tion Can be	r item 7- be dete be dete feasible determin	2 rmined directly and there are issues v rmined directly and can expect a ned directly, but there are issues with ed directly and can expect introduction	with	 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 								
Proces	S	Ko-3 : Det	oris retrieval				be feasi	ble												
Work		Sa-4 : Pro	: Processing of debris																	
				Important moni	itoring items					Weig	ghted ev	valuation of important monitoring iter	ns							
Risk		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	ltem (Evalu Res	7-4 lation ults)				
assess table an number	ment nalysis	Target equipment	get that the target is responsible for The properties of Fuel debris The properties of The properties		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				

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (17/59) No.206

■ Risk assessment table

Model ID Process

as	303	Sincin tab			
			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 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
K	(o-3	: Debris retrieval			
		: Processing of			

Work		Sa-4	Processing of lebris													
				Important n	nonitoring items					Weigh	ted	evaluation of important monitoring	g iten	ns		
Risk asses table	sment	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	ltem 6			ltem 7-1		Item 7-2		Item 7-3	ltem (Evalu Res	7-4 Jation ults)
numb	er	Targe equipme	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-A-	2	Debris processi mechani m	[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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (18/59) Risk assessment table

Model ID Process	-	Ko-3 : Deb	ris retrieval	Sc [4 po [3 po unde [2 po track [1 po appli	 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. 					for item 7-2 ot be determined directly a n ot be determined directly a be feasible be determined directly, but e determined directly and a be feasible	and the and ca there a can exp	ere are issues n expect are issues with pect Pect Pect Pect Score table [4 points] No dist is unknown [3 points] Cou decreases sig [2 points] Cou decreases dur [1 point] No in	 Score table for item 7-3 [4 points] No countermeasures, and impact on throug 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 p 			
WORK		debri	s					1					,			
Risk		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1	ignted	tevaluation of important monitor		ems	lte (Eva Re	m 7-4 aluation sults)
assessme table analysis number		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 ,	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 	3	Same as above	18	18

IRID

high-dose radiation environment.

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (19/59) ■ Risk assessment table **No.208**

■ Score table for item 7-2 ■ Score table for item 7-1 ■ Score table for item 7-3 [4 points] Cannot be determined directly and there are issues [4 points] No countermeasures have been determined [4 points] No countermeasures, and impact on throughput is unknown with introduction [3 points] Countermeasures exist, but they are still under [3 points] Cannot be determined directly and can expect suspension of task development introduction to be feasible [2 points] Countermeasures exist, but there are no track [2 points] Can be determined directly, but there are issues with limitations records of application at the Fukushima Daiichi introduction [1 point] Countermeasures exist, and have been applied at [1 point] Can be determined directly and can expect the Fukushima Daiichi. introduction to be feasible

[3 points] Countermeasures exist, but throughput decreases significantly due to [2 points] Countermeasures exist, but throughput decreases due to workload

[1 point] No impact on throughput, or when 7-1 is 1 point

Model ID

Proce	SS	Ko-3 : Deb	oris retrieval	-												
Work		Sa-4 debri	is													
				Important mor	nitoring items		1			V	Veigh I	ted evaluation of important monito	ring ite	ems	lter	m 7-4
Risk		Item 1	Item 2	from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	(Eva Re	luation sults)
asses table analys numbe	sment iis er	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (20/59) Risk assessment table No.209

Score table for item 7-1	Score table for item 7-2	1	Score table for item 7-3
[4 points] No countermeasures have been determined	[4 points] Cannot be determined directly and there are issues		[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still	with introduction		[3 points] Countermeasures exist, but throughput decreases significantly
under development	[3 points] Cannot be determined directly and can expect		due to suspension of task
[2 points] Countermeasures exist, but there are no	introduction to be feasible		[2 points] Countermeasures exist, but throughput decreases due to
track records of application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues with		workload limitations
[1 point] Countermeasures exist, and have been	[1 point] Can be determined directly and can expect		[1 point] No impact on throughput, or when 7-1 is 1 point
applied at the Fukushima Daiichi.	introduction to be feasible		

Model ID

D 1

Proce	SS	K0-3	: Debi	ris retrievai													
Work		Sa-4	: P	rocessing of													
			debris	5	Important m	onitoring items					Weight	ed ev	aluation of important monitor	ina ite	ems		
Risk asses	sment	lte	m 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	lt (E' F	em 7-4 /aluation tesults)
analys	sis er	Targe [.] equipr	nent	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 proces mecha	nism	[Gas phase] Equipment to prevent excessive heatup of debris	Excessive heatup of debris due to dust dispersion (poor visibility) causes volatilization of	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.	1 8	18
					radioactive materials			[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	1 8	18

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (21/59) No.210

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
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Model ID

Pro	cess	Ko	-3 : C	ebris retrieval	1												
w	ork	Sa	-4 : P de	rocessing of bris													
					Important n	nonitoring items					Weig	hted e	evaluation of important monitoring	j iten	ns		
Risk	sment		em 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	lte (Eva Re	m 7-4 aluation esults)
table numbe	analysis r	eq	arget iipment	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	Deb proc mec	is essing nanism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriat e shape due to darkness (poor visibility),	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
					and the debris approaches the state of criticality			[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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (22/59) Risk assessment table

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	[4 points] Cannot be determined directly and there are	[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still	issues with introduction	[3 points] Countermeasures exist, but throughput decreases significantly
under development	[3 points] Cannot be determined directly and can expect	due to suspension of task
[2 points] Countermeasures exist, but there are no	introduction to be feasible	[2 points] Countermeasures exist, but throughput decreases due to
track records of application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues	workload limitations
[1 point] Countermeasures exist, and have been	with introduction	[1 point] No impact on throughput, or when 7-1 is 1 point
applied at the Fukushima Daiichi.	[1 point] Can be determined directly and can expect	
	introduction to be feasible	

Model ID

Proce	SS	Ko-3 : D	ebris retrieval													
Work		Sa-4 : F	rocessing of de	bris												
				Important m	onitoring items						We	eighted evaluation of important monitoring item	s			
Risk		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		ltem 7-2		Item 7-3	ltem (Evalı Res	7-4 Jation ults)
asses table a numbe	sment analysis er	Target equipme	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requirement s 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 mechanisi	[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 countermeasur e 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 probleme. 	2	Same as above	24	24

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (23/59) No.212

R	iek s		eem	ont tak	סור												1	10.4.
Mode		13361	53111		16	Score t [4 points] [[3 points] (under dev	able for item 7-1 No countermeas Countermeasure elopment	sures have beer es exist, but the	deter / are s	mined still	Score table for item 7- [4 points] Cannot be dete there are issues with intro [3 points] Cannot be dete expect introduction to be	2 rmineo oductic rmineo feasib	d directly and on d directly and can le	Score table for iter [4 points] No countern unknown [3 points] Countermea	m 7-: mea: asur	3 sures, and impact or es exist, but through	n throu put de	ghput is creases
Mode	ID					[2 points]	Countermeasure	es exist, but the	e are	no nichi	[2 points] Can be determi	ned di	rectly, but there	I significantly due to su	asper	nsion of task	nut de	croscos
Proce Work	SS	Ko-3 Sa-4	: Debr : Proc	is retrieval essing of de	bris	[1 point] C applied at	ountermeasures	exist, and have Daiichi.	e beer)	[1 point] Can be determin expect introduction to be	on ed dir feasib	ectly and can le	due to workload limita [1 point] No impact or	ation n thr	oughput, or when 7-	1 is 1 j	point
			1		Important mo	nitoring items					V	Veigh	ted evaluation of	important monitoring ite	ms			
					Item 3 (excerpt	J											140	
		lterr	n 1	Item 2	from error	Item 4	Item 5	ltem 6			Item 7-1		Iter	n 7-2		Item 7-3	(Eva Re	aluation esults)
Dick					extraction table											1		—
asses table a numbe	sment analysis er	Tarç equipr	get ment	The function that the target is responsible for	Work delay facto	Direct r 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 accu site response b	rate and prompt on- y workers	Point	Impact on throughput due to error handling (Indirect causes)	Individual	Point of representation
Saku -A-	8	Debris process mechan	ing ism	[Criticality] Debris processing shape control function	Debris is processed into a 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 direct determina setting the neut The neutron of development in subsidized proj 	neutron detector, a ation can be made by ron flux threshold. letector is under the Fukushima Daiichi ect.	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 c difficult to direct dimension of de processing is re Droplets adhelens need to be other means (b project of invess RPV) or be treat fogging. General came resistance in a environment, and dovelopment of 	amera images, it is thy determine the abris, and image equired. ring to the camera blown off by gas or eing developed in the tigation inside the ted to prevent tras have low radiation high-dose radiation and there are	2	Same as above	24	24



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (24/59) **No.213**

■ Risk assessment table

Mode Proce Work	el ID ess	Ko-3 Sa-4	: Deb : F debri	ris retrieval Processing S	(1) (1) (1) (1) (1) (1) (1) (1) (1) (1)	Score table for it 4 points] No count etermined 3 points] Counterm ander development 2 points] Counterm ack records of app 1 point] Counterm pplied at the Fuku	tem 7-1 ermeasures have be neasures exist, but th t neasures exist, but th plication at the Fukus easures exist, and ha ishima Dailichi.	en ney are still nere are no shima Daiichi ave been	Scc [4 poir introdu [3 poir introdu [2 poir introdu [1 poir be fea	ore tal ats] Ca action ats] Ca action ats] Ca sible	ble for item 7-2 annot be determined directly an annot be determined directly an to be feasible an be determined directly, but t n be determined directly and c	nd th nd ca there an ex	Expect are issues with an expect e are issues with expect introduction to initial expect initial expect introduction to initial expect initial expect init	em 7- rmea easur suspe easur on thr	-3 asures, and impact on f res exist, but throughpu ension of task res exist, but throughpu roughput, or when 7-1	throug ut dec ut dec is 1 po	hput is reases reases due to pint
		Iten	n 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6		•	Item 7-1	vve	Ignited evaluation of important monitoring	Item	s Item 7-3	lter (Eva Re	m 7-4 Iluation sults)
Risk asses table a numbe	sment analysis er	Target equipme	ent	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 process mechan	ing ism	[Criticality] Debris processing shape control function	Debris is processed into an inappropriate shape due to dust dispersion (poor visibility), and the debris	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
					approaches the state of criticality			[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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (25/59) Risk assessment table

Score table for item 7-1	Score table for item 7-2	Score table
4 points] No countermeasures have been determined	[4 points] Cannot be determined directly and there are issues	[4 points] No c
3 points] Countermeasures exist, but they are still under	with introduction	[3 points] Cou
development	[3 points] Cannot be determined directly and can expect	due to suspen
2 points] Countermeasures exist, but there are no track	introduction to be feasible	[2 points] Cou
ecords of application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues with	[2 points] Cou
1 point] Countermeasures exist, and have been applied at the	introduction	
Fukushima Daiichi.	[1 point] Can be determined directly and can expect	[1 point] No im
	introduction to be feasible	

for item 7-3

countermeasures, and impact on throughput is unknown intermeasures exist, but throughput decreases significantly

sion of task intermeasures exist, but throughput decreases due to

ations

npact on throughput, or when 7-1 is 1 point

Process	Ko-3	: Debris retriev	al												
Nork	Sa-4	: Processing o	f debris												
			Important i	monitoring iten	าร				We	eigh	ted evaluation of important monitoring items				
Risk	ltem	Item 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	ltem 6			Item 7-1		Item 7-2		Item 7-3	lte (Ev re	em 7-4 aluation esults)
assessmen able analysis number	Targe equipm	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 processir mechanis	[Criticality] g Debris m processing shape control function	Debris is processed into an inappropriate shape due to high	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
			background (noise), and the debris approaches the state of criticality			[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

Model ID

IRID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (26/59)

Ris	ska ⊳	assess	sment	able	■ 5 [4 p [3 p dev [2 p rec	Score table for ite points] No counte points] Counterm relopment points] Counterm ords of applicatio	em 7-1 rrmeasures have been easures exist, but they easures exist, but ther on at the Fukushima Di	detern r are sti e are n aiichi	nined II under o track	Score table for item 7-2 [4 points] Cannot be determined directly and the with introduction [3 points] Cannot be determined directly and can introduction to be feasible [2 points] Can be determined directly, but there is with interduction	ere ar n exp are is	re issues bect ssues F 2 points] No countermeasures, al [3 points] Countermeasures exist, significantly due to suspension of [2 points] Countermeasures exist, workload limitations	nd impa but thro task but thro	ct on throughput is unknown oughput decreases oughput decreases due to		NŌ.
Process	s	Ko-3 : De	bris retrieval		[1 p	ooint] Counterme	asures exist, and have	been	applied	[1 point] Can be determined directly and can ex	pect	[1 point] No impact on throughput	, or whe	n 7-1 is 1 point		
Work		Sa-4 : Pro	ocessing of c	Important			anorn.			I introduction to be feasible	01/2	aluation of important monitoring items				
Risk	nent	Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	ltem (Evalı Res	7-4 uation ults)
table an number	alysis	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	2	Same as above	24	24
Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (27/59) Risk assessment table

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	[4 points] Cannot be determined directly and there are issues	[4 points] No countermeasures, and impact on throughput is unknown
[3 points] Countermeasures exist, but they are still	with introduction	[3 points] Countermeasures exist, but throughput decreases significantly due to
under development	[3 points] Cannot be determined directly and can expect	suspension of task
[2 points] Countermeasures exist but there are no	introduction to be feasible	[2 points] Countermeasures exist, but throughput decreases due to workload
track records of application at the Fukushima Daiichi	[2 points] Can be determined directly, but there are issues with	I point No impact on throughput, or when 7-1 is 1 point
[1 point] Countermeasures exist, and have been	[1 point] Can be determined directly and can expect	
applied at the Fukushima Daiichi.	introduction to be feasible	

Proce	SS	Ko-3 : De	ebris retrieva	d i												
Work		Sa-4 :	Processing	of												
		deb	oris													
				Important me	onitoring item	is				We	ighte	d evaluation of important monitoring	j item	15	—	
Risk		ltem 1	ltem 2	(excerpt from error extraction table)	ltem 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lte (Ev R	em 7-4 /aluation .esults)
assess table numbe	ment analysis r	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-		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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (28/59) No.217

■ Risk assessment table,

 Score table for item 7-1 [4 points] No countermeasures have been determin [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 Daiic [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 points] Can be determined directly and can expect introduction 	 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

Proce	SS	Ko-3	: Deb	ris retrieval													
Work		Sa-4	: P debris	rocessing of s													
					Important moni	toring items					W	eigh	ted evaluation of important monitoring items			_	
Risk		lter	n 1	ltem 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lte (Ev R	em 7-4 aluation esults)
assess table numbe	sment analysis r	Target equipn	nent	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 proces mecha	sing	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (29/59)

■ 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 	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	 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
applied at the Fukushima Daiichi.	introduction to be feasible	

Proces	SS	Ko-3	: Debris	s retrieval													
Work		Sa-4	: Pro debris	cessing of					-								
					Important monitor	ing items	_				Wei	ighted	evaluation of important monitoring items				
		lte	em 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			ltem 7-1		Item 7-2		Item 7-3	lte (Ev R	em 7-4 aluation esults)
Risk assess table a numbe	sment nalysis r	Ta equi	arget pment	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (30/59)

Mode		ASSES	sment ta	able	Score table f [4 points] No co determined [3 points] Count under developm [2 points] Count track records of	or item 7-1 untermeasures termeasures e nent termeasures e application at	es have been exist, but they are still exist, but there are no t the Fukushima Daiich	[4 w [3 in [2 in [1	Score t points] (ith introd points] (troductio points] (troductio point] C	able for item 7-2 Cannot be determined directly and th uction Cannot be determined directly and ca n to be feasible Can be determined directly, but there in an be determined directly and can e	nere are an expe e are iss xpect	Score table for item 7-3 [4 points] No countermeasures, and impact on throu [3 points] Countermeasures exist, but throughput de significantly due to suspension of task [2 points] Countermeasures exist, but throughput de workload limitations [1 point] No impact on throughput, or when 7-1 is 1	ughpu ecreas ecreas point	t is unknown ses ses due to	NO.2	219
Work	í.	Sa-4 : Pro	cessing of deb	oris	[1 point] Counte applied at the F	ermeasures ex ukushima Dai	ist, and have been ichi.	in	troductio	n to be feasible						
				Important I	monitoring items		•				. N	Veighted evaluation of important monitoring items				
Risk	ssmen	Item 1	ltem 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	ltem (Evalu Resi	7-4 lation ults)
t table analy numb	e sis ver	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	Fukushima Daiichi-2 PCV. Same as above		 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	Mechanica I/thermal external forces are not transmitted to debris	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.		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
				due to obstruction by water flow			[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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (31/59) Risk assessment table

Model Proce Work	ID ss	Ko-3 : De Sa-4 : I deb	ebris retrieval Processing of ris	Score ta [4 points] N [3 points] C under deve [2 points] C track record [1 point] C applied at ti Important mo	ble for item 7-1 o countermeasure lopment ountermeasure ds of application ountermeasures he Fukushima nitoring items	sures have b es exist, but t es exist, but t n at the Fuku s exist, and h Dailichi.	een determined hey are still here are no Ishima Daiichi iave been	Score points] th introd points] troductio points] troductio point] C	table for Canno duction Canno on to b Can be on Can be on to b	or item 7-2 t be determined directly and th t be determined directly and ca e feasible e determined directly, but there determined directly and can ex e feasible	an expe an expe are iss xpect eighted	Socre table for item 7-3 [4 points] No countermeasures unknown [3 points] Countermeasures significantly due to suspensi [2 points] Countermeasures to workload limitations [1 point] No impact on throug	es, ar exist, on of exist, ghput, ems	nd impact on throughput but throughput decreas task but throughput decreas , or when 7-1 is 1 point	is es es due	
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lten (Eva Re:	n 7-4 luation sults)
Risk assess table numbe	sment analysis er	Target equipment	The function that the t 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (32/59) No.221

Risk assessment table

Mode	ID			Score table for item [4 points] No counterme [3 points] Countermeas under development [2 points] Countermeas records of application a [1 point] Countermeas]	7-1 easures have b sures exist, but sures exist, but at the Fukushin ures exist and	been determin they are still there are no t na Daiichi have been ap	ed [4 points] issues wi [3 points] rack [2 points] blied with intro	table Cann th intr Cann on to Can I ductio	for item not be d oductio not be d be feas be dete on	7-2 etermined directly and there are n etermined directly and can exper- ible rmined directly, but there are issu	ct ues	Score table for item 7-3 [4 points] No countermeasures, and impact of [3 points] Countermeasures exist, but throug to suspension of task [2 points] Countermeasures exist, but throug limitations [1 point] No impact on throughput, or when 7	on th Jhpu Jhpu Jhpu 7-1 i:	nroughput is unknown t decreases significantly t decreases due to work s 1 point	due load	
Proc	ss	Ko-3 :	Debris retrieval	at the Fukushima Dalic	hi.	nare seen ap	[1 point]	Can b	e deteri	mined directly and can expect				·		•
work		Sa-4 :	Processing of lebris				Introducti		De leas			1				
				Important monitoring i	tems					W	eight	ed evaluation of important monitoring items	<u>s</u>			
Risk		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	lter (Eva n Re	n 7-4 aluatio esults)
asses table analy numb	sment sis er	Target equipme	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 mechanisi	Fuel debris g processing m 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	I/5] ions of ied ted by g water 4		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 mechanisi	Fuel debris g processing m 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (33/59) ■ Risk assessment table

No.222

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 [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 significantl 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
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Proce	SS	Ko-3	: Debris retrieval													
Work		Sa-4	: Processing of	F												
			debris							14/-:						
			I	Itom 3	foring items	s T				vveig	ntea e I	evaluation of Important monitor	ing ite	ims		
Risk	sment	Item 1	Item 2	(excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lter (Eva Re	n 7-4 luation sults)
table analys numb	sis er	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 mechanisn	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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (34/59)

No.223 Risk assessment table Score table for item 7-1 Score table for item 7-2 [4 points] No countermeasures have been determined [4 points] Cannot be determined directly and there are issues with [3 points] Countermeasures exist, but they are still under introduction Score table for item 7-3 [3 points] Cannot be determined directly and can expect introduction to development Model ID [4 points] No countermeasures, and impact on throughput is unknown be feasible [2 points] Countermeasures exist, but there are no track records [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of [2 points] Can be determined directly, but there are issues with of application at the Fukushima Daiichi task Process Ko-3 Debris retrieval introduction [2 points] Countermeasures exist, but throughput decreases due to workload limitations [1 point] Countermeasures exist, and have been applied at the Work Sa-4 Processing of debris [1 point] Can be determined directly and can expect introduction to be [1 point] No impact on throughput, or when 7-1 is 1 point Fukushima Daiichi. feasible Important monitoring items Weighted evaluation of important monitoring items Item 3 (excerpt Item 7-4 Item 7-1 Item 1 Item 2 from error Item 4 Item 5 Item 6 Item 7-2 Item 7-3 (Evaluatior Risk extraction Results) assessment table) table Point of representation The function Impact on throughput analysis Applicable function Individual Detection number Indirect that the Direct Point Point Point Effects on accurate and prompt due to error handling Work delay requirements Presence or absence of countermeasures Target target is causes of causes of equipment factor to avoid work for disturbing functions on-site response by workers (Indirect causes) responsible error error delays for Fuel debris Due to Darkness [Item 4] Radiation Low fuel In the case of debris pick-up operation for It is possible to make a direct Among the measures collection collection source darkness (a) Amount of collecting debris into the inner container, determination by the amount of for Item 7-1, there is function rate debris fillina collection (poor semi-automated repetitive operations that debris throughput per day, and a possibility that visibility), mechanism the inner do not rely on environmental introduction is feasible operator intervention collection container measurements on site are present in may reduce the task of debris ir general industrial technology and are speed. Work Saku the inner 11 2 8 24 4 expected to reduce disturbing work from Bcontainer the environment (poor visibility) inside the takes time PCV. Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems. [Item 5] The operator's trajectory (b) Relative correction measures (e.g., position of minute misalignment between debris and debris and inner container) for inner semi-automated operations container shown in Item 7-1 cannot be unaffected by determined directly when using Work darkness 3 Same as above 4 2 Same as above 24 24 camera images, as it requires discernment based on proficiency. When detecting with camera + lighting, impact assessment of radiation resistance in a highdose radiation environment is required.



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Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (35/59) No.224

Model Proces	Ris	Ko-3 : Deb	sment		Score [4 points] [3 points] under de [2 points] track rec [1 point] applied a	table for ite No counte Counterme velopment Counterme ords of appl Counterme t the Fukus	m 7-1 rmeasures have bee easures exist, but the easures exist, but the ication at the Fukus asures exist, and ha hima Daiichi.	en de ey ar ere a hima ve be	termine e still re no Daiich een	ed Score table for item 7-2 [4 points] Cannot be determined directly and th with introduction [3 points] Cannot be determined directly and ca introduction to be feasible [2 points] Can be determined directly, but there introduction [1 point] Can be determined directly and can ex- to be feasible	ere a an exp are is cpect	Score table for item 7-3 [4 points] No countermeasures, and impact on thi [3 points] Countermeasures exist, but throughput suspension of task [2 points] Countermeasures exist, but throughput limitations [1 point] No impact on throughput, or when 7-1 is	roughp decrea decrea 1 poin	ut is unknown ases significantly due I ases due to workload t	.0	
Work		Sa-4 : Proc	essing of del	bris	4 - 1 ¹ - 1 - 14 - 14 - 1					\A/-:						
Risk	mont	ltem 1	Imp Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			ttem 7-1		evaluation of important monitoring items		Item 7-3	lt (E\ R	em 7-4 /aluation lesults)
assess table analysi numbe	S	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (36/59)

Risk assessment table Score table for item 7-2 Score table for item 7-1 Score table for item 7-3 [4 points] Cannot be determined directly and there are issues [4 points] No countermeasures have been determined [4 points] No countermeasures, and impact on throughput is unknown with introduction [3 points] Countermeasures exist, but throughput decreases significantly due to [3 points] Countermeasures exist, but they are still under [3 points] Cannot be determined directly and can expect suspension of task development Model ID introduction to be feasible [2 points] Countermeasures exist, but throughput decreases due to workload [2 points] Countermeasures exist, but there are no track [2 points] Can be determined directly, but there are issues limitations records of application at the Fukushima Daiichi with introduction Process Ko-3 Debris retrieval [1 point] No impact on throughput, or when 7-1 is 1 point [1 point] Countermeasures exist, and have been applied [1 point] Can be determined directly and can expect at the Fukushima Daiichi. introduction to be feasible Work Sa-4 Processing of debris Important monitoring items Weighted evaluation of important monitoring items Item 3 Item 7-4 (excerpt from Item 7-1 Item 7-2 Item 7-3 (Evaluatio Item 1 Item 2 error Item 4 Item 5 Item 6 extraction n Results) Risk table) assessment Applicable function Impact on table analysis The Point of representation Detection throughput by number function Individual Direct Indirect Presence or absence of Point Point requirements that the Work delay Effects on accurate and prompt on-site response Target addressing errors auses of causes of countermeasures for disturbing eauipment target is factor to avoid work bv workers error error functions (indirect causes) responsible delavs for Radiation Fuel debris Due to Low fuel Dripping [Item 4] In the case of debris pick-up operation It is possible to make a direct determination by Among the collection dripping collection water (a) Amount of for collecting debris into the inner the amount of debris throughput per day, and source measures for Item water (poor debris filling introduction is feasible collection function rate container, semi-automated repetitive 7-1. there is a mechanism visibility), the inner operations that do not rely on possibility that collection of container environmental measurements on site operator debris in the are present in general industrial intervention may Work Saku technology and are expected to reduce inner 4 24 13 2 reduce the task 8 Bdisturbing work from the environment container speed. takes time (poor visibility) inside the PCV. Some shapes of the debris may require trajectory correction through operator manipulation, and there are development problems. [Item 5] The operator's trajectory correction measures (b) Relative (e.g., minute misalignment between debris and position of inner container) for semi-automated operations debris and shown in Item 7-1 cannot be determined directly inner when using camera images, as it requires discernment based on proficiency. container Work 3 Same as above Same as above 24 24 unaffected by In general, there are technologies such as dripping blowing off droplets adhering to the camera lens with gas, etc., and hydrophilic coating. water The camera has low radiation resistance in a high-dose radiation environment, and there are development problems.



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (37/59)

Score table for item 7-1 [4 points] No countermeasures have been determined [3 points] Countermeasures exist, but they are still [3 points] Countermeasures exist, but they are still [1 points] Countermeasures exist, but they are still [3 points] Cannot be determined directly and can expect [1 points] Countermeasures exist, but there are no [3 points] Cannot be determined directly, but there are issues [2 points] Countermeasures exist, but there are no [3 points] Countermeasures exist, but throughput decreases significantly of [2 points] Countermeasures exist, and have been [1 point] Countermeasures exist, and have been applied at the Fukushima Daiichi [1 point] Countermeasures exist, and have been more table for item 7-2 [4 points] Cannot be determined directly, but there are issues Work Sa-4 : Perocessing of debris Important monitoring items Weighted evaluation of important monitoring items							No ly due kload),22									
Risk	mont	ltem 1	Item 2	Important m Item 3 (excerpt from error extraction table)	Item 4	ns Item 5	Item 6			Wi	eighte	ed evaluation	n of important monitoring items Item 7-2		Item 7-3	lter (Eva Res	n 7-4 luation sults)
assess table analysi number	s r	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 workers	accurate and prompt on-site response by	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 possit amount of introductio	ble to make a direct determination by the i debris throughput per day, and on 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 oper minute mi container) Item 7-1 c camera im proficiency - Because fluidity, it i water flow - The cam dose radia developm	rator's trajectory correction measures (e.g., salignment between debris and inner of resemi-automated operations shown in cannot be determined directly when using mages, as it requires discernment based on y. the floating neutron absorbent has is possible to ensure visibility with artificial /. thera has low radiation resistance in a high- ation environment, and there are ent problems.	2	Same as above	24	24

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Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (38/59)

Risk assessment table



Mode Proces	ID	Ko-3 : D	Pebris retrieval	in	Score ta [4 points] N [3 points] C developmer [2 points] C records of a [1 point] Co the Fukush	ble for item 7- o countermea ountermeasur nt ountermeasur application at t untermeasure ima Daiichi.	1 Isures have been d res exist, but they a res exist, but there the Fukushima Daii as exist, and have b	etermi re still are no chi been a	ned under track pplied	Score table for item 7-2 [4 points] Cannot be determined directly and there are is with introduction [3 points] Cannot be determined directly and can expect introduction to be feasible [2 points] Can be determined directly, but there are issue with introduction at [1 point] Can be determined directly and can expect introduction to be feasible	sues	Score table for item 7-3 [4 points] No countermeasures, and impact on throu. [3 points] Countermeasures exist, but throughput der suspension of task [2 points] Countermeasures exist, but throughput der limitations [1 point] No impact on throughput, or when 7-1 is 1 p	ghput crease crease oint	is unknown ss significantly due to es due to workload	2	
WORK		Sa-4	rocessing of debi	15				-								
Risk		Item 1	Item 2	ltem 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	ltem 7 (Evalua Resul	7-4 ation lts)
assessment table analysis number		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 ltem 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (39/59)

Model Proce Work	ID ss	аззез ко-з : sa-4 :	Sment t	able	Score table for item [4 points] No counterme [3 points] Countermeas development [2 points] Countermeas records of application a [1 point] Countermeasu at the Fukushima Daiic	7-1 assures have be ures exist, but th ures exist, but th t the Fukushima res exist, and ha hi.	en determined ley are still under lere are no track Daiichi ave been applied	So [4 po with i [3 po introc [2 po with i [1 po introc	core ints intro oints oints intro oint] duct	a table for item 7-2 a Cannot be determined directly and there a oduction 3 Cannot be determined directly and can ex- tion to be feasible 3 Can be determined directly, but there are i oduction Can be determined directly and can expect tion to be feasible	re is pect ssue	■ Score table for item 7-3 [4 points] No countermeasures, and impact on unknown [3 points] Countermeasures exist, but throughp significantly due to suspension of task [2 points] Countermeasures exist, but throughp due to workload limitations [1 point] No impact on throughput, or when 7-1	n throi put de put de 1 is 1	ughput is ecreases ecreases point	N	0.22
				Import	ant monitoring items		1			Wei	ghte I	d evaluation of important monitoring items				
		Item 1	Item 2	from err extractio table)	or Item 4	Item 5	Item 6			Item 7-1		Item 7-2		ltem 7-3	Item (Evalı Res	n 7-4 uation sults)
Risk assess t analys numbe	smen table is er	Target equipment	The function that the target is responsible for	Work de factor	lay 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	I t t H 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 ver whether th debris has been colled in the inner container of to darknes (poor visibi	rify Unknown e amount of fuel debris filling cted the inner r container due (overflowing s from the inner illity) 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 s	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 ver whether th debris has been coller in the inner container of to fog (poo visibility)	rify Unknown e amount of fuel debris filling cted the inner r container due (overflowing or 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 s	Impact on throughput is unknown because the response shown in Item 7-1 is not determined	24	24



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (40/59)

■ Risk assessment table



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

Process		Ko-3	: De	bris retrieva	I													
Work		Sa-4	: 1	Processing	of													
	_		deb	ris	Ir	moortant monit	oring items			<u> </u>		Weighted	evalı	lation of important monitoring iter	ns			
Risk	nt	Item 1		Item 2	Iterr from extr	n 3 (excerpt n error raction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lten (Eval Re:	n 7-4 luation sults)
table analysis number	table analysis number T; er			The function that the target is responsible for	Wo	rk 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-	В	Radiation source collection mechanism	n	Fuel debris collection function	Car whe deb colld inne due watu visit	nnot verify ether the rris has been ected in the er container to dripping er (poor bility)	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (41/59) **No.230**

with introduction

Risk assessment table

Debris retrieval

debris

Processing

of

Ko-3

Sa-4

Model ID

Process

Work

Score table for item 7-1

Important monitoring items

development

[4 points] No countermeasures have been determined

[3 points] Countermeasures exist, but they are still under

[2 points] Countermeasures exist, but there are no track

records of application at the Fukushima Daiichi

Score table for item 7-2

[2 points] Can be determined directly, but there are issues with

[4 points] Cannot be determined directly and there are issues

Score table for item 7-3

Weighted evaluation of important monitoring items

[4 points] No countermeasures, and impact on throughput is unknown [3 points] Countermeasures exist, but throughput decreases significantly due to suspension of task

[3 points] Cannot be determined directly and can expect

[2 points] Countermeasures exist, but throughput decreases due to workload limitations

[1 point] No impact on throughput, or when 7-1 is 1 point

[1 point] Countermeasures exist, and have been applied	introduction
at the Fukushima Daiichi.	[1 point] Can be determined directly and can expect
	introduction to be feasible

introduction to be feasible

Risk		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	ltem (Evalu Res⊧	7-4 Jation ults)
assess table a numbe	ment nalysis	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (42/59) Risk assessment table

	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		[4 points] Cannot be determined directly and there are issues	[4 points] No countermeasures, and impact on throughput is unknown
	[3 points] Countermeasures exist, but they are still		with introduction	[3 points] Countermeasures exist, but throughput decreases significantly
	under development		introduction to be feasible	due to suspension of task
	[2 points] Countermeasures exist, but there are no		[2 points] Can be determined directly but there are issues with	[2 points] Countermeasures exist, but throughput decreases due to
	track records of application at the Fukushima Daiichi		introduction	Workload limitations
Model ID	[1 point] Countermeasures exist, and have been		[1 point] Can be determined directly and can expect	L [1 point] to impact on throughput, or when 7-1 is 1 point
	applied at the Fukushima Dalichi.	l	introduction to be feasible	

Process Ko-3 : Debris retrieval : Various records following processing work Work Sa-5 Important monitoring items Weighted evaluation of important monitoring items Item 3 Item 7-4 (excerpt Item 7-1 Item 1 Item 2 from error Item 4 Item 5 Item 6 Item 7-2 Item 7-3 (Evaluation Risk extraction Results) assessmen table) t table Effects on Impact on throughput Point of representation analysis The function Detection Presence or Work Indirect due to error handling Individual Direct accurate and number absence of Point Target that the target requirements to Applicable Point Point countermeasures prompt on-(Indirect causes) delay causes causes function equipment is responsible avoid work for disturbing of error factor of error site response functions for delays by workers No environmental changes inside the PCV

No task disturbing



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (43/59) No.232

Model Proce Work		Ko-3 : I Sa-6 : (Item 1	Debris retrieval Cell transfer of Item 2	debris Important m Item 3 (excerpt from error extraction table)	Score table [4 points] No ca [3 points] Coun development [2 points] Coun records of appl [1 point] Count the Fukushima onitoring items Item 4	for item 7-1 buntermeasures itermeasures ication at the ermeasures Daiichi.	res have been dete e exist, but they are e Fukushima Daiich exist, and have bee	ermir still e no i en ap	ned under track oplied	at Score table for item 7-2 [4 points] Cannot be determined directly and there are issues with introduction [3 points] Cannot be determined directly are expect introduction to be feasible [2 points] Can be determined directly, but there are issues with introduction [1 point] Can be determined directly and categories Weighted evaluat Item 7-1	nd car here an	Score table for item 7 [4 points] No countermeat unknown [3 points] Countermeasu significantly due to susp [2 points] Countermeasu to workload limitations [1 point] No impact on th of important monitoring items Item 7-2	7-3 asure ensio ires e irougl	es, and impact on the exist, but throughput n of task exist, but throughput hput, or when 7-1 is Item 7-3	1 dec t dec <u>3 1 p</u> t (E F	ghput is creases d creases d coint tem 7-4 valuation Results)
assess table analys numbe	sment .is er	Target equipment	The function that the target is responsi ble 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 transf mechanisr	Fuel debris collection function er n	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 transformechanisr	Fuel debris collection function er n	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (44/59)

Ris Proces Work	sk a	Ko-3 : Debr Sa-6 : Cell	ent tab	le pris	■ Score table for [4 points] No count [3 points] Counterr under developmer [2 points] Counterrr track records of ap [1 point] Counterrm applied at the Fukk	item 7-1 termeasures hav neasures exist, b t neasures exist, b plication at the F easures exist, ar ushima Daiichi.	e been determined out they are still out there are no ukushima Daiichi nd have been	■ [4 g witi [3 g intr [2 g intr [1 g	Score to points] h introd points] roductio points] roductio point] C	able for item 7-2 Cannot be determined directly and there are issue luction Cannot be determined directly and can expect on to be feasible Can be determined directly, but there are issues v on to be feasible	es with	 Score table for item 7-3 [4 points] No countermeasu unknown [3 points] Countermeasures significantly due to suspens [2 points] Countermeasures to workload limitations [1 points] No impact on through 	res, a exis ion o exis	and impact on thro t, but throughput d f task t, but throughput d t, or when 7-1 is 1	No oughput ecrease ecrease	is es due
Risk		Item 1	Item 2	Important mo Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6			Weighted evaluatio	on o	f important monitoring items Item 7-2	5	ltem 7-3	lter (Eva Re	m 7-4 Iluation
assess table analys numbe	sment is er	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (45/59) ■ Risk assessment table

Mode Proc Wor	el ID ess k	Ko-3 : Deb Sa-6 : Ce debri	oris retrieval Il transfer of is	Score [4 points] [3 points] under de [2 points] track rec [1 point] applied a	table for it No counter Countermevelopment Countermords of app Counterme at the Fukus	em 7-1 ermeasures ha easures exist easures exist plication at the easures exist, shima Daiichi.	ave been determined , but they are still , but there are no Fukushima Daiichi and have been	■ S [4 p with [3 p intro [2 p intro [1 p intro	Score t oints] introc oints] oductic oints] oductic oints] C oductic	table for item 7-2 Cannot be determined directly and the Juction Cannot be determined directly and conto be feasible Can be determined directly, but there on Can be determined directly and can e on to be feasible	here can e e are expe	e are issues expect e issues with ct expect e issues with ct expect e issues with ct expect e issues with ct expect e issues with ct expect expect e issues with ct expec	ritem ntern rmea o sus rmea tions ct on	n 7-3 neasures, and impact or isures exist, but through spension of task isures exist, but through throughput, or when 7-	ו throu put de put de <u>put de</u> <u>1 is 1</u>	ughput is ecreases ecreases du point
Risk asse table	ssment	Item 1 Item 2 Item 3 (excerpt from error extraction table) Item 4 Item 5 Item 6		ltem 6			Weight Item 7-1	ted e	evaluation of important monitorin Item 7-2	g iter	ms Item 7-3	lte (Ev; R€	m 7-4 aluation esults)			
analı num	/sis per	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
Sakı -B-	I 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 footure 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (46/59)

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
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Proces	ss	Ko-3	: Debr	is retrieval													
Work		Sa-6	: Cel debris	transfer of													
					Important monit	oring items					Weighted ev	alua	tion of important monitoring items				
Risk	mont	lte	ems 1	ltems 2	Item 3 (Extracted from the error extraction table)	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		ltem 7-3	lte (Ev R	em 7-4 aluation esults)
table analys numbe	is r	Target equipn	nent	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 tra mecha	nism	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 determinati on 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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (47/59) ■ Risk assessment table

No.236

Mode Proces Work	el ID ss	Ko-3 : Del Sa-6 : Cel	bris retrieval Il transfer of debr	is]	Score tabl [4 points] No [3 points] Cou development [2 points] Cou records of ap [1 point] Cou the Fukushim	e for item 7-1 countermeasures have beer untermeasures exist, but the untermeasures exist, but the plication at the Fukushima D ntermeasures exist, and hav a Daiichi.	n determir y are still re are no Daiichi e been ap	ned under track oplied at	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	S [4 po [3 po susp [2 po limit [1 po	core table for item 7-3 inits] No countermeasures, ai inits] Countermeasures exist, iension of task joints] Countermeasures exist, ations joint] No impact on throughput	nd imp but th but th , or wh	eact on throughput is i roughput decreases a roughput decreases a nen 7-1 is 1 point	Jnknown significa due to w	າ ntly due to rorkload
				Important	monitoring items	6				Weighted evaluation of imp	ortant n	nonitoring items				
Risk	ment	Item 1	Item 2	Item 3 (excerpt from error extraction table)	ltem 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	Item (Evalı Res	7-4 Jation ults)
table a numbe	inalysis r	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	1Work	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	3 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	3 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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (48/59)

No.237 Risk assessment table 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 [4 points] Cannot be determined directly and there are issues [4 points] No countermeasures, and impact on throughput is with introduction [3 points] Countermeasures exist, but they are still unknown [3 points] Cannot be determined directly and can expect under development [3 points] Countermeasures exist, but throughput decreases introduction to be feasible [2 points] Countermeasures exist, but there are no significantly due to suspension of task [2 points] Can be determined directly, but there are issues with track records of application at the Fukushima Daiichi [2 points] Countermeasures exist, but throughput decreases due introduction Model ID [1 point] Countermeasures exist, and have been [1 point] Can be determined directly and can expect to workload limitations applied at the Fukushima Daiichi. introduction to be feasible [1 point] No impact on throughput, or when 7-1 is 1 point Process : Debris retrieval Ko-3 Work : Transfer of Sa-7 debris ① Important monitoring items Weighted evaluation of important monitoring items Item 3 (excerpt from Item 7-4 Item 1 Item 2 error extraction Item 4 Item 5 Item 6 Item 7-1 Item 7-2 Item 7-3 (Evaluation table) Results) Risk Point Point assessment Impact on Point of representation Applicable function table throughput analysis Indirect Detection Effects on accurate Individual The function that Presence or absence of number Point Target Direct causes of due to error requirements countermeasures for the target is Work delay factor causes of and prompt on-site to avoid work handling equipment error disturbing functions delavs responsible for response by workers error (Indirect causes) Intra-cell Fuel debris canister Due to inner Delav in [Items 4/5] Monitoring for interference The more parallel Addressina transfer sealing function (a) Detection between parallel operations Item 7-1 is container radiation. ascertaining the work there are, the mechanism verification of the presence or of flow line in an unmanned more control assumed to 1 presence of flow line absence of flow interference environment and parameters there are, have no unaffected by interference on the line interference operations based on such making it impossible impact on with other work throughput. transfer route takes the inner monitoring is widespread in for workers to make Inner Work Saku 2 3 6 6 time container general industry (e.g., direct decisions 1 1 container -Bradiation manufacturing plants), so it Mechanical radiation is assumed that this monitoring needs to be

											technology will be introduced.		specially designed according to the characteristics of the work line.					
			Intra-cell	Fuel debris canister	Due to soaring dust	Delay in		[Items 4/5]										
			transfer	sealing function	in cell (R),	ascertaining the		(a) Detection										
			mechanism		verification of flow	presence or		of flow line										
Sa	ku	2	1		line interference on	absence of flow	Dust in cell	interference	2	×	Samo as abovo	2	Sama as abovo	1	Same as	6	6	
-E	3-	2			the transfer route	line interference	(R)	unaffected by	2	, ř	Same as above	3	Same as above	'	above	0	0	
					takes time	with other work		dust										



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (49/59)

Risk assessment table

No.238

 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
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Proce	ess	Ko	3 : De	bris retrieval													
Work		Sa	7 : Tra deb	nsfer of ris ①													
					Important monito	ring items					Weighted	evalu	ation of important monitor	ing it	tems		
Risk asses	sment	ŀ	em 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	ltem 5	Item 6			Item 7-1		Item 7-2		Item 7-3	lt (E [:] F	:em 7-4 valuation Results)
analy	sis er	Tarç equi	let pment	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 ascertaini ng whether there is an increase in contamina tion 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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (50/59)

Risk assessment table

No.239

Mode	IID			Score table [4 points] No [3 points] Council development [2 points] Counce records of ap [1 point] Council development Fukushima D	e for item 7-1 countermeasures h untermeasures exist untermeasures exist plication at the Fuku ntermeasures exist, taiichi.	ave been determine , but they are still un , but there are no tr ,shima Daiichi and have been app	ed nder ack vlied at the	Score table for item [4 points] Cannot be de with introduction [3 points] Cannot be de introduction to be feasil [2 points] Can be detern introduction [1 point] Can be determ	7-2 termin termin ole mined	ned di ned di direct	rectly and there are issues rectly and can expect tly, but there are issues with y and can expect	[4 µ [3 µ due [2 µ wor [1 µ	Sco oin oin to oin kloa	re table for item 7-3 ts] No countermeasures, and in ts] Countermeasures exist, but suspension of task ts] Countermeasures exist, but ad limitations t] No impact on throughput, or v	ipact o throug throug vhen 7	on throughput is ur hput decreases sig hput decreases du '-1 is 1 point	iknov gnific ie to	vn antly
Proce	SS	Ko-3	: Deb	ris retrieval				introduction to be feasil	ole		,							
Work		Sa-7	: Tran	sfer of debris ①														
					Important m	nonitoring items	I	1			We	ighted e	eval I	luation of important monitoring it	ems		1	
Risk	smont	lte	m 1	Item 2	(excerpt from error extraction table)	Item 4	Item 5	Item 6			Item 7-1			Item 7-2		Item 7-3	lte (Ev Re	em 7-4 aluation esults)
asses table analys numbe	sinerit sis er	Ta equir	rget oment	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 countermeasures for dist functions	e of turbing	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 (\	()	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 concentratio hydrogen or oxygen in the (Y) rises temporarily, the concentration will decreas over time due to ventilatio conditioning equipment, a nitrogen injection equipm The current PCV is also implementing safety mea with nitrogen injection. 	n of e cell se on, air and ent. o sures	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 	2	Same as above	2	2



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (51/59) Risk assessment table

No.240

[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

vorkload limitations

[1 point] No impact on throughput, or when 7-1 is 1 point

Process	10-3	-3 : Debris retrieval														
Work	Sa-7	: de	Transfer of bris ①													
			-	Important mor	nitoring items	-				Weighted evaluation	ation	of important monito	ing it	ems		
Disk	lte	em 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	ltem 6			Item 7-1		Item 7-2		Item 7-3	lterr (Eval Res	າ 7-4 uation sults)
assessment table analysis number eq	Ta equ	arget pment	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- 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

IRID

Model ID

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (52/59)

Risk assessment table

No.241

 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
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Proce	SS	Ko-3	: Debris	retrieval													
Work		Sa-7	: Transf debris (er of D					-								
					Important monitoring	g items		-			Weig	nted	evaluation of important mor	nitorir	ng items		
Risk		Ite	m 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	lte (Eva R€	em 7-4 aluation esults)
asses table analys numb	sment sis er	Target equipme	ent	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	Intra-ce transfer mechan	ll ism (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
Sak u-B-	5	Intra-ce transfer mechan	lism 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	1	Same as above	2	2



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (53/59) No.242

Risk assessment table

Model ID Process Ko-3 : Debris retrieval Work Sa-8 : Sealed collection of debris							bre table for it htts] No counter hined htts] Counterm Il under devel htts] Counterm b track records hima Daiichi	tem 7-1 ermeasures hav neasures exist, lopment neasures exist, s of application	ve been but they but there at the	■ Sco [4 poin with int [3 poin introdu [2 poin introdu [1 poin	ore tab troduce tro	ble f anno ctior anno to b an b <u>n be</u>	for item 7-2 ot be determined directly and there n ot be determined directly and can e be feasible be determined directly, but there are e determined directly and can expect the feasible	are is xpect issue	ssues Score table for item 7 [4 points] No counterme unknown [3 points] Countermeasu significantly due to susp [2 points] Countermeasu to workload limitations	7-3 asure ires (ensic ires (nroug	es, and impact on t exist, but throughpu on of task exist, but throughpu hput, or when 7-1	throughp ut decrea ut decrea is 1 poir	out is ases ases due at
Work	:55	Sa-8	: Seal debris	ed collection	of	[1 poir been a	nt] Counterme applied at the	easures exist, a Fukushima Da	ind have iichi.	lindodd] • • • • •		•		
Risk		Item	1	Item 2	Importa Item (excerp erro extrac tabl	ant mor n 3 t from or ction le)	itoring items	ltem 5	Item 6	3			Weighter	d eva	aluation of important monitoring Item 7-2	iten	ns Item 7-3	ltem (Evalı Res	n 7-4 uation ults)
asses table analys numb	sment sis er	Targ equipn	let nent	The function that the target is responsible for	Work of fact	delay or	Direct causes of error	Indirect causes of error	Detection requiremen to avoid wo delays	nts ork	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-	1	Sealed collection mechai	on d nism s	Fuel debris canister sealing function	Due to in container radiation takes tin verify wh the cont are prote	nner er n, it ne to nether ents ruding	Delay in ascertaini ng the presence or absence of contents	Contents of inner container	[Item 4] (a) Time to verify whet the conten are protruc from the in container o not	o ther ts ding iner or	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
					from the containe not	inner er or	protruding from the inner container		[Item 5] (b) Presen or absence contents protruding the inner container	ice e of from	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (54/59)

Risk assessment table

Model ID

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

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

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

No.243

[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					the	Fukushima Da	iichi.	ppiled	at	[1 point] Can be determined directly and ca	an e>	pect introduction to	ut, oi	when 7-1 is I point	1 point							
Work		Sa-8 : Seal	led collection	n of debris						be reasible												
				Importan	t monitoring item	S	1			We	ight	ed evaluation of important monitoring items										
		literate	14	Item 3 (excerpt											lt	em 7-4						
		1	2	from error	Item 4	Item 5	Item 6			Item 7-1		Item 7-2		Item 7-3	(Ev	aluation						
Risk			-	extraction table)											R	esults)						
asses	sment		The						A	Presence or absence of				Impact on								
table	sia		function			Indirect			ppli	countermeasures for disturbing				throughput by		rep						
numb	er	Torgot	that the	Work dolov	Direct cause	cause of	Detection requirements	ъ	icab	functions		Effects on accurate and prompt on-site	σ	(indirect causes)	Indi	Po						
		Components	torget in	factor	of orror	cause of	to avoid work dolove	oin	ole f		oint		oint	(mancer causes)	vid	sent						
			iarger is		of error	enor	to avoid work delays	-	unc		17	response by workers			Jal	of						
			responsibl						tior							B						
			e for																			
		Sealed	Fuel debris	Due to inner	Delay in	Damage	[Item 4]			If the inner container is		- Can be determined directly by obtaining		Addressing Item 7-								
		collection	canister	container	ascertaining	during	(a) Time to verify		5	damaged, it is expected to be		actual task hours		1 limits the								
Saku	2	mechanism	sealing	radiation, it	the presence	transfer of	whether the inner	2	/ork	returned to cell (R), and there will	1	- Can be executed in the control room,	2	workload.	4	12						
-B-	2		function	takes time to	or absence of	the inner	container is damaged			be measures such as replacing it		and there are no issues with introduction										
				verify whether	damage to the	container	or not			with another inner container.												
				the inner	inner container		[Item 5]					Although sensory determination (= direct										
							(b) Presence or					determination) may be possible with										
				container is			absence of damage to					camera images, there are cases in which			Item 7-3 Item 7-4 (Evaluation Results) Impact on throughput by idressing errors ndirect causes) ni vitic indirect idressing ltem 7- mits the rkload. ni idressing ltem 7- mits the rkload. 1 me as above 1 12 me as above 1 12 ere is no impact throughput if a eign matter noval method is ablished 2 6 Same as above 6 6							
				damaged or not			the inner container	2	₹	Same as above	3	wrong determinations may be made	2	Same as above	1	12						
									7			depending on the conditions for			2							
												photography, and certainty cannot be										
												guaranteed.										
		Sealed	Fuel debris	Dust (debris	Slow foreign		[Items 4/5]			Although the method of removing		- Can be determined directly by obtaining		There is no impact								
		collection	canister	powder) from	matter (debris	Fuel	(a) Removal time of			foreign matter varies depending		actual task hours		on throughput if a								
		mechanism	sealing	the inner	powder)	debris	foreign matter (debris			on the mode of dust adhesion to		- Can be executed in the control room,		foreign matter								
Saku			function	container	removal speed	powder	powder) caught in the		≶	the container (electrostatic force		and there are no issues with introduction		removal method is								
-B-	3			adheres to the		inside the	transfer container	2	ork	or surface tension due to	1		1	established	2	6						
				lid and main		transfer				droplets), it is assumed that there												
				body of the		container				are no major technological												
				transfer						problems with the removal itself.												
				container, and			[Items 4/5]			Same as above		Although sensory determination (= direct										
				removal takes			(b) Amount of foreign					determination) may be possible with										
				time			matter (debris powder)		_			camera images, there are cases in which										
							adhering to the transfer	2	Nor		3	wrong determinations may be made	1	Same as above	6	6						
							container		Â			depending on the conditions for										
											photography, and certainty cannot be											
												guaranteed.										



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (55/59) ■ Risk assessment table

No.244

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 [4 points] No [3 points] Cou due to susper [2 points] Cou workload limit [1 point] No ir
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le for item 7-3

countermeasures, and impact on throughput is unknown untermeasures exist, but throughput decreases significantly nsion of task

untermeasures exist, but throughput decreases due to

itations

mpact on throughput, or when 7-1 is 1 point

Proce	SS	Ko-3	: Debris retrieva	I												
Work		Sa-8	: Sealed collection	on of												
				Import	ant monitoring	items				Weighted ev	alua	tion of important monitorir	ng iter	ns		
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	ltem 6			Item 7-1	Item 7-2		Item 7-3	ltem (Evalu Res	7-4 Jation ults)	
Risk assessment table analysis number		Target equipmer	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		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 collectior mechanis	Fuel debris canister m 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

Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (56/59) ■ Risk assessment table No.245

■ Score table for item 7-1 [4 points] No countermeasures have been of [3 points] Countermeasures exist, but they under development [2 points] Countermeasures exist, but there track records of application at the Fukushim [1 point] Countermeasures exist, and have applied at the Fukushima Daiichi.	determined Image: Score table for item 7-2 determined [4 points] Cannot be determined directly and there are issues are still [3 points] Cannot be determined directly and can expect are no [2 points] Can be determined directly, but there are issues with a Dalichi [2 points] Can be determined directly, but there are issues with been [1 point] Can be determined directly and can expect introduction [1 point] Can be determined directly and can expect introduction to be feasible [2 points] Can be determined directly and can expect	 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
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Proce	SS	Ko-3	: Debris retrieval													
Work		Sa-9	: Transfer of debris 2													
				Important m	ionitoring items					Weighte	d eva	luation of important m	onitc I	oring items		
Risk assessment table analysis number		ltem	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	ltem (Evalı Res [,]	7-4 Jation ults)
		Target equipme	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



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (57/59)

Risk assessment table			essment ta	able Score table fo	r item 7-1 Intermeasures have be	Score table for item 7- [4 points] Cannot be deten introduction	2 rmined	d direc	tly and there are issues with			<u>No.2</u> 4								
Nodel	ID			[2 points] Counter [2 points] Counter records of applic [1 point] Counter	rmeasures exist, but t ation at the Fukushima measures exist, and h	[3 points] Cannot be deter to be feasible [2 points] Can be determi introduction	mined ned di	directl rectly,	y and can expect introduction but there are issues with	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										
Proces	S	Ko-3 : [Debris retrieval	at the Fukushima	ushima Daiichi. [1 point] Can be determined directly and can expect introduction to be feasible							[1 point] No impact on throughput, or when 7-1 is 1 point								
Work		Sa-9 :	Transfer of debris																	
			Important monitoring items Weighted evaluation of important monitoring items																	
		Item 1	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	ltem 6			Item 7-1		Item 7-2	Item 7-3		ltem 7 (Evalu Result	-4 ation s)				
Risk assessment table analysis number		Target equipmen	The function that t 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	Decontam ation wate drainage	nin Decontamination er function for transport cask	Reduced drainage capacity due to partial blockage caused by dust	Reduced drainage capacity	Contaminated water from water decontamination	[Item 4] (a) Flow rate in the system	1	Safety	If there is a significant trend towar blockage, it can be handled by flushing the piping.	d 1	Direct determination is possible by comparing with the threshold.	1	Because item 7- 1 is 1 point	1	4				
		mechanisi	m	accumulation migrating into contaminated water drainage piping.			[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 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 	e is 4 of	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	Decontam ation wate drainage	nin Decontamination er function for transport cask	Acceleration of piping deterioration (deterioration of	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				
A- 7 (mechanis	m	boundary function) due to corrosion resulting from potential difference caused by dust accumulation migrating to contaminated water drainage piping.			[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				



Appendix 6.2.4.3-3: Risk assessment table for operational equipment (Detailed version) (58/59) ■ Risk assessment table No.247

Mode Proce Work	el ID ss	Ko-3 Sa-9	: Debris : Trans	s retrieval fer of debris ②	Score ta [4 points] N [3 points] C under deve [2 points] track record [1 point] C applied at t	able for item 7- to countermeasure countermeasure elopment Countermeasure ds of application countermeasure the Fukushima	1 sures have been def res exist, but they are res exist, but there an on at the Fukushima rs exist, and have be Daiichi.	termined e still re no Daiichi æn	Score ta [4 points] C with introdu [3 points] C introduction [2 points] C introduction [1 point] Ca introduction	ble fc anno anno anno a to be an be a n be a to be	or item 7 It be dete to be dete e feasible e determi determi <u>e feasibl</u>	-2 ermined directly and there are i ermined directly and can expect le nined directly, but there are issu ned directly and can expect le	ssue t les w	s Score table for item [4 points] No counterm [3 points] Countermea significantly due to sus [2 points] Countermea workload limitations [1 point] No impact on	17-3 neasu sures spens sures throu	7-3 asures, and impact on throughput is unl ures exist, but throughput decreases pension of task ures exist, but throughput decreases dur hroughput, or when 7-1 is 1 point				
Risk asses	sment	lte	em 1	Item 2	Importa Item 3 (excerpt from error extraction table)	Item 4	items	lter	n 6			Weight Item 7-1	ed ev	valuation of important monito Item 7-2	ring i	tems Item 7-3	lterr (Eval Res	7-4 uation ults)		
analysis number		Ta equi	arget ipment	The function that the target is responsible for	Work delay factor	Direct causes of error	Indirect causes of error	Detection requireme avoid work	ents to k 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- tra verif mec	-of-cell nsfer rication hanism	Fuel debris transfer function	Dispersion of contaminate d water contaminate s the inspection	Delay in inspection task	Contaminated water from water decontamination	[Item 4] (a) Time to complete decontam transfer co	o ination of ontainer	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		
					inspection takes time.			[Item 5] Inspection (surface d degree of hermeticity concentrat surface contamina unaffected contamina	n items lose rate, y, tion of ation) d by ated 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
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Process	Ko-3	: Debris retrieval																
Work	Sa-10	: Transfer of debris																
			Important monitor	ing items			Weighted evaluation of important monitoring items											
Risk assessment table analysis number	Item '	Item 2	Item 3 (excerpt from error extraction table)	Item 4	Item 5	Item 6		lt	em 7-1	Item 7-2		ltem 7-3 (f		em 7-4 aluation esults)				
	Targe equipm	The function t that the targ ent is responsib for	et Work delay e 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 environm	ental chan	ges inside the PC	/															





Appendix 6.2.4.3-4: Correlation between debris retrieval model and risk assessment table

No.249



error analysis table, so when the analysis table is changed, the risk assessment table is updated via ②.