PROGRESS REPORT 2020

IRID

International Research Institute
for Nuclear Decommissioning

IRID gathers knowledge from around the world for R&D on nuclear decommissioning under the integrated management system.

Decommissioning of Fukushima Daiichi is unprecedented and extremely difficult tasks in the world. IRID is promoting R&D to overcome technological challenges with global knowledge.

Greeting

Ever since establishment in August 2013, the International Research Institute for Nuclear Decommissioning (IRID) has focused on strengthening the platform for nuclear decommissioning technology, undertaking R&D on the technologies necessary to decommission the Fukushima Daiichi Nuclear Power Station (NPS), which is an urgent issue at present. In August 2014, the Nuclear Damage Liability Facilitation Fund was restructured as the Nuclear Damage Compensation and Decommissioning Facilities Corporation (NDF). With this restructuring, the decommissioning scope has been clearly defined: NDF develops decommissioning strategy and R&D plans, Tokyo Electric Power Company Holdings, Inc. (TEPCO) undertakes onsite work, and IRID implements R&D for technologies required for decommissioning. The four key players, including the government, have been closely working together in the process of decommissioning the Fukushima Daiichi NPS.

As a result, the conditions of the nuclear reactor and the primary containment vessel (PCV) interiors have been clarified by development of technologies for investigating inside the PCV and for utilizing cosmic rays to detect the position of fuel debris, while the technical issues that ought to be overcome have been also identified.

This decommissioning work is being undertaken in accordance with the “Technical Strategic Plan for Decommissioning of the Fukushima Daiichi NPS of TEPCO Holdings, Inc.,” published by NDF, which provides the technological basis for the Mid-and-Long-Term Roadmap for Decommissioning of the Fukushima Daiichi NPS of TEPCO Holdings, Inc., (Mid-and-Long-Term Roadmap, hereinafter). This prioritizes the task of retrieving fuel debris from the PCV bottom, focusing on the partial-submersion side-access method, as a fuel debris retrieval policy. In accordance with the government and the NDF policy, IRID is dedicated to R&D toward achievements in technology for more detailed investigation inside the PCV and for fuel debris retrieval.

In ensuring the safe decommissioning of the Fukushima Daiichi NPS, IRID is committed to the responsibility of making steady achievements in R&D with respect to the reconstruction of Fukushima, and amassing knowledge from all over the world. Furthermore, IRID would like to contribute to the involvement of future generations through R&D.

We sincerely appreciate your kind guidance, continued support, and encouragement.

December 2019

International Research Institute for Nuclear Decommissioning

President
Hideo Ishibashi

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Our visions

Purpose

To conduct testing and research for the decommissioning of nuclear power stations, and implement projects aimed at improving the technological level of IRID member organizations and to put technologies they develop into practical use.

Basic principles

We devote ourselves to research and development (R&D)
of technology for the current, most urgent challenge,
the decommissioning of the Fukushima Daiichi Nuclear Power Station (NPS),
from the standpoint of strengthening the foundation of nuclear decommissioning technology.

Our Principles in Action

1. We work on R&D projects effectively and efficiently while advancing integrated project management to develop and propose the best technologies and systems that are able to be applied on site at the Fukushima Daiichi NPS at an early stage, in the face of numerous extremely difficult technological challenges.

2. We build an optimal R&D structure through cooperation with relevant organizations as well as IRID member organizations and gathering knowledge from Japan and abroad.

3. We actively promote efforts to develop and secure human resources who will comprise the next generation of those working in nuclear decommissioning and related technologies, including efforts to collaborate with universities and research institutions.

4. We strive to release information on our R&D activities and results to obtain the understanding of Japanese people, including those in Fukushima, and the international community to relieve their anxieties.

5. We form an international research hub (center of excellence) through our R&D activities and contribute to the acceleration of the decommissioning of the Fukushima Daiichi NPS and improvement of technological capabilities in the international community.

IRID Organization Information

Organization Profile

1. Name of the Organization

International Research Institute for
Nuclear Decommissioning (IRID)

2. The Head Office

5F, 3 Toyokaiji Building, 2-23-1 Nishi-Shimbashi,
Minato-ku, Tokyo 105-0003, Japan
TEL:+81 3 6435 8601

3. Establishment Date

August 1, 2013：Establishment of IRID was approved by the Minister of Economy, Trade and Industry according to the Research and Development Partnership Act.

4. Scope of Work

- R&D for nuclear decommissioning
- Promotion of cooperation on nuclear decommissioning with international and domestic organizations
- Cultivation of human resources for R&D

<The Circumstances until Establishment>

The 1st report on Mid-and-Long-Term actions to be taken at the Fukushima Daiichi Nuclear Power Station (NPS) was created in July 2011, four months later than March 2011 when the accident at the Fukushima Daiichi NPS occurred. At that time various experts proposed that a dedicated national organization to engage in the decommissioning would be necessary, and this proposal was then discussed by the Atomic Energy Commission.

In response to that situation, the need for establishment of a new organization was specifically expressed at the Council for the Decommissioning of TEPCO's Fukushima Daiichi NPS in March 2013. As a result of continuous study by the establishment of a preparation organization, a request for approval for the establishment of IRID was submitted to the Ministry of Economy, Trade and Industry (METI) in late July, which was then granted by the minister of the METI on August 1, 2013. That approval resulted in a General Meeting of the autonomous legislative body of the organization being held to commence operation of IRID on August 8, 2013.

5. Memberships (18 organizations)

<National research and development agency>
Japan Atomic Energy Agency
National Institute of Advanced Industrial Science and Technology
<Plant manufacturers, etc.>
Toshiba Energy Systems & Solutions Corporation
Hitachi-GE Nuclear Energy, Ltd.
Mitsubishi Heavy Industries, Ltd.
ATOX Co., Ltd.
<Electric utilities, etc.>
Hokkaido Electric Power Co., Inc. Tohoku Electric Power Co., Inc.
Tokyo Electric Power Company Holdings, Inc.
Chubu Electric Power Co., Inc. Hokuriku Electric Power Company
The Kansai Electric Power Company, Inc.
The Chugoku Electric Power Co., Inc.
Shikoku Electric Power Company, Inc.
Kyushu Electric Power Company, Inc.
The Japan Atomic Power Company
Electric Power Development Co., Ltd. Japan Nuclear Fuel Limited

6. Board of Directors

President	：	Hideo Ishibashi
Vice president	：	Tamio Arai
Managing Director	：	Akihisa Heike
Directors	：	Shunji Yamamoto, Hiroshi Arima, Satoshi Ueda, Akihiko Kato,Satoshi Sekiguchi, Koichi Noda, Toshihiko Fukuda, Goro Yanase
Auditor	：	Masao Nakanishi

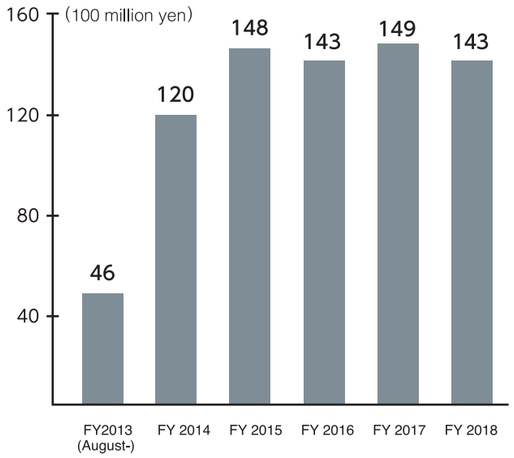
7. Number of Staff

792 people*
(excluding executives)

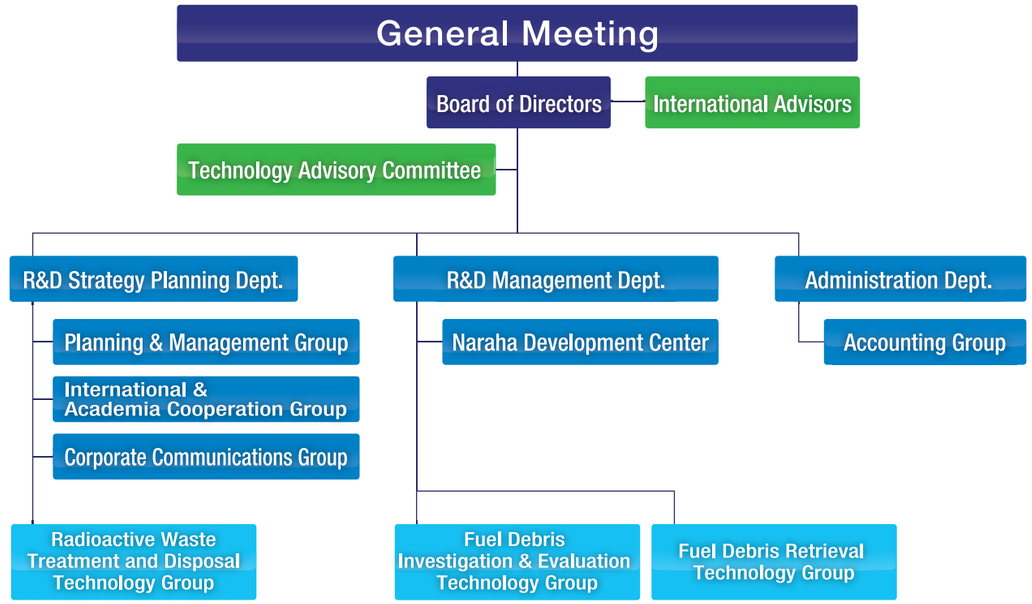
*Including members of the above membership organizations who engage in IRID's research

(As of November 1, 2019)

Project Costs



Organizational Structure

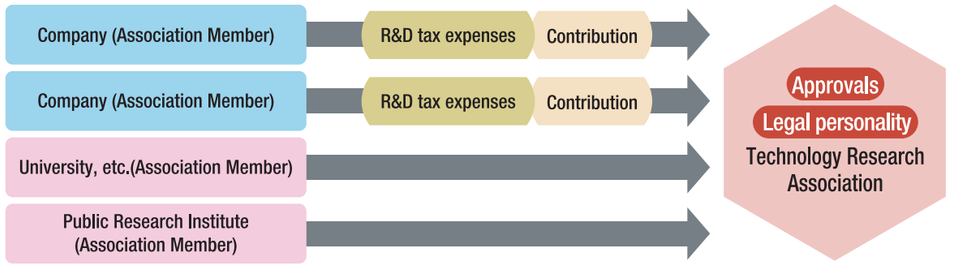


(As of April, 2019)

Reference: Technology Research Associations

Technology Research Associations are mutual aid organizations (non-profit mutual benefit corporations) that conduct joint research on technologies for use in industrial activities that can benefit the association members. IRID was founded as a Technology Research Association in order to rapidly systemize its activities, and to take advantage of the transparency and flexibility offered within the running of the organization.

Overview of the Technology Research Association Model



Features of a Technology Research Association

- Each of association member provides researchers, funds, and equipment for use in joint research. These are jointly managed and utilized among all the members.
- Technology Research Associations are joint research organizations that have a legal identity independent of association members.
- Transparency and reliability of the management of the association can be increased with the approval of the Minister in charge, and by holding regular association member meetings/board of director meetings
- Those directly or indirectly using the results of the joint research (including corporations, individuals, foreign companies and foreign nationals) can become association members.
- Universities, research and development incorporated administrative agencies, technical colleges, local government organizations or foundations primarily engaged in testing and research can participate as association members. This participation then provides opportunities for cooperation between industry, academia and the government.

*Sourced from the "Technological Research Association", the Ministry of Economy, Trade and Industry Website.

Roles of IRID

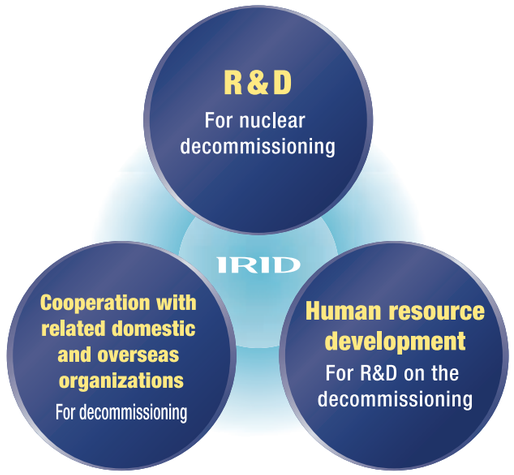
IRID works for R&D of decommissioning under a major policy of the national government while closely cooperating with related organizations involved in the decommissioning work of the Fukushima Daiichi NPS. IRID has a three-pronged strategy; R&D of decommissioning, cooperation with domestic and overseas organizations and human resource development.

Activities of IRID

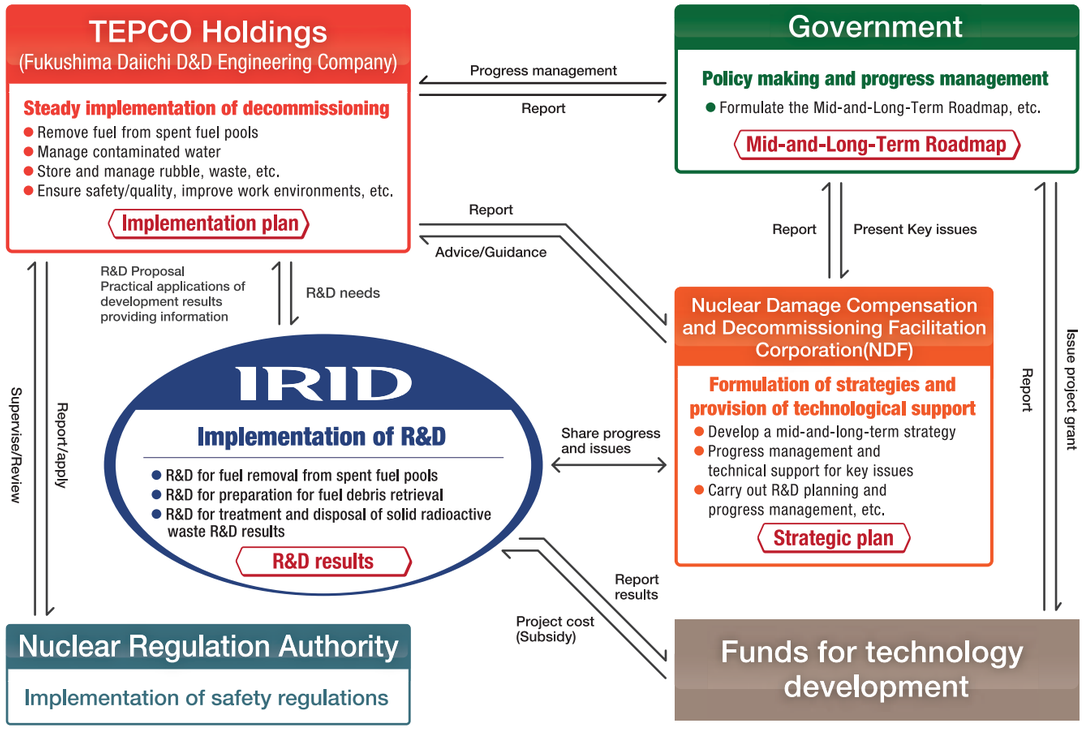
IRID is an organization composed of 18 corporates that are leading players for research and development (R&D) of decommissioning the Fukushima Daiichi Nuclear Power Station (NPS).

Currently, IRID undertakes R&D for the decommissioning of the Fukushima Daiichi NPS, as an urgent challenge based on the Mid-and-Long-Term Roadmap developed by the government, while aiming to cultivate, accumulate and upgrade technologies necessary for nuclear decommissioning over the whole of Japan for the future.

In addition, it is necessary to amass knowledge from both Japan and abroad to proceed with the decommissioning of the Fukushima Daiichi NPS, a globally unprecedented and extremely difficult task; therefore, IRID is promoting cooperation with related domestic and international organizations. Moreover, IRID commits to the cultivation of the necessary human resources to continue the decommissioning work of the Fukushima Daiichi NPS.



Roles of the Organizations for the Decommissioning Project of the Fukushima Daiichi NPS



HISTORY Chronology of IRID activities

■…General ■…R&D ■…Human resources development ■…International relationship

2013

〈August〉
- Establishment of International Research Institute for Nuclear Decommissioning (IRID) (Started with 17 corporates) First president Hajimu Yamana

〈September〉
- Holding the 1st workshop as development of human resources contributing to R&D

〈December〉
- Holding the 1st Technology Advisory Committee

2014

〈January〉
- Holding the 1st International Advisors meeting

〈March〉
- Verification tests on the suction and blast decontamination devices

〈April〉
- Verification tests on low place decontamination devices (Dry ice blast device)
- Verification tests on low place decontamination devices (High pressure water decontamination device)

〈May〉
- Investigation of the upper part of the suppression chamber (S/C) in unit 1 using an investigative device.
- With the joining of ATOX Co., Ltd., the organization became an 18-corporate structure as is current

〈July〉
- Holding the 1st IRID Symposium 2014 (In Tokyo)
- Investigation of the wall of the torus room in unit 2 using a submersible robot and a floor traveling robot

〈August〉
- Nuclear Damage Compensation Facilitation Corporation was restructured to Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF).
- Appointment of the 2nd president Hirofumi Kaneda

〈September〉
- Investigation of the S/C lower outer surface in Unit 2 using investigation apparatus

〈November〉
- Investigation of the spent fuel pool that was transferred to the common pool at Unit 4.
- Holding the 2nd International Advisors Meeting.

2015

〈February – May, May – September〉
- Observing unit 1 by using muon transmission method technology

〈April〉
- Investigation of the inside of the unit 1 Primary Containment Vessel (PCV) using a robot, namely the PMORPH 1

〈July〉
- Holding the IRID Symposium 2015 (In Fukushima city)

〈December〉
- Developing an upper floor decontamination device
- Holding the 3rd International Advisors meeting

2016

〈March – July〉
- Observing unit 2 by using muon transmission method technology

〈April〉
- Completing the Full-scale mock-up facility in the JAEA Naraha Remote Technology Center

〈May〉
- Verification tests of a high place decontamination device (Dry ice blast decontamination device) on the 1st floor of the unit 3 reactor building

〈August〉
- Holding IRID Symposium 2016 (In Tokyo)

〈November〉
- Holding the 4th International Advisors meeting

2017

〈February〉
- Investigation of the inside of the unit 2 PCV using a scorpion robot

〈March〉
- Investigation of the inside of the unit 1 PCV using PMORPH 2

〈May – September〉
- Observing unit 3 by using muon tomography

〈June〉
- Executing a full-scale test by filling water stoppage material in the suppression chamber (S/C)
- Appointment of the 3rd president Hideo Ishibashi

〈July〉
- Investigation of the inside of the unit 3 PCV using a submersible ROV
- Full-scale testing of reinforcement technology for the S/C support columns

〈August〉
- Holding the IRID Symposium 2017 (In Iwaki city)

〈December〉
- Holding the 5th International Advisors meeting

2018

〈January〉
- Investigation of the inside of the Unit 2 PCV using a telescopic investigative device

〈August〉
- Holding the IRID Symposium 2018 (in Tokyo)

〈December〉
- Holding the 6th International Advisors Meeting

2019

〈February〉
- Investigation inside Unit 2 PCV using a telescopic investigative device with a new unit on the tip of the device

〈August〉
- Holding IRID Symposium 2019 (in Iwaki, Fukushima Prefecture)

〈December〉
- Holding 7th International Advisors Meeting

Roles of IRID

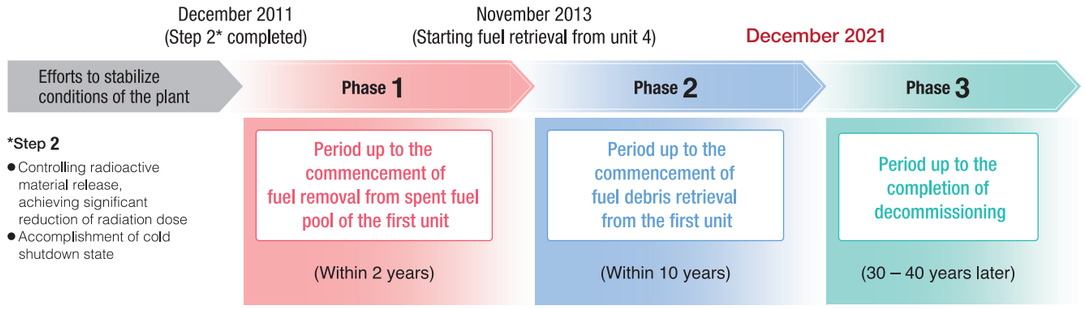
Overview of the Mid-and-Long-Term Roadmap (Revised on September 26, 2017)

Decommissioning of the Fukushima Daiichi Nuclear Power Station (NPS) is preceded based on the "Mid-and-Long-Term Roadmap for Decommissioning of the Fukushima Daiichi NPS of the Tokyo Electric Power Company (TEPCO) Holdings, Inc." (Mid-and-Long-Term Roadmap, herein after) that was decided by the government.

The period until completion of the decommissioning work is divided into 3 phases, the 1st phase, the 2nd phase and the 3rd phase, ; the 2nd phase, "R&D to prepare for fuel debris retrieval" is currently underway.

The current Mid-and-Long-Term Roadmap was revised in September 2017 (4th revision), in which the target schedule (milestones) is stated under the premise that it is subject to be revision of the Roadmap depending on the on-site situation and R&D results aiming for starting fuel debris retrieval at the first implementing unit during 2021.

Phases in the Mid-and-Long-Term Roadmap



( ) means the period from completing phase 2.

IRID has been engaged in various R&D activities under the Mid-and-Long-Term Roadmap. As a result, IRID successfully visualized inside the reactor by investigation inside the primary containment vessel using remote-operated robots and tomography utilizing cosmic-ray muons, while also clarifying technological issues to overcome.

IRID continues challenging technical issues and commits to R&D required for the commencement of fuel debris retrieval from the first implementing unit during 2021.

◯Clarification of target schedule (milestones)

For fuel debris retrieval

- Decision on fuel debris retrieval policy (September, 2017)
- Finalization of fuel debris retrieval methods for the first implementing Unit (FY2019)
- Start of fuel debris retrieval at the first implementing Unit (within 2021)

*Resource: Mid-and-Long-Term Roadmap (4th revision) on September 26, 2017

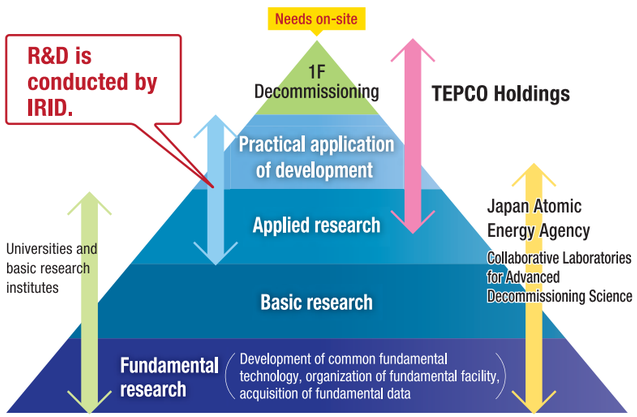
R&D Scope of IRID

Decommissioning work

- Continuation of cold shutdown state of the reactor
- Treatment of accumulated water (Countermeasure for contaminated water)
- Reduction of radiation dose and preventing spread of contamination in the whole plant
- Fuel removal from spent fuel pool
- Fuel debris retrieval
- Solid waste storage management and planning for treatment and disposal
- Decommissioning plan of the nuclear reactor facility

R&D is conducted by IRID.

Overview of R&D



* The above chart was created based on the NDF Technology Strategy Plan 2019.

List of Government Subsidized R&D Projects Conducted by IRID

Subsidy Project on Decommissioning and Contaminated Water Management in the FY2017 and the FY2018 Supplementary Budgets

Ministry of Economy, Trade and Industry
Agency for Natural Resources and Energy

(As of end of June 2019)*1

Project Name	Summary	Period	Supplementary Budgets in the Year of	Subsidy Limits (subsidy rate)*2
Development of investigation technology for inside reactor pressure vessel	(1) Planning of investigation and development (2) Planning of investigation methods (3) Study on supplementary systems for investigation (4) Development of access and investigation devices	April 1, 2018 - March 31, 2020	FY2017	1.3 billion yen (50% or less)
Development of technologies for detailed investigation inside PCV (on-site demonstration of detailed investigation technologies through X-6 penetration)	(1) Planning of investigation and technology development (2) On-site verification of access and investigation devices and investigation technology	April 27, 2018 - March 31, 2020	FY2017	4 billion yen (Fixed)
Development of technologies for detailed investigation inside PCV (on-site demonstration of detailed investigation technologies considering management of deposits)	(1) Planning of investigation and development (2) On-site verification of access and investigation devices and investigation technology	April 27, 2018 - March 31, 2020	FY2017	2.6 billion yen (Fixed)
Development of technologies for construction of water circulation systems in PCV	(1) Organizing technology specifications for upgrading water circulation systems, study on work plan and establishment of development plan (2) Development/verification of elemental technologies for access and connection in PCV	April 1, 2018 - March 31, 2020	FY2017	0.5 billion yen (50% or less)
Development of technologies for construction of water circulation systems in PCV (full-scale test)	(1) Full-scale verification of technologies for access and connection of PCV developed under the subsidy project of "Development of technologies for water circulation systems in PCV"	April 1, 2018 - March 31, 2020	FY2017	1 billion yen (Fixed)
Development of analysis and estimation technologies for characterization of fuel debris	(1) Development of technologies, required for analysis of fuel debris characteristics (2) Development of technology for estimating fuel debris particle behavior	April 1, 2019 - March 31, 2021	FY2017, FY2018	1 billion yen (Fixed)
Development of sampling technologies for retrieval of fuel debris and internal structures	(1) Planning of development of sampling technology for fuel debris and fuel debris sampling (2) Development of devices and systems to sample fuel debris in PCV	April 1, 2019 - March 31, 2021	FY2017, FY2018	3.5 billion yen (Fixed)
Development of technologies for retrieval of fuel debris and internal structures	(1) Development of fuel debris retrieval method (2) Development of handling technology for fuel debris (3) Development of technology to ensure safety during fuel debris retrieval	April 1, 2019 - March 31, 2021	FY2018	4 billion yen (Fixed, but 50% or less for part of project)
Development of technologies for retrieval of fuel debris and internal structures (development of fuel debris dust collection system)	(1) Conceptual study and element testing of systems for collecting dust generated from fuel debris processing and controlling airborne spread	May 10, 2019 - March 31, 2021	FY2018	0.3 billion yen (Fixed)
Development of technologies for containing, transfer and storage of fuel debris	(1) Investigation and research planning for containing, transfer and storage of fuel debris.	April 1, 2019 - March 31, 2021	FY2018	1.3 billion yen (Fixed, but 50% or less for part of project)
R&D of treatment and disposal of solid waste	(1) Study on storage management methods (2) Establishment of treatment/disposal concepts and development of safety evaluation methods (3) Development of efficient analysis method for waste properties (4) Integration of R&D results	April 1, 2019 - March 31, 2021	FY2018	2.7 billion yen (Fixed)

*1 Projects listed in IRID's Project Plan *2 Maximum costs and rates of the subsidy projects are cited from the value given in the Solicitation Information.

Scope of work 1 — # R&D for Nuclear Decommissioning

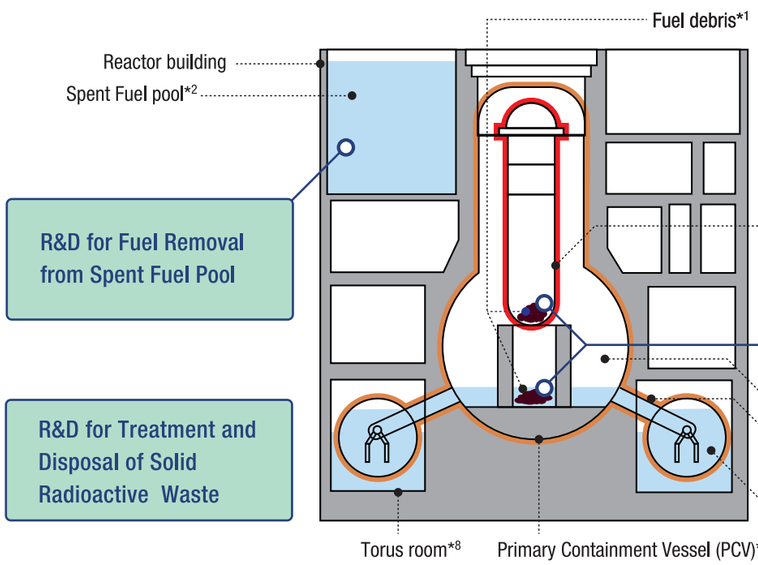
The IRID's major R&D are: R&D for fuel debris removal from spent fuel pool, R&D for preparation for fuel debris retrieval, and R&D for treatment and disposal of solid radioactive waste. IRID is promoting further R&D based on the "Fuel Debris Retrieval Policy" issued in 2017.

IRID's R&D

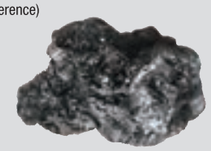
IRID has been conducting R&D to proceed with the decommissioning of the Fukushima Daiichi Nuclear Power Station (NPS), according to the Mid-and-Long-Term Roadmap. In order to improve decommissioning strategies, IRID is studying alternative appropriate approaches, how to reduce risks, while exploring the end state (the most appropriate final form) through tie-ups with TEPCO and relevant organizations.

Our three-major-R&D for the decommissioning are; **R&D for fuel debris removal from spent fuel pool, R&D for preparation of fuel debris retrieval and R&D for treatment and disposal of solid radioactive waste.**

Overview of the Reactor Building and IRID's R&D



(Reference)



Fuel debris retrieved from Three Mile Island Nuclear Power Station Unit 2 (TMI-2) in the USA. (Photo provided by the Japan Atomic Energy Agency (JAEA))

*1 **Fuel debris:** Lava-like fuel containing material that is produced under high temperatures through melting with control rods and structures inside the RPV, after which it cools and re-solidifies.

*2 **Spent fuel pool:** A water tank that stores spent fuel that is inserted into a rack under water until decay heat generated from fission products decreases. This tank is located on the top floor of the reactor building.

*3 **Reactor Pressure Vessel (RPV):** A cylindrical steel container that houses fuel assemblies. This container can resist high-temperature water and high-pressure steam generated by the energy released by nuclear fission inside. The RPV is housed within the PCV together with cooling equipment.

*4 **Primary Containment Vessel (PCV):** A steel container that houses the RPV, cooling equipment, and other devices that perform important functions. This prevents radioactive substances from being released into the outside environment under abnormal plant conditions, such as when a reactor accident occurs, or in the event of a breakdown of cooling equipment. It should be noted that each of the PCVs installed in Units 1-3 at the Fukushima Daiichi NPS consists of a flask-shaped drywell, a doughnut-shaped suppression chamber and eight vent pipes connecting the drywell and the suppression chamber.

*5 **Drywell (D/W):** A safety structure that is comprised of a flask-shaped container that houses equipment, including the RPV, and contains radioactive substances at the time of an accident.

*6 **Suppression chamber (S/C):** Doughnut-shaped equipment that stores water located in the basement of the reactor building. Condenses vapor generated in the case of reactor piping breakage and prevents excess pressure from building up. It also serves the important function of providing a water source for the Emergency Core Cooling System (ECCS) in the case of a loss-of-coolant accident.

*7 **Vent pipe:** Connecting piping that takes vapor generated within the D/W to the S/C in case of a reactor pipe breakage. Eight vent pipes are installed in the PCV of Units 1-3 at the Fukushima Daiichi NPS.

*8 **Torus room:** A room containing the torus-shaped (doughnut-shaped) S/C located in the basement of the reactor building.

CLOSE UP — Policy of Fuel Debris Retrieval and Current Approach

Based on feasibility evaluation and proposals of fuel debris retrieval methods that were studied in the NDF Strategy Plan, IRID is promoting future activities according to the following fuel debris retrieval policy.

1 **Step-by-step approach**
Fuel debris retrieval starts from a small-scale and the scale of retrieval should be expanded by step-up.

2 **Optimization of the overall decommissioning work**
Examine retrieval work as a comprehensive plan aimed at total optimization, including preparations and series of retrieval work from transportation, treatment, storage and clean-up..

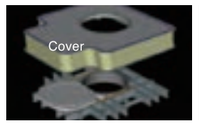
3 **Combination of multiple methods**
Study the combination of multiple retrieval methods; the side-access method for the bottom of the PCV and top-access method for the inside of the RPV.

4 **Approach focused on the partial submersion method**
Currently focus on the more feasible partial-submersion method than the submersion method, considering the difficulty of stopping water leakage and radiation exposure at work.
*The submersion method may be studied in the future, considering the advantage of shielding effects.

5 **Prioritizing the side-access method, which is horizontal access to the bottom of the PCV**
The fuel debris exists both at the bottom of the PCV and inside of the RPV in each unit.
Prioritize the side-access method for the bottom of the PCV to minimize the increase of risk accompanied with the retrieval in consideration of the following.
[1] The best accessibility to the bottom of the PCV and knowledge obtained from investigating inside the PCV,
[2] Possibility to start retrieving at an earlier stage, and [3] Spent fuel removal can be processed in parallel l.

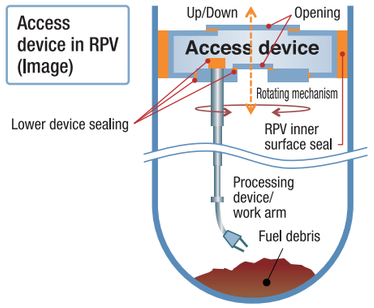
IRID's current approach based on the policy for fuel debris retrieval → **Continuous investigation of the inside PCV, and acceleration of focused R&D**

Top access method –Image of debris retrieval–



Shielding Port with openable

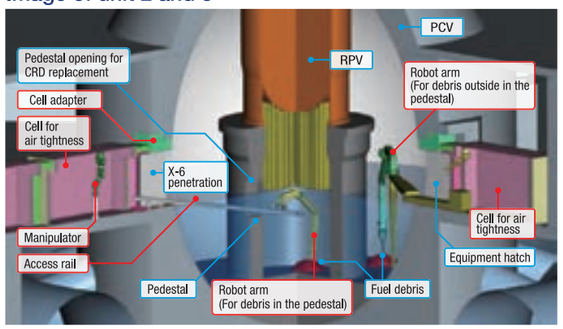
Film for prevention of dust scattering



AR Side access method: Access rail method –Image of debris retrieval–

- Debris "inside" the pedestal ⇒ Insert the access rail through X-6 penetration into the pedestal and retrieve by using a robot arm.
- Debris "outside" of the pedestal ⇒ Retrieve by using a robot arm through the equipment hatch.

Image of unit 2 and 3*



Note) Those in the red frames are new equipment. *Position of X-6 penetration of unit 1 is different from those of unit 2&3.

*Scan the text or photos marked with AR by COCOAR2.

Overview of IRID's R&D Projects

R&D for fuel debris retrieval including the development of investigation robots of inside the reactor and retrieval technology are being promoted according to the Mid-and-Long-Term Roadmap.

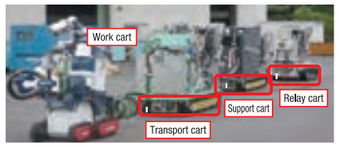
1 ···R&D for fuel removal from the spent fuel pool
2 ···R&D for fuel debris retrieval
3 ···R&D for treatment and disposal of solid radioactive waste

1 ⓐ R&D for Fuel Removal from Spent Fuel Pool

- Evaluation of long-term integrity of fuel assemblies
  (Evaluation of surface deposits of fuel assemblies and evaluation of fuel integrity during dry storage)
- Basic tests for long-term integrity

2 Technology for Decontamination and Dose Reduction

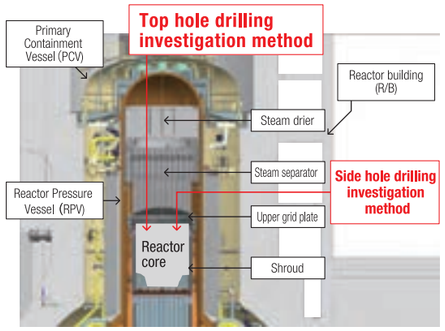
○Technology for Remotely-operated Decontamination in the Reactor Building



2 Technology for Investigation inside the Reactor

ⓑTechnology for Investigation inside the RPV

Evaluation for feasibility of the following two methods (Conceptual view of the investigation method)



ⓒTechnology for Investigation inside the PCV

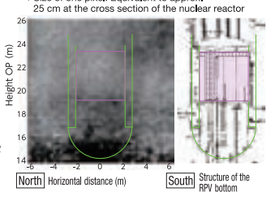
Development of investigation robots inside the PCV

ⓓDetection Technology for Fuel Debris

Investigative technology for the fuel debris distribution inside the RPV by utilizing cosmic ray muons

Shadows of high-density substances which are believed to be fuel debris were confirmed at the bottom of the RPV.
*Measurements at unit 2 and 3 were performed by TEPCO Holding Inc. as part of IRID projects.

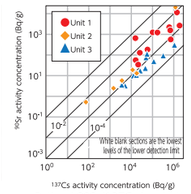
＊Size of one pixel: Equivalent to approx. 25 cm at the cross section of the nuclear reactor



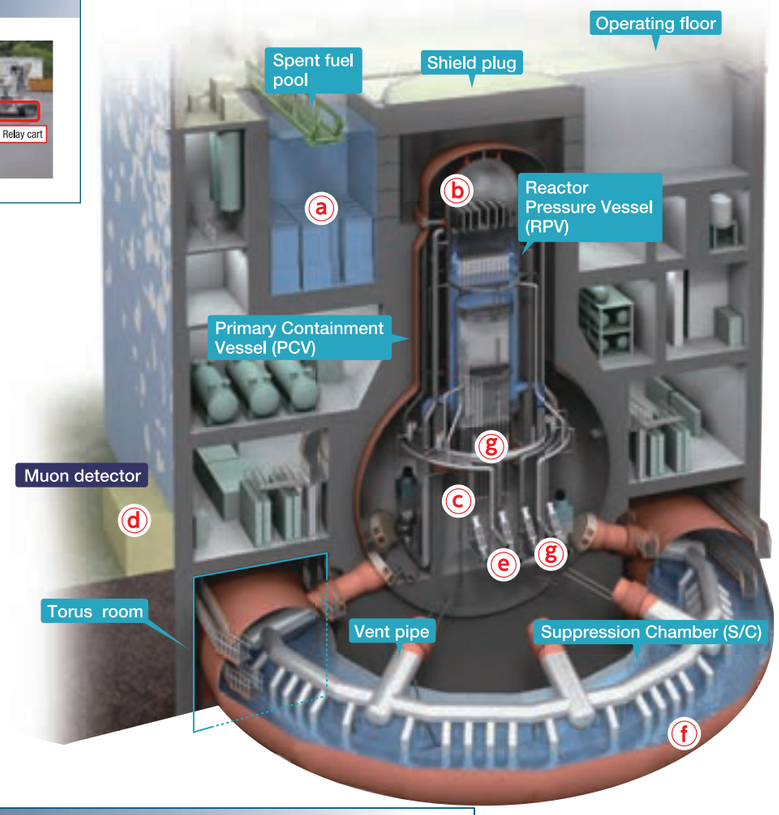
3 Technology for Treatment and Disposal of Solid Waste

Full-scale absorber vessel to be used for various absorption tests

Pressure filtering test device to examine dehydration treatment of ALPS slurry

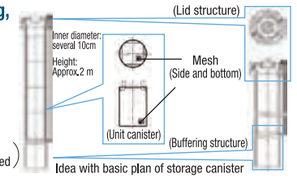


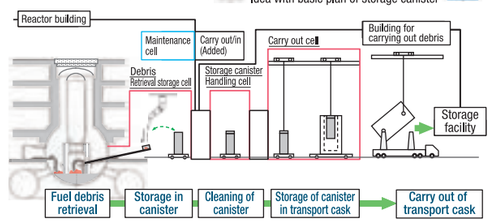
Ratio of 90Sr/137Cs in rubble



2 ⓖ Technology for Fuel Debris Retrieval

Technology for Containing, Transfer and Storage of Fuel Debris

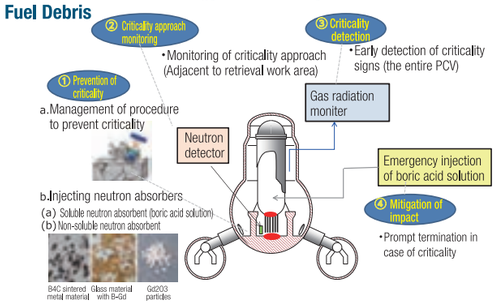




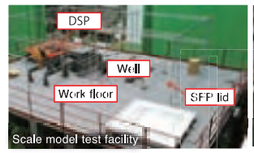
Development of Seismic-resistance and Impact Assessment Method for RPV / PCV

- Formulation of safety scenario for large earthquake
- Development of seismic resistance / impact assessment method for formulating safety scenario
- Safety scenario upgrading

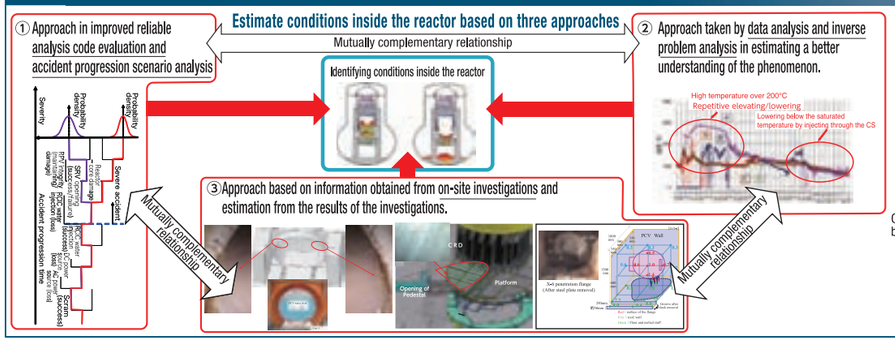
Development of Technology for Criticality Control of Fuel Debris



AR Technology for Retrieval of Fuel Debris and Reactor Internals

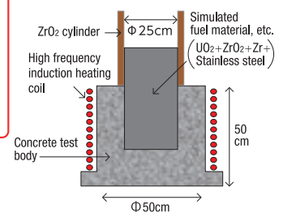


2 Technology for Investigation and Analysis (Characterization) inside the Reactor



ⓔFuel Debris Characterization

Characterization using simulated debris



Large MCCI test device in cooperation with CEA

A simulation test of the Molten Core Concrete Interaction (MCCI) was conducted.

A MCCI test that used a molten core with several kilograms of uranium and concrete was conducted in cooperation with a research institute in France.

2 ⓕ Repair Technology for Water Leak in PCV

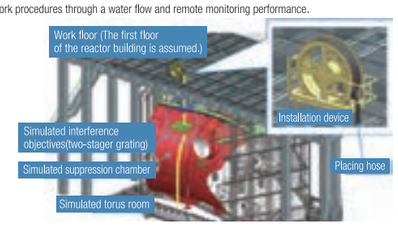
Preparation for Full-scale Mock-up Tests

Implementation of reinforcing workability verification test for S/C support columns

Appearance of test facility

Workability verification test for reinforcement of S/C support columns

- Verification of workability of installation and collection of the placing hose by using the installation device on the work floor
- Verification of work procedures through a water flow and remote monitoring performance.



*Scan the text or photos marked with AR by COCOAR2.

Major R&D Topics

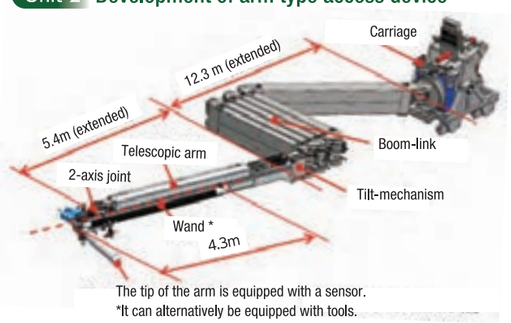
In 2019, IRID completed R&D projects for investigating inside Unit 2 PCV and developing a device for detailed investigation. Furthermore, IRID is promoting R&D projects for fuel debris retrieval and treatment and disposal of solid waste.

Technology for Detailed Investigation of inside the Primary Containment Vessel (PCV)

Development of investigative device

Unit 1 AR **Development of submersible type remotely operated vehicle (ROV)**

Unit 2 **Development of arm type access device**



Unit 1

Scanning type ultrasonic distance measuring device

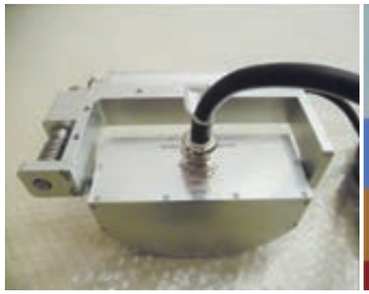
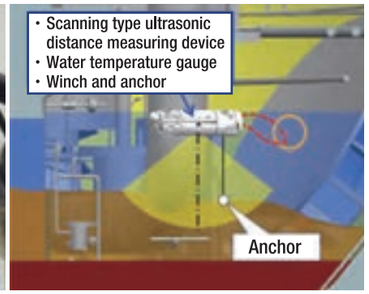


Image of sediment 3D mapping



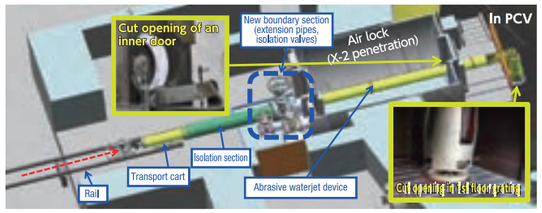
Unit 2

AR Small-amount sampling device

Development of access route into PCV

Unit 1

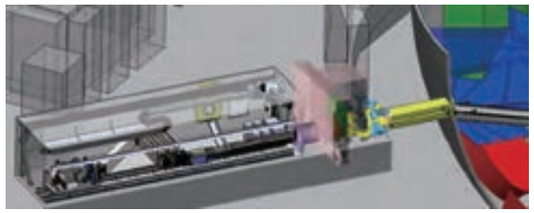
An abrasive water jet device was developed to cut openings through an inner door and grating in the PCV while maintaining isolation from a new boundary section and the PCV interior.



New boundary section of X-2 penetration and cut opening in grating

Unit 2

Technology for connecting the access device was developed. It can be used to remotely open the hatch of X-6 penetration while maintaining isolation inside the PCV.



Access structure in front of X-6 penetration

Technology for investigating inside PCV

Contact investigation of sediment

IRID confirmed changes of the sediment by using a modified investigation unit with the finger structure to move the sediment. The original investigation unit was used for investigating inside PCV in Unit 2 of Fukushima Daiichi NPS in January 2018.

Before contact with sediment

During contact with sediment

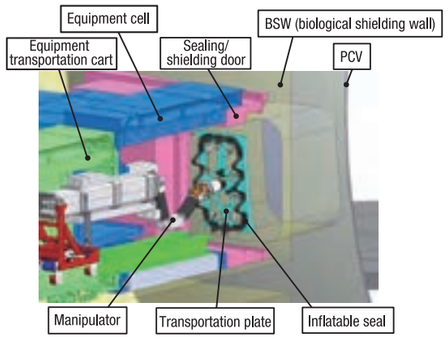
After contact with sediment

This investigation confirmed that the sediment - assumed to be pebble-shaped materials/structures at the bottom of the pedestal - was movable. Furthermore, the pebble-shaped materials/structures on the platform were also movable.

R&D for Fuel Debris retrieval

IRID is proceeding with specific R&D projects to expand the scale of fuel debris retrieval after retrieval work starts in the first targeted unit (within 2021).

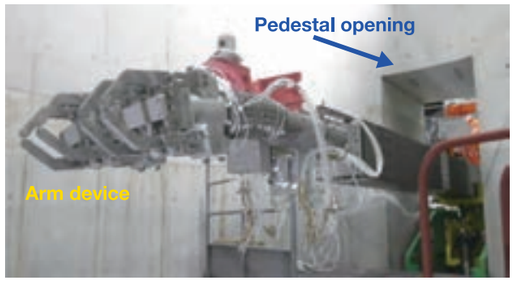
Technology for preventing spread of contamination (example)



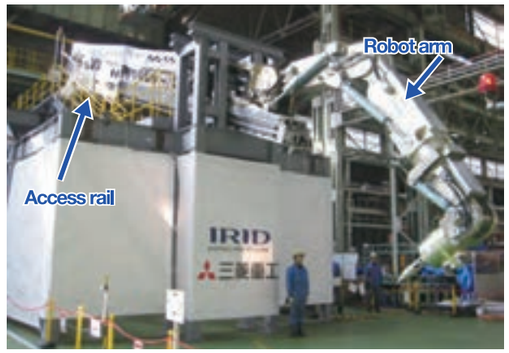
Element testing for ensuring sealing capability of PCV wall and inflatable seal

Technology for retrieving fuel debris and reactor internals (example)

Element testing for removing interferences in the pedestal



AR Element testing combined with robot arm and access rail for processing and retrieving debris

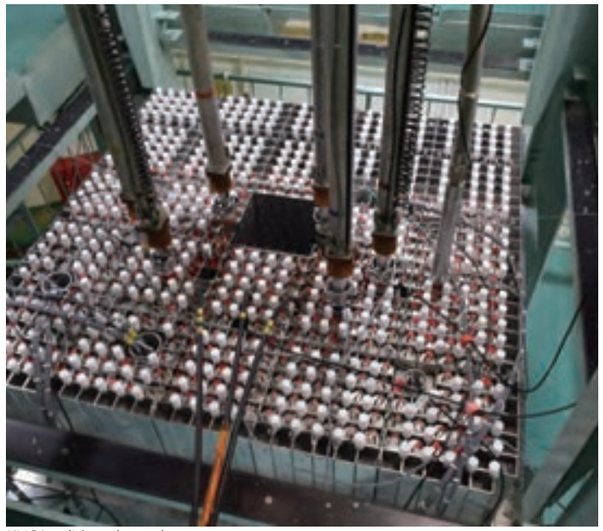


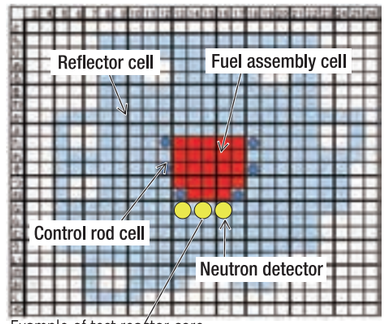
* AR Use COCOAR2 to scan text or photos marked with AR.

CLOSE UP R&D Collaboration with Universities (Actual Projects)

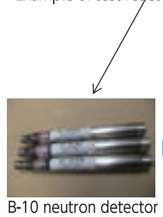
■ Development of Criticality Control Technology [Misawa Laboratory, Kyoto University]

Aiming at verification of criticality approach monitoring technology for detecting any sign of criticality approaching and the nuclear characteristics of neutron absorbent material in preventing criticality, a feasibility verification test was conducted using the Kyoto University Critical Assembly (KUCA) in collaboration with professor Tsuyoshi Misawa, the Institute for Integrated Radiation and Nuclear Science, Kyoto University, which owns the KUCA.
It can be used with variable amounts of fuel and moderators according to the purpose of the test; therefore it is the appropriate experimental system for use in simulating various fuel debris conditions, which can acquire large amounts of useful data, and enabled us to verify criticality control technology being developed by IRID.


KUCA solid moderated core



Example of test reactor core


B-10 neutron detector

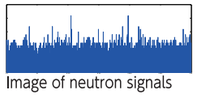
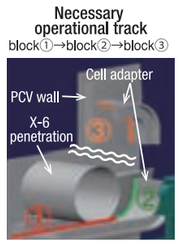
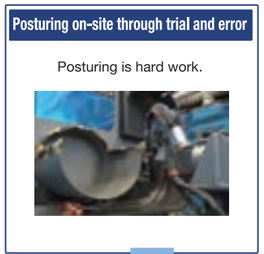


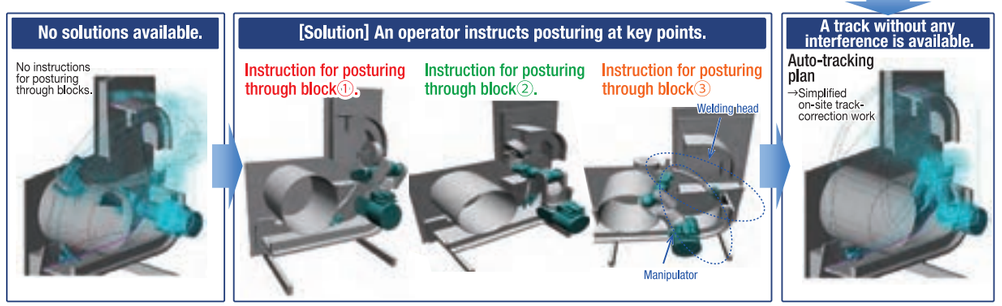
Image of neutron signals

■ Development of Operational Plan considering Multi Flexible Robots to Avoid Obstacles in Environment [Yokokohji/Tasaki Laboratory, Kobe University]

Multi flexible robots (ex. An access rail + a robot arm or an electric manipulator + a welded head, etc.) can be used to increase the range of operations in narrow places; however, there are some places where it is difficult for operators to access them because accurate positioning is required. For this reason, an automatic planning method that is capable of determining a continuous track while avoiding any surrounding interference was developed in a way that the operator can instruct the necessary positions at every key point of continuous operational tracks (block①→block②→block③), and assuming that the multi flexible robot will be used in detailed operations in narrow places.







Nuclear decommissioning is a long-term project that may take 30 to 40 years. It is therefore essential that young people should involve in nuclear decommissioning activities. IRID is committed to cultivating the next generation that will be involved in R&D for nuclear decommissioning.

1. PR Activities for Universities and Research Institutes

IRID is actively involved in the cultivation of human resources by providing information through visits to universities and research institutes.


Lecture at the International Research Center for Nuclear Materials Science (Oarai-machi, Ibaraki Prefecture), Institute for Materials Research, Tohoku University


Lecture at Waseda University


Lecture at University of Fukui

2. IRID Symposium

The IRID Symposium 2019, titled “Challenges for Fuel Debris Retrieval III ”, was held with the aim of reporting R&D achievements as well as nurturing young researchers and engineers. Additionally, this symposium provided a presentation session for students, to enable them to report their research results, as occurred in the previous year’s symposium.
In addition, on the following day of the symposium, a site tour of the Fukushima Daiichi NPS and the JAEA Naraha Remote Technology Development Center was conducted for students from universities, graduate students, and students from the National Institute of Technology who gave presentations and exhibited panels at the symposium.

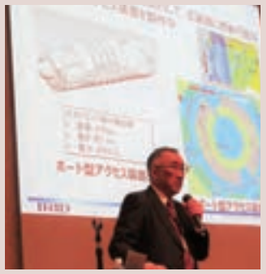

Lecture at the Symposium


Opening remark

Site tour with students

3. Participation in Various Events

IRID actively participates in lectures and events held by various organizations, including academic meetings.


Lecture at the Kanagawa Institute of Industrial Science and Technology (KISTEC) (March 2019)


Lecture at the 37th Annual Conference of The Robotics Society of Japan (September 2019)


Lecture at Japanese Geotechnical Society (October 2019)


Exhibiting at "Robot & Aerospace Festa Fukushima 2019" (November 2019)

Scope of work 3 — # R&D with Overseas Organizations

IRID is enhancing relationships with international research institutes and experts based on an open structure management policy, as well as disseminating information of R&D achievements.

CLOSE UP Enhancement of Cooperation with International Organizations

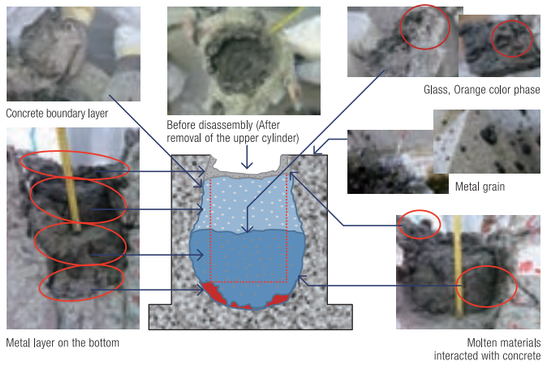
Acceleration of R&D with overseas organizations and implementation of the latest technology for the nuclear decommissioning

Joint Research with Overseas Research Institutions

French Atomic Energy and Alternative Energies Commission (CEA)

A simulation test of the Molten Core Concrete Interaction (MCCI) was performed as international cooperative research with the CEA. As a result, the characteristics of the products were identified that they have porous appearance and separated layers with metal and oxide layers.

Conditions of the product



Technical Cooperation with Overseas Nuclear Organizations

Idaho National Laboratory (INL), USA

As part of a task in the IRID project "Study on safety requirements and specifications for containing, transportation and storage of fuel debris", IRID held a workshop at the INL, to share information and discuss issues. IRID acquired many valuable information and the knowledge from US experts who experienced at the Three Mile Island accident (TMI-2).

National Physical Laboratory (NPL), UK

IRID is proceeding with the development of detection technology using Kr-88 measurements to detect at an earlier stage the symptoms if criticality occurs during fuel debris retrieval. For the improvement of the measurement accuracy for Kr-88, it is necessary to calibrate the volume and concentration of γ-ray. IRID produced actual Kr-88 at the NPL, a world standards authority, and established a calibration method for the detector.

International Advisors

The International Advisor committee consists of three nuclear experts from abroad. This advisory committee was established with the purpose of advising the IRID Board of Directors on organizational operation and management. International Advisors provide advice on future issues and required improvements as well as leading discussions on international efforts and management approaches.

Members * From left of the photo

○**Professor Melanie Brownridge (UK)**
Technology and Innovation Director, Nuclear Decommissioning Authority (NDA), UK

○**Mr. Luis E. Echavarri (Spain)**
Former Director General of the OECD/NEA (Experienced in the International Nuclear Safety Group (INSAG))

○**Mr. Lake Barrett (USA)**
Independent Consultant (former Site Director for the Nuclear Regulatory Commission (NRC) for the Three Mile Island accident)

International Public Relations

IRID has introduced R&D achievements at forums organized by international organizations.

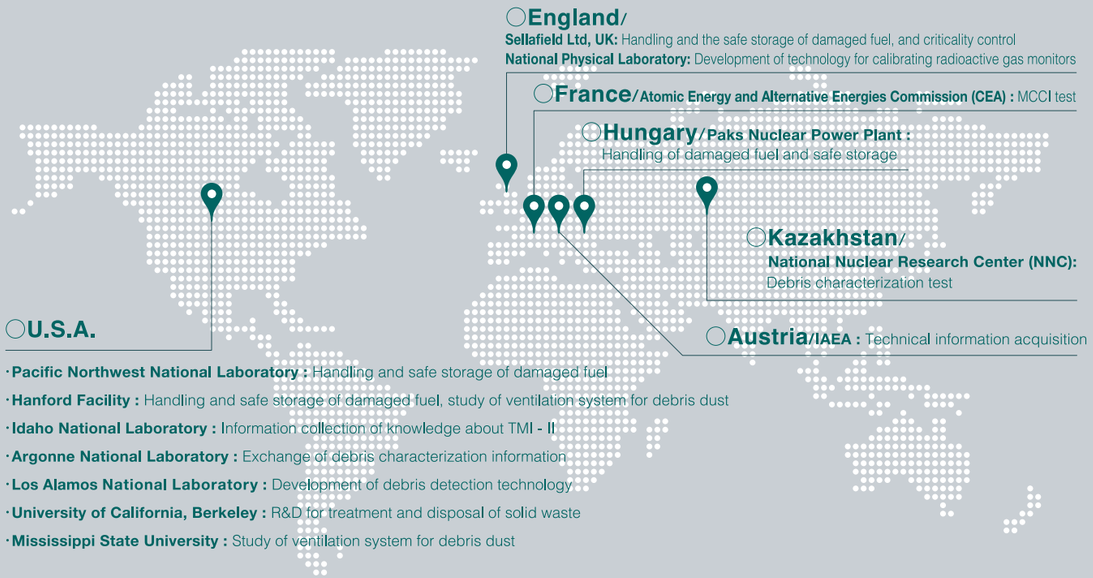
OECD/NEA SAREF Joint WS on Fukushima Daiichi Decommissioning/PreADES Project (January 2019)
IRID reported the current status of technological development including fuel debris retrieval technology.

Technical Seminar with National Physical laboratory (NPL), UK (January 2019)
IRID and the NPL, a world authority of measurement standards, mutually shared research results useful for decommissioning of Fukushima NPS.

International Topical Workshop on Fukushima Decommissioning Research (FDR2019)(May 2019)
IRID introduced robotic technology for decommissioning of Fukushima Daiichi NPS.

The 9th INMM-ESARDA-INMM Japan Workshop (October 2019)
IRID explained the status of technological development for fuel debris retrieval of at Fukushima Daiichi NPS.

R&D Activities with Overseas Organizations (List of major activities)



International Research Institute for
Nuclear Decommissioning

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Minato-ku, Tokyo 105-0003, Japan
TEL:+81 3 6435 8601
http://irid.or.jp/en/

Learn more about the smartphone application "COCOAR2" to know more details about the decommissioning status!

More detailed information of the brochure can be viewed with videos or websites.
Scan the text or photos marked with AR by COCOAR2.

First of all, install the smartphone application "COCOAR2"!

*COCOAR2 is a free application for smartphones.

STEP 1 Install"COCOAR2" application

Search "COCOAR2" at "Apple store" or "Google Play," then install it.

Or read the QR code at the left and install the "COCOAR2" application.

STEP 2 Start"COCOAR2" and hold it over

Start the "COCOAR2" application and hold it over to scan the designated image.

Taking a photo is also possible by pressing the camera mark.

* By posting periods, the location for photo taking (scanning) could change.

Issued in December 2019

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