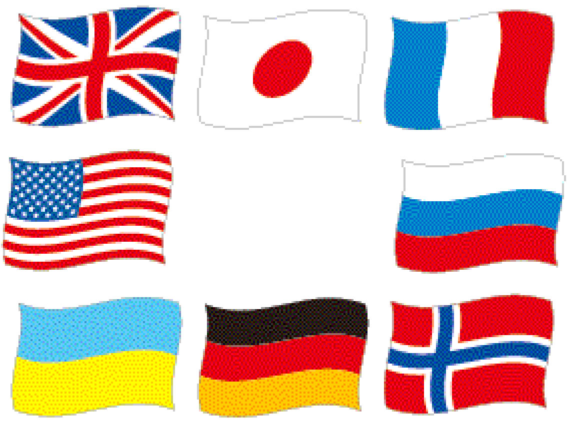
ABSTRACTS of the Technical Poster Session

The 2nd International Forum on the Decommissioning of the Fukushima Daiichi Nuclear Power Station

-Moving forward together-



Mon, July 3, 2017

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NDF

Nuclear Damage Compensation and Decommissioning Facilitation Corporation (NDF)

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1: British Embassy Tokyo, 2: Sellafield Ltd., 3: Oxford Technologies Ltd,
4: National Nuclear Laboratory, 5: NUVIA, 6: James Fisher Nuclear Ltd,
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Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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A01 Measurement of lower part of PCV of Hamaoka NPP Unit 2 by transmission type muon radiography using nuclear emulsion

Kunihiro Morishima[1], Mitsuhiro Nakamura[1], Kenji Tsuji[2] and Masataka Ooyama[2]
[1]Nagoya University, [2] CHUBU Electric Power Co., Inc.

Abstract

In order to take images of the bottom of RPV and the lower part of PCV non-destructively by muon radiography, nuclear emulsion detectors, that have many advantages, were set at the lower level than the ground at Hamaoka NPP Unit 2. It enables us to catch the bottom of RPV and the lower part of PCV in the field of view.

1. Introduction

In order to carry out the decommissioning of Fukushima Daiichi NPP (hereinafter referred to “1F site”) smoothly, it is important to grasp where and how much fuel debris is.

Transmission type muon radiography has been carried out at 1F site, but detectors are installed on the ground level from the viewpoint of detector size, radiation shield and power supply.

By using nuclear emulsion (Fig.1), three-dimensional trajectories of muons can be detected with the resolution of microns and mrad. Also nuclear emulsion has features such as small size, light weight, no power supply required and waterproof property, so there is almost no restrictions on installation location. Therefore, nuclear emulsion enables us to realize transmission type muon radiography to observe the bottom of RPV and lower part of PCV.

2. Observation and model calculation

Nuclear emulation plates were set on the 2nd floor basement of reactor building of Hamaoka NPP Unit2 (Phase 1 and 3), and were set in the lower part of sub-drains for groundwater drainage around of the reactor building (Phase 2) (Fig.2)

Phase 1: 2015 May 22 – Jun. 12, Phase 2: 2016 Jan. 28 to Mar. 10 ,Phase 3: 2016 Aug. 23 - 2017 Feb. 17

In parallel with the observation, model calculations were performed using building data of such as RPV, in-core components, PCV, biological shielding, etc.

3. Results and Future work

We have confirmed that by setting nuclear emulsion on the 2nd floor basement of reactor building or in the sub-drain around the reactor building, we can observe the bottom of RPV and the lower part of PCV (Fig.3).

In the future, we will further polish up the model calculation and continue the study to estimate the limit resolution how far we can grasp the bottom zone in detail.

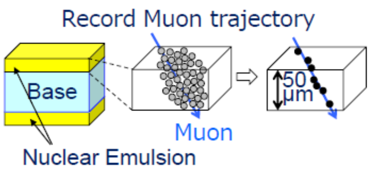

Fig.1 principle of muon detection

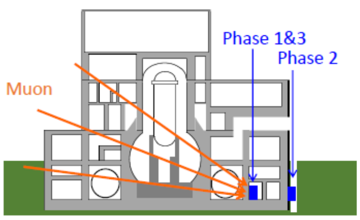

Fig.2 place of nuclear emulsion plates

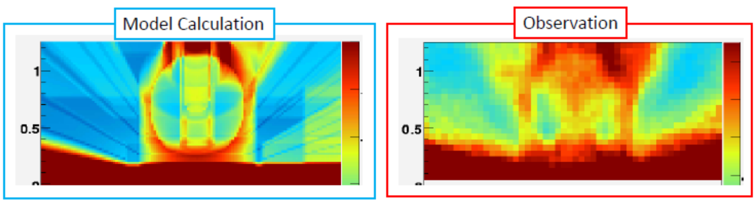

Fig.3 example of results

A02 Technology Development to Predict Dose Rate Distribution in PCV of Fukushima Daiichi Nuclear Power Station

Eka Sapta RIYANA and Keisuke OKUMURA
Collaborative Laboratories for Advanced Decommissioning Science (CLADS), Japan Atomic Energy Agency (JAEA)

Abstract

A technology to predict the most probable dose rate distribution in the primary containment vessel (PCV) of the Fukushima Daiichi Nuclear Power Station (1F) have been developed by combined use of sophisticated theoretical calculation and local measurement results. The technology was applied to the Unit-1 of 1F.

1. Introduction

In order to ensure the safety of 1F-decommissioning workers, it is important to grasp dose rate distribution in PCV. Although local dose rate has been measured by IRID, it is difficult to estimate the overall dose rate distribution. Therefore, we developed a method to estimate the dose rate distribution by combining theoretical calculation and measured values.

2. Dose Rate Distributions Calculation Method and Current Result

To determine the radiation source nuclides, we carried out a series of calculations such as: 1) burnup calculation to obtain fuel compositions at the time of accident, 2) activation calculation for the structural materials including its impurities, 3) mixing of fuel and structural materials, 4) release of volatile fission products, 5) decay calculation of radioactive nuclides. The spatial position of fuel debris and Cs contamination in PCV were determined based on the results of 1F accident progression analyses by IRID.

Using the determined radiation sources, photon transport calculation with a three-dimensional plant model was performed by PHITS [1] to produces the dose rate distribution inside PCV and its surroundings. After that, the Cs contamination on the surface of the wet-well was modified by comparison between the calculated and measured dose rates to obtain modified dose rate distribution. Figure 1 shows the finally obtained dose rate distribution inside PCV of Unit-1 of 1F.

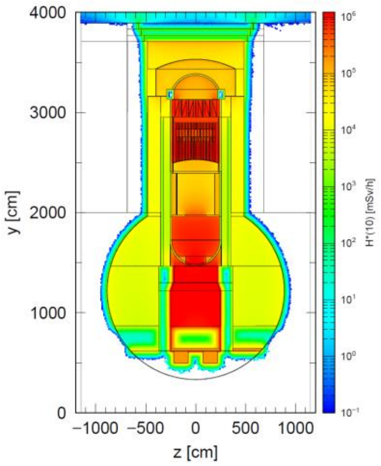

Figure 1. Predicted Dose rate distribution in PCV of Unit-1

3. Conclusion

A method to predict the most probable dose rate distribution for 1F has been successfully developed. The reliability of the method expected will be improved by obtaining more local measurement data in the future.

Present study includes the results of “Technology development to evaluate dose rate distribution in PCV and to search for fuel debris submerged in water” entrusted to Nagaoka University of Technology by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT).

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A03

Investigation inside the Primary Containment Vessel (PCV)

Yoichi Murai[1], Satoshi Okada[1, 2] and Atsuyoshi Uranishi[1, 3]
[1]International Research Institute for Nuclear Decommissioning (IRID),
[2]Hitachi GE nuclear Energy, Ltd, [3]Toshiba Corporation

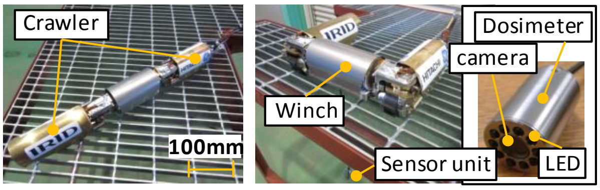
Abstract (60word)

As R&D projects for the preparation of fuel debris retrieval of the Fukushima Daiichi NPS, IRID has developed the technology that enables to investigate inside PCV. In FY 2016 the investigation robots successfully entered the PCV at Unit 1 and Unit 2. The result of investigation such as images collected by the robot camera and radiation dose detected are shown.

1. Investigation robots

1-1. For Unit 1 : B2 investigation

The Robot (Fig.1) named "PMORPH" can pass through a pipe (Diameter is 100mm), and run rough plane after shape changing. And, the robot lets a sensor unit descend for investigate downstairs situation.



(a) "I" shape (b) "U" shape

Fig.1 Investigation robot for Unit 1

1-2. For Unit 2 : A2 investigation

The Robot (Fig.2) has been developed to investigate inside the pedestal of the Unit 2 PCV (Fig.2). After entering the PCV, the shape of robot changes into a shape like a scorpion raising its tail to improve its field of view. Also this mechanism enables to restore if the robot overturned.

Fig.2 Investigation robot for Unit2

2. Investigation result

2-1. Unit 1

As a result of B2 investigation, underwater images (Fig.3) and dose rate distribution (Fig.4) were provided, and the situation of the basement floor of Unit 1 gradually became clear.

Fig.3 Bottom image

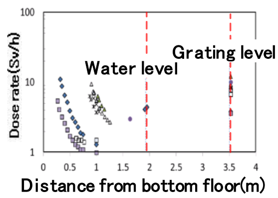


Fig.4 Measured dose rate

2-2. Unit 2

At the first time after the accident, image inside the pedestal of Unit 2 (Fig.5) were captured. As the result, the opening and deposition were found on the structure inside the pedestal.

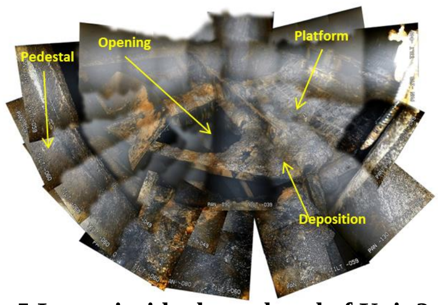


Fig.5 Image inside the pedestal of Unit 2

3. Conclusion

IRID has developed the investigation technology and applied for the inside PCV of the Fukushima Daiichi NPS. As results of the investigation, valuable data for the preparation of fuel debris retrieval were obtained.

References

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[2] IRID HP : http://irid.or.jp/wp-content/uploads/2017/04/20170330_2.pdf

A04

OECD/NEA International Joint Research Project regarding fuel debris characterization PreADES & TCOFF

Akira Nakayoshi[1], Tadahiro Washiya[1], Masaki Kurata[1], Kimihiko Yano[1], Yuji Nagae[1], Masahiko Osaka[1], and Hideki Ogino[1]

[1]Japan atomic energy agency

Abstract

JAEA is conducting two projects on OECD/NEA. One is PreADES (Preparatory Study on Analysis of Fuel Debris) aims at ensuring processes are in place for the debris retrieval and analysis. The other is TCOFF (Thermodynamic Characterization of Fuel Debris and Fission Products based on Scenario Analysis of Severe Accident Progression at Fukushima-Daiichi NPS(1F)) aims at improving of thermodynamic databases for core and FPs. Outlines are introduced at the poster.

1. PreADES

The purpose of PreADES (2017-2020) is summarizing of expertise that contribute to understanding debris characteristics and creating of appropriate methodologies for future safety assessment of the debris retrieval and analysis. Following actions are ensuring this project; (1)To share and update information and expertise on debris in nuclear accidents, (2)To jointly compile and evaluate selected topical issues based on updated data and information, and identify research gaps and priorities and (3)To prepare future collaborative research and development plan on analysis of debris. Expected outcomes are; (1) Information and data provision（1F study, SA study, etc.）, (2) Methodologies of estimation of current properties of fuel debris and future prospect, (3) Methodologies of safety evaluation on 1F sampling and retrieval and (4) International R&D framework on fuel debris analysis. Regarding the cost for the project, Japanese communities and participants will share the cost arising from activities in the project. The kick-off meeting will be held in 6-7th of July 2017.

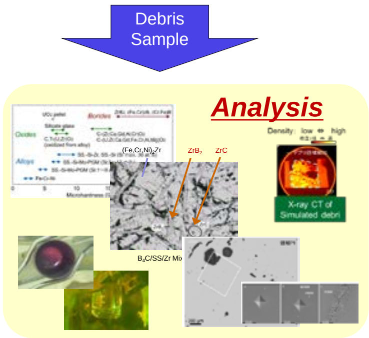


Figure1. Image of debris analysis and characterization

2. TCOFF

The purpose of TCOFF is improvement of thermodynamic database (TD) for core materials and fission products (FP) by analytical and experimental studies by referring accident progression in 1F. The updated TD is able to contribute to evaluation of fuel degradation progression, FP-behavior, and debris characterization from material science viewpoints. Benchmark evaluation using various TDs, prioritization of improvement of each TD, and evaluation using updated analytical and experimental knowledge will be performed in collaboration of 15 research institutes. Each participants contributes to TCOFF as in-kind, which include thermodynamic evaluation, simulation study, material science analysis and etc. JAEA will act as the technical advisor of these assessment. Two task forces (TF) are supposed to be established in TCOFF, such as (TF1) corium and fuel and (TF2) FPs. The kick-off meeting will be held in 3rd and 4th of July 2017.

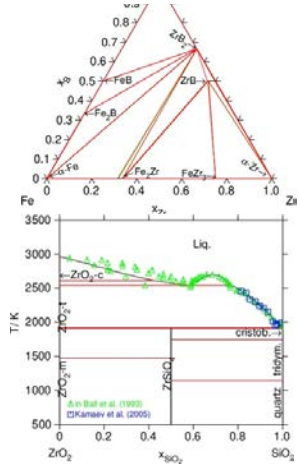


Figure.2 Example of phase diagrams planned to be updated in TCOFF

The participation of additional experts are very welcome in both projects.

A05

Development of Ultrasonic Underwater Imaging Method for Decommissioning of Fukushima Daiichi Nuclear Power Station

Ryosuke Kobayashi[1], Hayato Mori[1], Takahiro Nagai[1] and Naoyuki Kono[1]

[1]Hitachi Ltd., Research & Development Group

Abstract

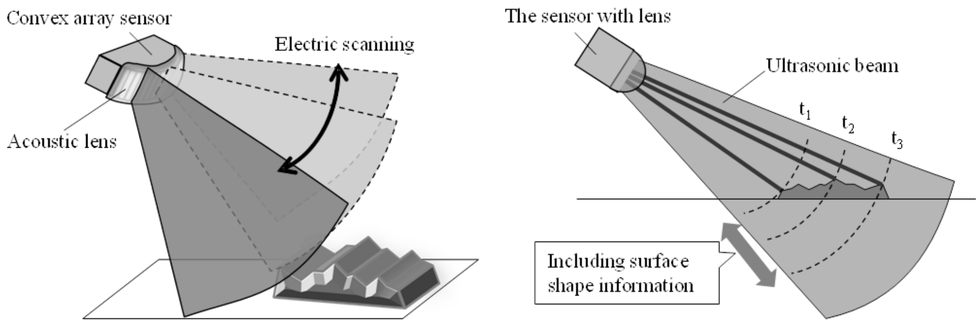
For the safe decommissioning of Fukushima Daiichi Nuclear Power Station (1F), survey techniques have been expected to provide an understanding of the current plant status. Environmental conditions of survey targets are high radiation, having underwater areas and so on. This paper describes an ultrasonic imaging method combined with a convex scan and a divergent beam to visualize environments in turbid water.

1. Introduction

Survey techniques have been demanded to facilitate the planning and the actual decommissioning of 1F. Underwater imaging techniques are essential for recognizing the surrounding environment.

2. Ultrasonic Underwater Imaging Method

A method that combined a convex array sensor with a defocusing acoustic lens is proposed for wide area imaging. Ultrasonic beam scanning in the proposed method is shown in Fig.1 (a). Ultrasonic beams are focused in a direction parallel to the element array direction and defocused in a direction perpendicular to it. Each beam has a thin fan shape and scanned electrically. Information on the surface shape of an underwater object is obtained as the difference of time-of-flight in each spread fan beam, as shown in Fig.1 (b).

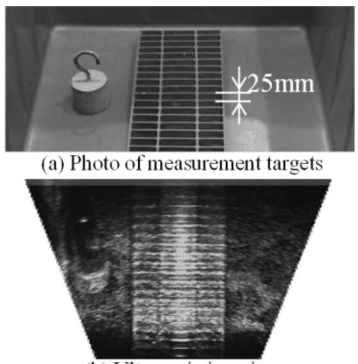


(a) Spread fan beam scanning (b) Imaging method using time-of-flight

Figure 1. Ultrasonic imaging method using convex array sensor and acoustic lens

3. Experiments and Results

A grating panel and a cylindrical weight were measured as a confirmation experiment of imaging performance. Locations of measurement objects were about 1 m from the sensor. A photo of the measurement targets and the measurement results of the ultrasonic imaging are shown in Fig. 2. From the results, a wide region was visualized with the three-dimensional effect and spatial resolution was about 20 mm because the 25-mm spacing of the grating panel was identified.



(a) Photo of measurement targets

(b) Ultrasonic imaging

Figure 2. Measurement results of our proposed imaging method

4. Conclusion

An ultrasonic imaging method combined with a convex scan and a divergent beam was developed to visualize environments in turbid water. As a result of imaging performance test, it was confirmed that the spatial resolution was about 20 mm.

B01

3-D sensing technologies of radiation and environmental structure at the Fukushima Daiichi NPS

Yuta Terasaka[1], Yuta Tanifuji[1], Masaaki Kaburagi[1], Yuki Sato[1], Hiroshi Usami[1], Kuniaki Kawabata[1], Hiroko Nakamura Miyamura[1] and Tatsuo Torii[1]

[1]Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency

Abstract

We confirmed that the compact Compton camera (C3) developed in this study can visualize the radiation distribution of the hot spot in the coastal region of Fukushima Prefecture. Additionally, we confirmed that the laser scanner applied in this study can construct the 3-D point cloud data of the mock-up staircase that simulated the staircase inside Fukushima Daiichi Nuclear Power Station (FDNPS).

1. Introduction

Radiation distribution imaging inside the FDNPS building is urgently required to reduce the external dose of workers and for the efficient decontamination. In this study, radiation distribution imaging using C3 and 3-D modelling of mock-up staircase using laser scanner were tentatively conducted for the 3-D sensing of radiation distribution and environmental structure inside the FDNPS building.

2. Instruments

Compton camera is a radiation imaging device which can estimate the incident direction of gamma-rays using Compton scattering principle [1]. C3 developed in this study consists of gamma-ray sensor, signal processing unit, and optical camera. The total weight of C3 is less than 1.0 kg. The gamma-ray sensor employs a Ce-doped GAGG ($Gd_3Al_2Ga_3O_{12}$) scintillator coupled with a multi-pixel photon counter. An operation test of C3 was conducted in the outdoor environment of coastal region of Fukushima Prefecture, where the dose rate at 1cm above the ground surface exceeds 20 μSv/h very locally.

Laser scanner is the sensor which can measure distance to the object surface using a principle of TOF (Time of Flight). In this experiment, we used YVT-X002, Hokuyo Automatic CO. LTD, the sensor that can get 3D point cloud data, and we measured the mock-up staircase that simulated the staircase inside FDNPS and can change step height, inclination and width of the handrail.

3. Results and future task

Figure 1 shows the result of performance test of C3 in Fukushima Prefecture. Measurement time and distance from the hotspot were 20 min and 5 m, respectively. C3 visualized the hotspot very clearly, where the dose rate at 1cm above the ground surface exceeds 20 μSv/h. Figure 2 shows the picture of mock-up staircase and measured 3-D point cloud data by the laser scanner. We confirmed that we can recognize the shape of the staircase structure roughly.

In the future, we plan to use the C3 and laser scanner for the 3-D sensing of radiation distribution and environmental structure inside FDNPS.

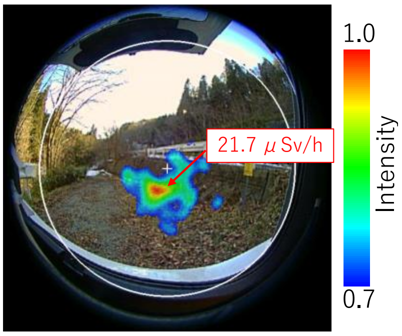


Figure 1. Radiation image by C3

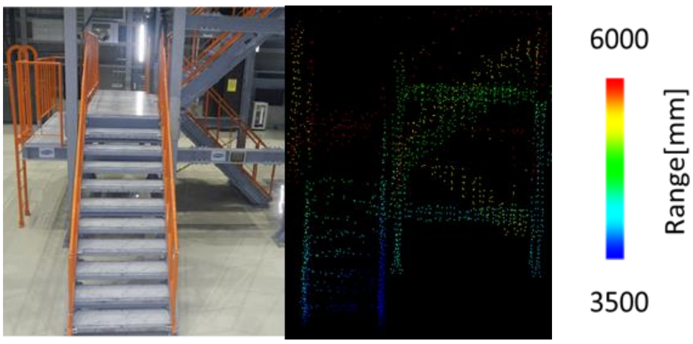


Figure 2. Laser scanner data and picture of mock-up staircase

References

[1] J. Kataoka et al., Nucl. Instr. and Meth. A, vol. 732, 2013, pp. 403-407.

B02

Development of a small and modular UROV for surveying radioactive materials on the lakebed

Mizuki Tanaki[1], Kanno Ryo[1], Luis Canete[1] and Takayuki Takahashi[1]

[1]Fukushima Univ.

Abstract

An underwater robot for surveying radioactive materials on the lakebed is being developed by the authors. This underwater robot has a modular structure for easy handling and is capable of undisturbed soil core sampling from many points over a wide area. This paper describes the soil core sampling and underwater communication method. Results of experiments are also presented.

1. Introduction

Surveying of radioactive materials on lakebeds requires soil core sampling without disturbing the soil layers to investigate sediment chronology. Conventional soil core sampling by divers is manually intensive, physically challenging, dangerous, and difficult to perform in deep lakes with depths beyond 40 meters. Other sampling devices that can be dropped from boats exist but do not give accurate position data for mapping. These problems can be solved by the underwater robot being developed [1].

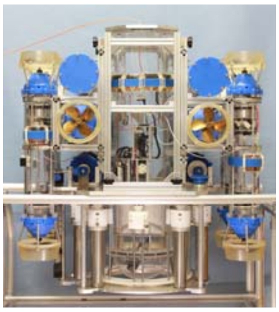


Figure 1. Underwater robot

2. Soil core sampling module and inter-module communication

Based on the estimated radioactivity concentration and the sediment accumulation rate of the lakebed, the specification of the core sample is determined to be at least 100g in weight and 100mm in depth. We conducted various experiments and finally concluded that a method of intruding a stainless pipe with 40 mm diameter and 0.5 mm thickness yields the best result [2]. A soil core sampling module that can collect 8 samples per dive is installed to the robot.

Power and communication ports may cause water breaches and so each module has an individual battery and communicates wirelessly. However, the reliability of radio-communications in underwater environments was not enough due to the significant attenuation of radio signals. To overcome the issue, the authors developed a patch antenna which is simply attached to the module surface. The radio signal strength was drastically improved which increased the reliability of inter-module communication.

3. Experiment for soil core sampling

The prototype of the robot that features the developed patch antenna and soil-core sampling module was tested in Lake Inawashiro. It was shown that inter-module communication was improved and soil-core sampling can be performed successfully by the robot.

References

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B03 Decommissioning Operations Planning Using Proven Technologies

Yasushi Kikkawa[1], Daphne Ogawa[1], Bastien de Lazzari[1],
[1]AREVA ATOX D&D SOLUTIONS Co. Ltd.

Abstract

ANADEC proposes proven technologies and expertise for the decommissioning of the Fukushima-Daiichi (1F) plant based on AREVA's unique experience as both operator and dismantling entity of its facilities, and ATOX knowledge of site operation conditions in Japan. Fukushima-Daiichi situation is unique, and requires both innovative solutions, and robust proven solutions. ANADEC aims to provide dedicated filed engineering services.

1. Introduction

Dismantling and decommissioning works at the 1F plant has entered into new phases which will require technologies to:

- achieve dose reduction and prevention of contamination dispersion,
- perform remote decommissioning to clear access to strategical work area such as PCV, operating floor.
- manage and stabilize radioactive waste.

2. Proven technologies applied by ANADEC for Fukushima-Daiichi D&D

2-1. Dose reduction plan, chemical decontamination and prevention of contamination dispersion

The first step to elaborate a dose reduction plan is to perform a contamination cartography. ANADEC has developed with a French company IZYmap, remote dosimeter ball sensors that record relative position and radiological data in order to build a 3D mapping of contamination.

Once the hot spot are identified, there are three ways to lower the dose rate: by shielding, by decontamination of the source, and by removal of the source term. ANADEC is specializing in the second solution, by providing decontamination operations using gel or foam-based chemical reagents.

Moreover, to prevent contamination dispersion when performing dismantling works, ANADEC with the support of French CEA and AREVA develops fixative foams that can be sprayed to cover rubbles to avoid dissemination of contamination.

2-2. Remote-controlled dismantling operations

Given the high dose rate and the difficult accessibility of 1F operation sites, ANADEC offers solution engineering for intervention using remotely controlled robot such as the TEΩ600 force-feedback arm developed by AREVA TEMIS. This robot can be adapted with various tools to carry out complex operations in hostile environment. By using the force-feedback feature, remote operations such as cutting, drilling, welding, opening of valves, etc. can be performed with more accuracy, more safety.

Figure 1. MC-TEΩ600

3. Field engineering planning by ANADEC

Interventions onsite 1F requires the elaboration of a thorough planning and operation scenario. By leveraging on AREVA's extensive experience in complex dismantling operations, ANADEC performs field engineering that makes the best use of pragmatic solutions for both indoor and outdoor works.

- **Definition of end state objectives**:
- **Investigation to obtain initial state conditions**:
- **Definition of scenario and corresponding operational sequence**:
- **Selection of technologies to perform the tasks**:
- **Mock-up tests**
- **Equipment procurement, on-site installation, commissioning, and actual operation**

4. Conclusion

ANADEC considers D&D is a just-mix of high-tech solutions (e.g. TEΩ600 force-feedback arm) and robust proven solutions. By combining both, the best cost/time/dose compromise can be provided to solve the customer issue.

ANADEC benefits of D&D technologies which are already proven by AREVA in France, Germany, UK and the US. The operational return-on-experience from AREVA and ATOX is an asset of which ANADEC takes advantage to propose solutions to the particular situation of Fukushima-Daiichi.

B04

Radiation Tolerant Camera by Mirion Technologies
The world's highest radiation tolerant performance camera

Ken Takahashi, Tadashi Sato
Cornes Technologies Limited

Introduction

The Mirion (IST-Rees) brand of radiation tolerant cameras is recognized as the market leader and specialist of CCTV & Imaging Systems in the nuclear industry, continuing supplying the systems over 30 years world-wide.

1. Radiation tolerant performance camera

1-1. R93 High Radiation Camera, R942 High Radiation Zoom Camera

The R93 camera, equipped with a non-browning prime lens and the R942 compact zoom camera with a non-browning 12 to 72mm zoom lens are designed to provide high resolution monochrome images in the most extreme radiation environments, such as class leading radiation tolerance of > 2 MGy for the use of periodical inspection purposes, as well as for decommissioning reactors in Nuclear Power Plant. Both cameras are composed of camera, camera controls and cables.

1-2. R981 Compact System Camera

The R981 compact system camera is a pan-tilt-zoom camera with higher radiation tolerant to 1MGy. The camera and pan and tilt are combined into an integral unit with three positions for additional lights and microphone.

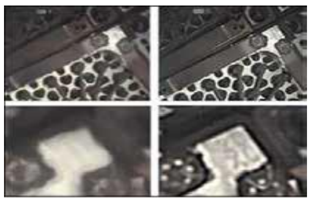
1-3. DOTCAM HR Radiation Resistant Camera, Small Footprint

The Dotcam HR is a miniature color camera designed for use in higher radiation environments, up to a total absorbed dose of 100krad (1kGy), and being equipped with an integral white LED lighting ring, 4.0mm f/5.0 lens and is fully immersible to a depth of 60m.

2. Real-Time Video Deblurring and Processing System for Live Nuclear Core Inspection

The NOTURB® system was developed following many years close collaboration between Techway and EDF.

The Techway NOTURB® video processing system assists operators during outage inspection by removing the effects of underwater thermals when viewing hot fuel assemblies. This can reduce the inspection time required for outages and increase operator confidence in the accuracy of the inspection process. Additional standard features including fuel gap measurement to assist operators in fuel handling operations and a filter to remove radiation induced video noise from CCD or CMOS based camera systems.



A) raw video　B) processed video

B05 3D information technology based support for nuclear decommissioning

István Szőke
Institute for Energy Technology / OECD Halden Reactor Project, Norway

Abstract

New concepts enabled by advanced information technologies are being employed for improving safety and efficiency of the upcoming extensive nuclear decommissioning work worldwide. The need for such techniques is especially clear for degrading legacy and accident sites where safety planning is demanding due to the high radiological and other risks. In this work we present how such modern concepts are applied for improving nuclear decommissioning by enabling effective training and informed safety planning.

1. Introduction

Advanced information technologies like 3D simulation, virtual and augmented reality, advanced user interfaces, and mobile and wearable computing devices support innovative concepts for improving safety and efficiency of nuclear decommissioning projects. Application of such technologies in combination with 3D radiological simulation methods enable planning and training for decommissioning work with an effective perception of risk and readiness for risk mitigation. Hence, such techniques are especially indispensable at degrading legacy and accident sites where a common awareness of the radiological situation, effective training for safe execution of complex jobs and preparedness for reposing well to unexpected situations is crucial.

2. Methods

This work describes how 3D radiological simulation methods in combination with advanced 3D visualization techniques and hardware can be applied for supporting decommissioning of nuclear sites.
At accident sites, for instance, such techniques will enable cost effective training for remote and manual work in environments with high radiation levels (Fig 1).

Figure 1. Training in Virtual Reality

3. Conclusion

Advanced support systems based on 3D simulation are successfully being applied in the decommissioning of a number of nuclear installations (e.g. Chernobyl NPP, Andreeva Bay branch of Northwest Center for Radioactive Waste Management in NW Russia, Leningrad NPP, Fugen NPP) [1-4].

References

[1] I. Szőke, T. Johnsen, *Nuclear Safety and Simulation*, **4**(3), 219-25, 2013.

[2] I. Szőke et al. *Journal of Radiological Protection*; **34**(2), 389–416, 2014.

[3] I. Szőke et al. *Journal of Nuclear Science and Technology*, **52**(3), 371-82, 2014.

[4] K. Chizhov, M. Sneve, I. Szőke et al. *Journal of Radiological Protection*, **34**(4), 755-73, 2014.

B06

Activities of the Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response

Yoshiro Owadano[1],

[1] Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response

Abstract

In order to promote the market entry of manufacturing companies in Fukushima Prefecture to the decommissioning, decontamination and disaster response robotics industry, Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response (hereinafter called "the Consortium") is working to establish a network among manufacturing industries in Fukushima Prefecture and related organizations.

1. Overview of the Consortium

The Consortium was established to support the manufacturing companies in Fukushima Prefecture which intend to participate in the decommissioning and decontamination projects at TEPCO's Fukushima Daiichi NPS, and to expand their business to disaster response robotics by utilizing their technologies developed and accumulated in the decommissioning and decontamination projects. This Consortium organizes technical seminars and business matching events as well as a variety of exhibitions and demonstrations of robots and other products for networking and information exchange with related organizations.

2. Main activities of the Consortium

2-1. Technical seminars and technology matching events

The Consortium provides for its members opportunities to exchange technical information useful in the field. It also offers meetings for discussing various use of the robots under development.

Figure 1. Technology matching events

2-2. Robots demonstration events and exhibitions

These exhibitions could be a good opportunity for the Consortium members to expose their products and technical capabilities, because they can appeal their robots by demonstrating in front of potential customers.

Figure 2. Robots demonstration events

2-3. Other activities

The Consortium members can be supported by expert coordinators. Field survey and site visit to related companies, and information gathering from governmental organizations are possible. Besides, latest project information of new tenders will be provided timely to our members.

3. Unique Features of the Consortium

Because the Consortium is managed by Fukushima Technology Centre, a public testing research organization established by Fukushima local government, the members can exchange information with companies involved in the projects at TEPCO's Fukushima Daiichi NPS, and also can get the latest information about the decommissioning and decontamination projects headed by the national government. Normally, it is difficult for local companies alone in Fukushima to get such opportunities, but the Consortium members have various privileges.

B07

Outline of Robots Developed by the Members of Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response

Yoshiro Owadano[1],

[1] Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response

Abstract

Aiming for the entry into the market of the decommissioning, decontamination and disaster response robotics, member companies of the Fukushima Consortium of Robotics Research for Decommissioning and Disaster Response have developed robots with unique features. Below are some examples.

1. Overview of robots developed by the Consortium members

1-1. Fire Fighting Robot（Kouyou Co., Ltd.）

This fire-fighting robot is configured with no electrical components in the main body, and all parts are powered by water pressure.

Because of such feature, secondary damage doesn’t occur even if this robot would accidentally be broken. It works even in high temperature fire site.

Figure 1. Fire Fighting Robot

1-2. Small electric-powered disaster response robot「SPIDER」（Aizuk, Inc./ The University of Aizu）

“SPIDER” is capable of climbing up and down the stairs and climb over debris by using four sub-crawler that is operational independently.

“SPIDER” applies wireless manipulation using a commonly used game controller and tablet terminal. For this reason, “SPIDER” can search for disaster victims in the site where the person is hard to enter directly because it is too narrow to enter, and may occur the secondary disaster such as landslide and collapse of tunnel.

Figure 2. SPIDER

1-3. Non-contact laser cleaning machine「ELASER」（Tosei EB Tohoku Co., Ltd.）

The cleaning laser device "ELASER" is capable of noncontact dry cleaning without using chemical liquid or abrasive, and no post-processing is necessary.

It can clean impurities on metal surface such as rust, paint, oil content and resin residue by laser irradiation without damaging base materials.

This is an innovative and environmentally-friendly cleaning machine with high versatility, less work and lower cost.

Figure 3. ELASER

2. Others

In addition to the robots introduced above, many other products developed by the Consortium members are available in the market.

We are pleased to introduce our member companies capable of helping your new product development. They can provide proper technical solutions in your business related to the decommissioning and disaster response. So, if you are interested in such services, please contact the secretariat of the Consortium.

C01 Mirion Technologies (Canberra) Experience and Success for Efficiency and Safety Decontamination and Decommissioning

Atsuo Suzuki, Lou Sai Leong and Helene Lefebvre
Mirion Technologies (Canberra) KK

Abstract
Mirion Technologies (Canberra) Inc. (MTC) has more than 30 year experiences of various radiation measurement and safety Decontamination and Decommissioning (D&D). Every type of D&D projects has different requirements and characteristics. MTC proposes a large range of effective products and technologies for D&D. For example, In-situ Object Counting System (ISOCS), Ultra Portable Gamma-Ray Imaging System (iPIX), Alpha/Beta Portable Air Monitor and Depth Profiling of Contamination Distribution technology are already widely applied in Nuclear Facilities worldwide. MTC solutions are the key for efficient and cost effective of D&D.

1. Introduction
Every type of D&D projects has different requirements and characteristics. For example, if you are decommissioning a Nuclear Power Plant, you will predominantly perform gross gamma counting and you will need well-defined waste fingerprints and streams and re-categorization of waste for storage. D&D activities for fuel cycle facilities and research reactors run the risk of criticality accidents and usually require a full re-characterization of the facility prior to decommissioning and a high level of expertise using our products.

2. MTC Products and Technologies
2-1. ISOCS The ISOCS (*In Situ* Object Counting System) Calibration Software brings a new level of capabilities to gamma sample assay by eliminating the need for traditional calibration sources during the efficiency calibration process. ISOCS efficiency calibration is usually more accurate than that of standard source calibration method. With 21 geometry templates available, most objects can easily be modelized. In addition to this, ISOCS Uncertainty Estimator is very strong tool for evaluation of uncertainty.

2-2. Depth Profiling of Contamination Distribution
In-situ Measurement of Depth Tagged Dust Samples (TruPro Technology)
Drill small holes (few cm) but deep (up to 6 m) with a hollow drill, and collect dust samples at various depths (5cm incremental steps). Place the dust samples in a lead shielding, to directly measure on site the activity by high resolution gamma spectroscopy using ISOCS system.
Tools are dedicated drilling system (TruPro) with ISOCS system and iSOLO αβ counting system

Detectors Inserted Inside Drilled Holes
Insert a gamma detector into a drilled hole and shift the detector in several equal or non-equal distance positions. The results give the distribution of activity along the hole axis. In addition, using a gamma simulation code with a Monte-Carlo code based on this result give a better evaluation of radionuclide distribution and dose rate.
Tools are LaBr, HPGe Sealed probe or Geiger Muller. For Software are MERCURAD, MCNP5 and so on.

3. Successful achievements (Activity depth profiling of building in France)
Objects were decommissioning the building, mapping of the walls, the grounds and the floors without releasing any dust. By TruPro Technology and ISOCS calibration and analysis, 280 samples were measured and the project was completed in 21 working days. Our technology was evaluated as follows by EDF. Excellent detection and reduce project timescales and costs, immediate availability of the data and the accuracy of its results allowed the team to identify hot spots.

C02

Active/passive neutron/gamma assay systems for fuel debris and nuclear waste activity and isotopic mass determination

Lou Sai Leong, Atsuo Suzuki and Helene Lefebvre
Mirion Technologies (Canberra) KK

Abstract

CANBERRA has more than 30 year experiences of various automated neutron, gamma and combined Non Destructive Assay (NDA) systems. These systems allow determining the fissile isotopes (Pu/U) quantification, high dose rate activity measurement, in the field of safeguard and safety. This method is widely applied in the world.

1. Introduction

The neutron system is normally consisted of two types of detectors: active and passive detector. We used passive neutron coincidence counter to derive the spontaneous fission. Active counting system is based on the Differential Die-Away (DDA) method which allows separating the prompt neutrons and delayed neutrons.

2. Neutron counting system

2-1. Passive coincidence system

The detection system is based on ^{3}He gas for neutron absorption. The passive assay is able to measure spontaneous fission neutrons emitted by the waste. Recorded signals are analyzed using neutron coincidence or multiplicity electronics, such as shift registers, to derive the **spontaneous fission isotopes mass** (^{238}Pu, ^{240}Pu and ^{242}Pu) of the waste sample.

2-2. Active system

The principle is to use a pulsed neutron generator to produce at a set frequency of fast neutrons. These neutrons will be slowed down in the counter moderator and be absorbed in ^{3}He gas counting system. Quantitative analysis gives the mass of fissile material (^{235}U and ^{239}Pu) which is calculated by the gate of counts between prompt and delayed neutrons signals.

2-3. Gamma spectrometry system

Gamma spectroscopy is able to obtain the isotopes ratio using Multi-group analyzer, especially in Pu/U isotopes mass determination using correlations between fission product and U/Pu content.

3. Experiences

Several projects of customized NDA systems designs were performed for the challenge D&D application in the world, such as high dose rate debris removal in UK or feasibility study of NDA system performance in Fukushima site. These customized NDA systems depends on the characterization on different project.

http://www.canberra.com/literature/brochures/pdf/Waste_Management_Solutions_C49012.pdf

C03

Development of simple and rapid analytical methods for Sr-90 in the contaminated and treated water in the Fukushima Daiichi Nuclear Power Station.

Tomomune MATSUNAGA[1], Takuya NAKAGAWA[1], Takuyo YASUMATSU[1] Hirofumi TAZOE[2] and Masatoshi YAMADA[2]

[1]Tokyo Power Technology Ltd., [2]Hirosaki Univ.

Abstract

It is necessary to improve the analytical methods for Sr-90 for assessment of the performance of decontamination facilities. A simple and rapid method for Sr-90 in the contaminated and treated water in the Fukushima Daiichi Nuclear Power Station is reported. We developed simple and rapid chemical separation of Sr method by automatically controlled solid phase extraction system using Sr-Resin column.

1. Introduction

Multiple decontamination facilities including Multi-nuclide Removal Facility (Advanced Liquid Processing System = ALPS) treat the contaminated water in the Fukushima Daiichi Nuclear Power Station. It is necessary to simplify the analysis of radionuclide, such as Sr-90, to evaluate the performance of the facilities. Furthermore, the demand of Sr-90 analysis has been increased (Fig.1) For the purpose of improvement of the sample throughput and the quality of analysis, we developed simple and rapid chemical separation of Sr by automatically controlled solid phase extraction system using Sr-Resin column.

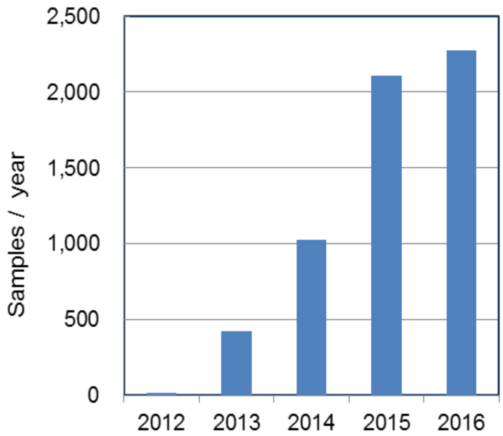


Fig. 1 The temporal variation of the number of Sr-90 data. (estimation value)

2. Experimental

2-1. The automated Sr separation system

The three-way valve and the peristaltic pump was controlled by a sequencer. Operation sequence was programmed for column preparation (cleaning and conditioning) and sample separation (loading, washing and elution) for Sr.

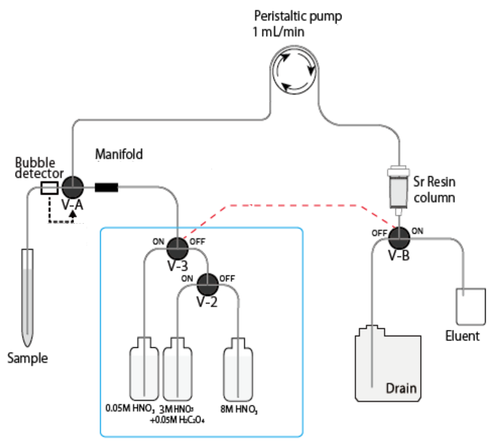


Fig. 2 Schematic layout for the automatic Sr separation system.

2-2. Spike and Recovery Test

Automated separation was performed for simulated sample spiked stable Sr. The elution profile and the chemical yield of Sr in eluent were obtained by ICP-MS analysis. Sr was quantitively recovered (98.4%).

3. Conclusion

The automated Sr separation system make it possible to simplify and hasten chemical separation of Sr. In the future, we will carry out the practical application of the developed system using contaminated or treated water .

C04 ICP Mass-Spectrometric Analysis of Radioactive Strontium Without Calibration Curve

Mizuki Odashima[1], Makoto Furukawa[1,2,3], Katz Suzuki[4], Yoshitaka Takagai[1,5]
[1]Fukushima Univ., [2]Tokyo Univ., [3]Perkin Elmer, [4] JAMSTEC,[5]IER Fukushima Univ.

Abstract

After the accident at Fukushima Daiich Nuclear Power Station, a rapid analysis system for ^{90}Sr, "cascade-type ICP-MS method" was developed.[1] In this study, a mass spectrometric isotope dilution method for the cascade-type ICP-MS is presented. The total run time and high precision can be improved using this method.

1. Introduction

In 2011, East Japan great earthquake occurred and the accident happened at Fukushima Daiichi Nuclear Power Station. ^{90}Sr is difficult to analyze due to fundamental interference in instrumental analysis. Recently, a cascade-type ICP-MS method for ^{90}Sr was developed, and very short time analysis can be conducted as compared with traditional analytical methods. Not only this method but also other quantitative analysis of ^{90}Sr has required calibration curve in quantification analysis. We have invented applying a mass-spectrometric isotope dilution method to the cascade-type ICP-MS. Using the isotope dilution method, the calibration curve is unnecessary; thus the total analytical run time can be improved. In this study, a cascade-type ICP mass-spectrometric isotope dilution method for ^{90}Sr was demonstrated.

2. Experiments

Optimized ICP-MS measurement parameters were used and the mass bias in MS was adjusted to natural isotope abundance ratio (^{88}Sr/^{86}Sr). The sample including ^{90}Sr was added ^{86}Sr-enriched spike solution. The mix solution was measured using cascade ICP-MS. After measurement, amount of stable Sr was quantified by isotope dilution method, and then an amount of ^{90}Sr in the sample was calculated by the intensity ratio (^{88}Sr/^{90}Sr).

2-1. Results and Discussion

The proposed method was optimized for the quantification of stable isotopes (^{86}Sr and ^{88}Sr) and radioactive ^{90}Sr. To demonstrate the efficacy of this method, the spike and recovery tests were conducted under the optimized condition. As these results, stable isotopes were quantified in the concentration range of environmental level. In addition, the results between amount of radioactive spiked and recovered were satisfactorily corresponded. In the application to diluted radioactive contaminated water, the quantification value was corresponded with value which was obtained by typical radiometric analysis.

3. Conclusion

New quantitative method for ^{90}Sr without calibration curve based on isotope dilution method was developed and demonstrated. In this method, the addition amount and the measured values were significantly corresponded. The total analytical run time of presented method became shorted as compared with the previous cascade ICP-MS (original version).

References

[1] Y. Takagai, M. Furukawa, Y. Kameo, and K. Suzuki, *Anal. Methods*, 2014, **6**, 355.

The project is supported by the MEXT, Human Resource Development and Research Program for Decommissioning of Fukushima Daiichi Nuclear Power Station

C05 Development of Quantitative Method for Strontium-90 Using Thermal Ionization Mass-Spectrometry

Chihiro Ito[1], Takashi Miyazaki[2], Shigeyuki Wakaki[2], Katz Suzuki[2], Yoshitaka Takagai[1, 3]
[1]Fukushima Univ., [2]JAMSTEC, [3]IER Fukushima Univ.

Abstract

In the decommissioning of Fukushima Dai-ichi Nuclear Power Station (1F), there are problems in radionuclide analysis, in particular, quantification of ^{90}Sr. In the time, the thermal ionization mass-spectrometric quantification method of ^{90}Sr based on the combination system of an isotope dilution method (ID) and a total evaporation (TE) method is presented.

1. Introduction

^{90}Sr is one of important fission product that is pure β-ray emitter. Typical public analytical method based on radiometric analysis such as a milking process-low background gas-flow counter consumes time from two-weeks to a month. Recently, an inductively coupled plasma mass-spectrometric quantification method for ^{90}Sr analysis was developed; thereby, the rapid and sequence analysis can be achieved. However, in the previous method, there was problem in analytical sensitivity of ^{90}Sr, when environmental samples contained highly concentration of natural stable Sr. To overcome this problem, the highly-precision analysis, isotope dilution thermal ionization mass spectrometry (TIMS), was applied to ^{90}Sr analysis with TE method.

2. Experimental

A trace amount of target Sr nuclide was quantified by TIMS. Quantificational certification was conducted using stable Sr standard solution. Mass observation was m/z = 90 in secondary electron multiplier (SEM) as detector, and other stable Sr nuclides were observed using multi-cup faraday counters. To optimize the TIMS conditions, 1 μL of mixture solution (sample solution containing Sr and ^{86}Sr enriched spike solution (1:1)) was loaded on a filament, and then measured using ID-TE-TIMS.

3. Result and discussion

In the study, 1 μL of sample solution containing Sr and Ta activator was loaded on Re filament. When the sample was measured in the condition of 100 mA min^{-1} (heat-slope) and 4 V (max-intensity for ^{88}Sr), the typical profile of TE-TIMS was obtained (Fig. 1). The run time was 30-40 min which contains ion beam tuning (10 min). As comparison with typical ID-TIMS, the repeatability (relative standard deviation (RSD)) was 0.147 and 0.109% for ID-TIMS and ID-TE-TIMS, respectively. As the results, the quantification values were highly accurately corresponded with additional amount.

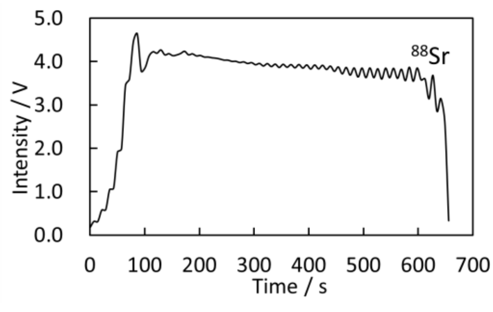


Fig. 1 Signal profile of ID-TE-TIMS for stable ^{88}Sr

4. Conclusion

Precise determination method for Sr using ID-TE-TIMS was proposed. It would be expected to application to ^{90}Sr analysis in highly concentration of stable Sr samples such as concentrated sea water.

The project is supported by the MEXT, Human Resource Development and Research Program for Decommissioning of Fukushima Daiichi Nuclear Power Station

C06

Simultaneous Quantification Method for Radioactive Strontium and Radioactive Iodine in ICP-MS

Hiroaki Ogata[1], Makoto Furukawa[1,2,3] and Yoshitaka Takagai[1,4]

[1]Fukushima Univ., [2]Tokyo Univ., [3]Perkin Elmer, [4] IER Fukushima Univ.

Abstract

In order to sensitively measure β-rays emitter, chemical isolation processes have been required prior to the measurement using a low background β-ray spectrometer or a mass-spectrometry. However, the identification of beta-ray emission nuclides is complicated and consumes long time. In this study, a simultaneous quantitative analytical method for ^{90}Sr and ^{129}I was developed by a split flow path system with cascade ICP-MS[1).

1. Introduction

Large quantities of radioactive contaminated water have been generating from the melted-fuels cooling system in Fukushima Daiichi Nuclear Power Plant. To administrate secure decommission, the development of a rapid analysis for radionuclide has required. Particularly traditional radiometric analysis of β-ray emitting nuclides, ^{90}Sr is complicated and consumes two weeks and more. Similarly ^{129}I is also a beta-ray emitting nuclide and is employed as tracer of environmental dynamics. Recently, a cascade type ICP-MS[1)] was developed for the anlysis of ^{90}Sr within 20 minutes; however, multi-nuclides analysis were difficult in that method. In this study, a split flow path following cascade ICP-MS method presents simultaneous measurement of ^{90}Sr and ^{129}I.

2. Analysis system design

The presented system was constructed basing on a cascade type ICP-MS method[1)] and a split method[2)]. The sample solution splits two directions at a volume ratio of 1:1 in the flow path. One was introduced into a solid phase extraction column for Sr analysis (SPE line). The other flow was directly introduced to ICP-MS for analysis (split line). After switch of the flow path using automatic valve, each flows were sequentially introduced to ICP-MS and measured.

3. Results and discussion

Preliminarily, simulated sample water containing stable isotopes (Sr and I) was measured by this method. As a result, the system was satisfactorily operated as expected. In the simultaneous quantification, the chromatographic peak area of Sr and the average signal intensity of I was employed. Regarding these values of the limit of detection (LOD) can be lower using ultrasonic nebulizer (USN) and coaxial nebulizer for Sr and I, respectively.

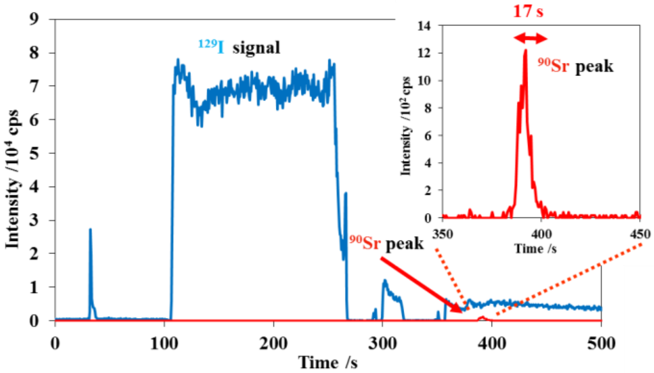


Fig. 1 Signal profile of ^{90}Sr and ^{129}I

From this reason, we have developed new chamber system and it was applied to the addition and recovery test for radionuclides was conducted. As a result, the LODs were 30.4 and 0.01 Bq/L for ^{90}Sr and ^{129}I, respectively (sample volume: 10 mL) with 3.7 and 6.7% of repeatability (RSD (n=3)) for ^{90}Sr and ^{129}I, respectively.

References

1) Y. Takagai, M. Furukawa, Y. Kameo, and K. Suzuki, *Anal. Methods*, 2014, **6**, 355.

2) M. Furukawa and Y. Takagai, *Anal. Chem.*, 2016, **88**, 9397.

The project is supported by the MEXT, Human Resource Development and Research Program for Decommissioning of Fukushima Daiichi Nuclear Power Station

C07

Rapid detection of radioactive Sr using inexpensive reagent and a simple-mass-spectroscopy

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Abstract

We developed a rapid and easy method to detect radioactive ^{90}Sr by a commercial Matrix Assisted Laser Desorption Ionization (MALDI)-tof-mass spectrometer. As a new matrix, dipicolinic acid (2,6-pyridine dicarboxylate) was introduced to select Sr ions for ionization. Analyte ions are separated two dimensionally both by mass numbers, and by affinity to the matrix molecule.

1. Introduction

Since the accident in Fukushima No.1 nuclear power plant, analysis of radioactive substances have been quotidian concern not only for the people inside the disaster area but also for the ones worldwide. For the gamma-emitting nuclides with shorter half-life such as ^{131}I (8 days) and ^{134}Cs (2 years), the decay of the radiation level is quick and can be monitored easily. On the other hand for the nuclides with longer half-life, people feel more anxious about the long-term effect of the radiation. ^{90}Sr is a beta-emitting nuclide, with a half-life of 28.8 years. Detection of ^{90}Sr by the conventional quantitative analysis takes long time (~3 weeks). The necessity of the depthful preparation process to prepare pure Sr from each analyte has prevented us from the rapid and on-demand screening.

As we learned from the last disaster, the peak of the demand for the analysis is supposed to be sudden and tentative. In order to decrease the fear in the mind of the people, we need an easy and rapid method for the rough screening of ^{90}Sr.

2. Methods and results

For MALDI-tof-mass experiments, Shimadzu AXIMA CFR+ was used. Before the experiment, a new stainless sample plate was washed with 1% formic acid, methanol, acetone, and distilled water, following the recommendation in the instrument manual. The way for the sample preparation was simple. A sample solution containing ^{88}Sr and additional impurity ions, and a matrix solution including dipicolinic acid was mixed and spotted on the MALDI-tof-ms sample plate and dried. Measurement was performed in ref ectron-mode.

The results were as follows.

1. Using the dipicolinic acid as a matrix, stable ^{86}Sr, ^{87}Sr and ^{88}Sr peaks were observed depending on its abundance ratio, even with the other impurity ions in the sample solution.
2. All the alkali soil metal ions (Sr^{2+}, Ca^{2+}, Mg^{2+} and Ba^{2+}) are bound to the dipicolinic acid and observed in the mass spectra as singly-charged ions.

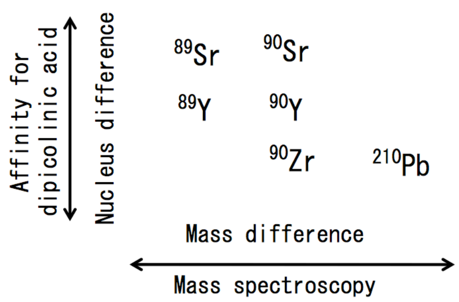

Figure 1. MALDI selection

C08

Laser remote analysis for in-core and in-situ monitoring of debris in decommissioning of Fukushima Daiichi nuclear power station

Ikuo Wakaida, Hironori Ohba, Katsuaki Akaoka, Masaki Ohoba,
Ayumu Matsumoto, Masabumi Miyabe
Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency

Abstract

Radiation resistant optical fiber based laser induced breakdown spectroscopy (Fiber LIBS) is developed for in-core and in-situ elemental analysis of debris and its activity is performed under severe environmental conditions such as high radiation field of about 10kGy/h and under water. Long pulse laser, microwave assisted LIBS for more high sensitivity and liquid sample application are also introduced.

1. Introduction

For the decommissioning of "Fukushima Daiich Nuclear Power Station" which contained damaged or melt downed core, development of rapid, easy, onsite and in-situ remote diagnostic/analysis techniques under the severe environments such as extremely high radioactive condition will be strongly required. In order to accomplish these requirements, the concept of probing by light and diagnostic by light with radiation resistant optical fiber will be one of the simple, powerful and applicable choices as the innovative development based on LIBS technology

2. Optical fiber based laser induced breakdown spectroscopy

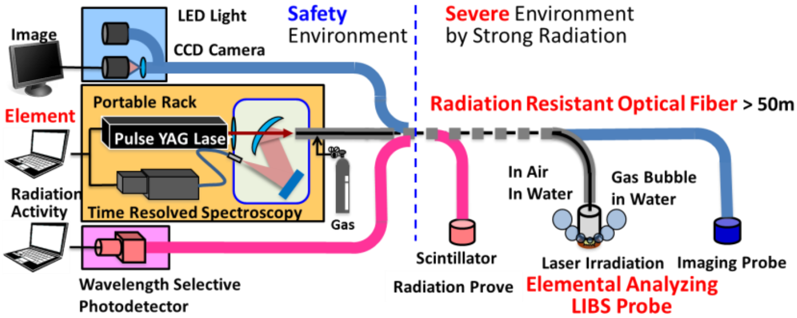

Fig.1 Concept of optical fiber based remote analysis

Optical Fiber based LIBS probe (Fig.1) is constructed, and under water condition, we have successfully observed some specific spectra from the simulated sample of molten debris made by sintered oxide of Zr and U, and also observed the spectrum from simulated metal sample under radioactive condition of 10kGy/h and after total dose of 2MGy. For the use of more longer optical fiber, which will be required for the necessary from on-site or for the human safety, long-pulse laser with the pulse duration about 100 ns will be introduced to compensate the delivery power loss and/or to enhance the emission signal. In the experiment by a metal sample, although the emission intensity was not higher than that by conventional laser, the decay time of the emission came to be longer. And the result, signal enhancement of several times was obtained by the time integration of emission signal. Detailed characteristics of long-pulse laser LIBS are now under studying.

3. Signal enhancement technology and application for liquid sample

As for the signal enhancement technique, microwave assisted LIBS technique coupled with simple antenna for the combination use with fiber LIBS will be under developing, and about ten times enhancement was observed under the atmosphere condition.

For the application to the liquid phase sample, especially for the analysis of the polluted cooling water, the thin-sheet liquid jets will be also introduced as the convenience and high sensitive monitoring for dissolved elements of nuclear fuel debris.

Present study includes the results of "Advanced study on remote and in-situ elemental analysis of molten fuel debris in damaged core by innovative optical spectroscopy" entrusted to Japan Atomic Energy Agency by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT)

D01 Development of the insoluble neutron absorbers using self-assembled surfactant aggregates

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[1]Kao Corporation

Abstract

For the purpose of removing fuel debris from the Fukushima-Daiichi Nuclear Power Plants safely and smoothly, we are developing a re-criticality prevention technology using insoluble neutron absorbers. We have found out that high viscosity fluid insoluble in the water which can hold B_4C particles stably by using the VISCOTOP (complex of alkyl aryl sulfonate and alkyl ammonium salt). VISCOTOP forms self-assembly surfactant aggregates known as a worm-like micelle. We also studied improvement of radiation resistance and elution resistance in hot water using VISCOTOP as a key compound, then found a direction of improvement.

1. Introduction

In an aqueous solution, the surfactants can form various self-assembled aggregates. In many self-assembled surfactant aggregates form, the worm-like micelle can make a fluid with very high viscoelasticity. The worm-like micelle can hold many B_4C particles and can spread on new fracture surface of fuel debris in water.

2. Holding B4C to the worm-like micelle

As the result of having made B_4C holding to 55% to VISCOTOP, it turned out that the insoluble neutron absorbers which has moderate fluidity and the good spreadability on the fuel debris surface can be created.

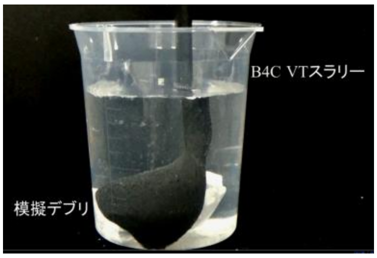

Figure1. Insoluble neutron absorbers using VISCOTOP

3. Radiation resistance of VISCOTOP

If alkyl aryl sulfonate and alkyl ammonium salt were irradiated by strong γ-ray, decomposition will start and viscoelasticity will disappear by decay of a worm-like micelle. We looked for the stabilizing agent, although the decomposition rate improved, it was not enough to maintain of elasticity. When alkyl aryl sulfonate was changed into salicylic acid salt, the decomposition rate improved and elasticity maintained.

4. Elution resistance against hot water

VISCOTOP was solved in hot water. In reactor containment vessel, since water may become high temperature, high temperature resistance is required for it. When the alkyl chain length of the alkyl ammonium salt was changed to long, it became clear that high temperature resistance improves.

5. Conclusion

We developed insoluble neutron absorbers holding many B_4C particles to re-criticality prevention of fuel debris by applying the worm-like micelles. We will continue to improvement examination of radiation resistance and elution resistance against hot water.

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Acknowledgement

This work was performed under the Shared Use Program of QST Facilities.

D02 Corrosion inhibition of carbon steel piping by addition of sodium nitrite and sodium pentaborate

Kazutoshi Fujiwara[1], Junichi Tani[1], Joji Ohta[1], Yuichi Fukaya[2] and Toshifumi Hirasaki[2]

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Abstract

The corrosion inhibition effects of sodium nitrite and sodium pentaborate on the carbon steel piping in flowing diluted synthetic seawater at 40℃ were evaluated. A clear inhibition effect of sodium nitrate on corrosion was confirmed at low linear velocity. The corrosion inhibition effect of sodium pentaborate was confirmed in the range of flow rate used in the experiment.

1. Introduction

In alternative cooling systems for the spent-fuel pool of the Fukushima Daiichi nuclear power plant, the corrosion of carbon steel piping induced by flowing diluted seawater should be carefully considered. Although the water in the present pool has been purified to the level of fresh water[1], further countermeasures to prevent corrosion should be prepared in advance. In the present study, the corrosion inhibition effects of sodium nitrite and sodium pentaborate in flowing diluted synthetic seawater at 40℃ were evaluated.

2. Experimental Procedure

The diluted synthetic seawater at 40 ºC was fed to the tube specimens made from carbon steel. The dilution factor was about 200 and the chloride ion concentration was about 99 ppm. Four specimens were attached to the test section in series. The linear velocity in the tube specimen was varied from 0.6 to 5.3 m/s. Sodium nitrite ($NaNO_2$) or sodium pentaborate ($Na_2B_{10}O_{16}$) was added to the solution and the concentration was increased in a stepwise manner. The change in the wall thickness of the specimen was evaluated by the potential drop method[2].

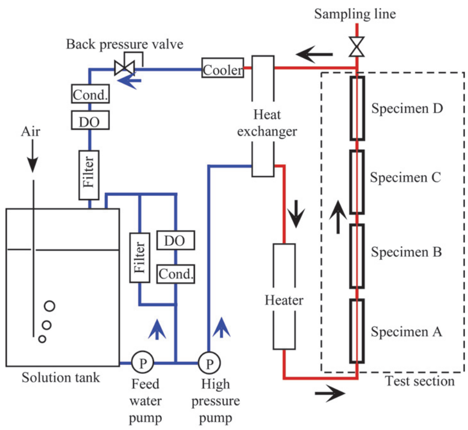

Figure 1. Schematic diagram of loop system.

3. Results

A clear inhibition effect of sodium nitrate on corrosion was confirmed at a low linear velocity. The corrosion rate was decreased to 0.004 mm/y at a linear velocity of 3.2 m/s or less when the sodium nitrite concentration was increased to 14.7×10^{-3} mol/dm^3 or more. At a relatively high velocity of 5.3 m/s, although the corrosion inhibition effect of sodium nitrate was unclear, the corrosion rate decreased to about 0.03 mm/y.

The corrosion inhibition effect of sodium pentaborate was confirmed at velocities of 0.6 to 5.3 m/s. The linear velocity dependence of the corrosion inhibition effect was not confirmed.

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D03 Fundamental study for maintaining integrity of cooling water circulation system: experimental examination of carbon steel corrosion under flow

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Abstract

In order to proceed the decommissioning of the Fukushima Daiichi Nuclear Power Plant safely, it is important to maintain cooling function and piping system for it, most of which is made of carbon steel. This study was conducted to evaluate corrosion rate of carbon steel under flowing conditions by electrochemical tests using rotating cylindrical electrode.

1. Introduction

For the present Fukushima Daiichi NPP, the degradation mode we need to pay the most attention is "corrosion" of key components made of metals. In order to maintain cooling systems, a technical package including understanding rate limiting mechanism of corrosion and effects of key variables on the rate, accurate prediction of wall thinning rate in the piping systems, and wall thickness monitoring at key locations, is needed. The key factors would include flow velocity, dissolved oxygen, pH, chloride ion, gamma irradiation, sodium bicarbonate, sodium pentaborate, and etc. This study aims to understand rate-determining process of carbon steel corrosion under current and future Fukushima Daiichi NPP conditions as functions of flow conditions and dissolved oxygen level by using electrochemical tests with rotating cylindrical electrodes.

2. The study on the rate determining process based on the characteristics of the polarization curve

Polarization measurement was carried out as functions of flow conditions (rotative velocity of a cylindrical electrode) and dissolved oxygen level, and the rate-determining process of the corrosion was investigated. The obtained cathodic polarization curves were classified into four types based on comprehensively judging presence / absence of diffusion limit current, influence of flow on cathode current density, and corrosion potential. As an example, Fig. 1 shows the results of polarization measurement under different conditions of the dissolved oxygen concentration with the rotation speed fixed at 2000 rpm. When the dissolved oxygen concentration is as low as below 10ppb, since the dominant cathodic reaction is reduction of water, the charge transfer determines the corrosion rate, so there is no influence of flow on the cathode polarization curve and a linear portion appears (Type 1). When flow rate or oxygen partial pressure was slightly increased, both reduction reactions of water and dissolved oxygen together contribute to cathodic current density. In this condition, diffusion-limited current density of oxygen could not be identified (Type2). When dissolved oxygen concentration is high enough and the reduction of oxygen is the dominant cathodic reaction, a diffusion-limited current density appears in the cathodic polarization curve (Type 3). Furthermore, when oxygen is sufficiently supplied to the steel surface, both the charge transfer process and the diffusion process of the oxygen reduction reaction determine the reaction rate, so that the cathode polarization curve draws a curve (Type 4). Also, it was confirmed that the corrosion potential was lowered by the increase in dissolved oxygen concentration or flow rate.

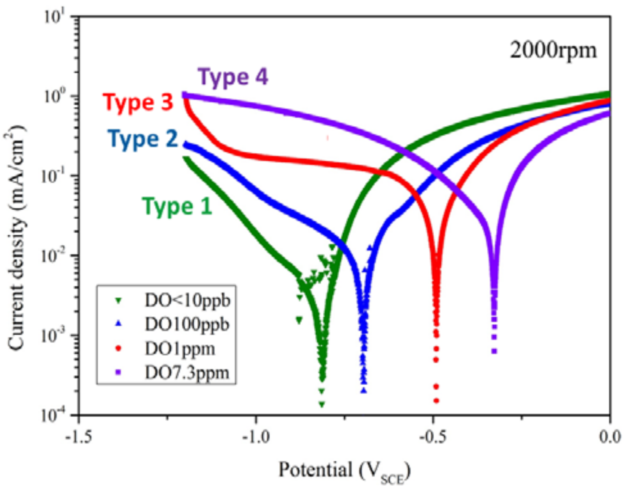

Fig.1 Results of polarization measurement

3. Conclusion

In order to understand rate-determining process of carbon steel corrosion as functions of flow condition and dissolved oxygen level, polarization measurement was carried out using rotating cylindrical electrodes. The results indicated the rate-determining process changes depending on mass transfer rate of oxygen and provide database to develop prediction model of corrosion in the coolant circulation systems of Fukushima Daiichi NPP.

Acknowledgment

This study is the result of "Fundamental Research and Human Resources Development Program for Nuclear Decommissioning related to Integrity Management of Critical Structures including Primary Containment Vessel and Reactor Building, and Fuel Debris Processing and Radioactive Waste Disposal" carried out under the Center of World Intelligence Project for Nuclear S&T and Human Resource Development by the Ministry of Education, Culture, Sports, Science and Technology of Japan.

E01 SFP Fuel Removal at Fukushima-Daiichi NPS

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Abstract

About 3000 fuel assemblies were stored in 4 Units at March 11 2011.We planned that they were transported to the Common Pool and stored there. However, about 6400 fuels had already been stored in the Common Pool at that time. Therefore, Temporary Cask Custody Area (TCCA) was newly built to store fuels that were in the Common Pool in order to ensure free space.

1. Introduction

On March 11, about 3000 fuels were already stored in 4 unit's SFPs. So removing those from SFPs and transporting to the Common Pool for safe-storage were intended.

2. Outline of fuel removal

2-1. Introduction

Unit 1, 3 and 4 R/Bs were damaged and FHMs and cranes became out of order. Therefore, new installation of those after completion of rubble removal and sufficient decontamination was required. For unit 2, R/B wasn't broken but a radiation dose was high in the operating floor. So first of all, needed to implement sufficient dose reduction and removals of walls and ceilings in order to set up new FHM and crane.

2-2. Preparations of fuel removal

For unit 3 and 4, removals of rubbles and machines of operating floors were completed. For unit 1, works are still in progress; investigation and removing process are now taken on the operating floor. For unit 2, walls and ceilings of the operating floor will be removed.

2-3. Fuel removal

For unit 4, a new FHM and a new crane were installed, that equivalent to the previous machines, and removed all fuels during period of time of Nov. 2013 to Dec. 2014. For unit 3, a new remote control FHM and a crane are under construction to start removing fuels from 2018. For unit 1 and 2, currently we are examining to install new machine.

3. Related Facilities

3-1. Common Pool

About 6400 fuels had already been stored in the Common Pool whose storage capacity was about 6800 fuels at March 11. After that time, about 1000 of them were removed to TCCA and about 1400 fuels were transported from unit 4 to there.

3-2. Temporary Cask Custody Area

TCCA was built after March 11. It is stored about 400 fuels which were stored in the Cask Custody Building and about 1000 fuels which were stored in the Common Pool.

4. Conclusions

For unit 3, removal of fuels will be started in 2018, and part of fuels in the Common Pool will be removed to TCCA accordingly. For unit 1 and 2, preparations of fuel removals will be proceeded surely and safely.

E02 Unit-3 Covering Structure Plan for Spent Fuel Removal and Work Progress

Shinya Okada[1], Kenichiro Go[1], Takashi Inoue[1], Norio Ryoki[1], Taimei Hida[1], Atushi Kikuchi[1], Kazuhiro Kato[1], Miho Miyazaki[1], Ippei Matsuo[1], Kihei Ogawa[1]

[1]Kajima Corporation

Abstract

Unit-3 covering structure plan for spent fuel removal is outlined: (i) reduction of radiation dose rate for constructing cover structure, (ii) decontamination and shielding by remote control, (iii) design of cover structure, (iv) practice for fabricating cover structure and (v) constructing cover structure at Fukushima site.

Cover structure is currently under construction at Fukushima site.

1. Reduction of Radiation Dose Rate for Constructing Cover Structure

The rubble removal, decontamination and shielding were performed to reduce radiation exposure in construction work of the cover structure for fuel removal.

2. Decontamination and Shielding by Remote Control

The decontamination and shielding were performed to further reduce dose rates since they were still high even after removing the rubble.

1) Large concrete rubble was removed by Bucket attached 600ton-Crawler crane.

2) Small concrete rubble was collected by Dozer and removed by Vacuum.

3) Penetrated contamination was removed by Scabbler.

4) The shielding plates were installed by remote control to further reduce the radiation dose rates.

3. Design of Cover Structure

1) The weight of the cover was reduced using dome-shaped steel frame.

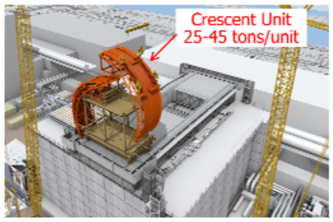
2) The vertical and horizontal loads to the reactor building were reduced as much as possible.

4. Practice for Fabricating Cover Structure

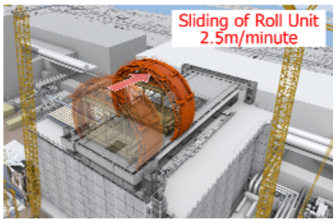
We have practiced fabrication of the cover structure at the area with no radiation effects to steadily construct it without reworking at Fukushima Site.

5. Constructing Cover Structure at Fukushima Site

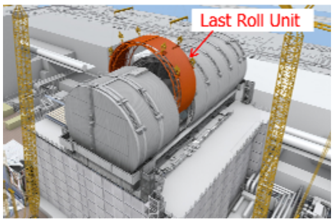
Since the cover structure will be constructed partially by manned work, the reduction of dose rates are crucial for the construction work at the site.



Fabrication of Roll Unit



Sliding of Roll Unit



Installation of the Last Roll Unit

H01

Study for the Bottom Access Route to remove the Debris from the Nuclear Reactor Buildings

Atsuo YAMADA[1], Hisashi IMAI[1], Masanori IMAZU[2], and Toshihiko FUKUDA[2]

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[2]Technological Strategy Group, Nuclear Damage Compensation and Decommissioning Facilitation Corporation

Abstract

It is important to remove the fuel debris from the primary containment vessel (PCV) and/or the reactor pressure vessel (RPV) for the decommissioning of the Fukushima Daiichi Nuclear Power Plant. Authors investigated the possibility of the construction of an access route for removing the fuel debris from the basements of the nuclear reactor buildings.

1. Access from the bottom of the PCV

As results of investigation of conventional techniques, it is possible to construct the access route from the surface to the basements by using civil engineering methods (a shield tunneling method, an open caisson method, and so on). It is considered that an all casing method will be able to make an approach hole through the base foundation of the buildings. However the problems, such as sealing of bearings of boring tools, and so on, are left behind. A clear perspective is not necessarily provided under the present conditions about such problems.

2. Conclusion

As described above, regarding bottom access retrieval method, even if a route for the bottom-access can be established, a lot of critical issues are involved in the subsequent management of contaminated water and fuel debris retrieval work. Therefore, since its feasibility was evaluated as low for a short or mid-term time period to be developed and verified, this option will not be focused in the studies for the practical application.

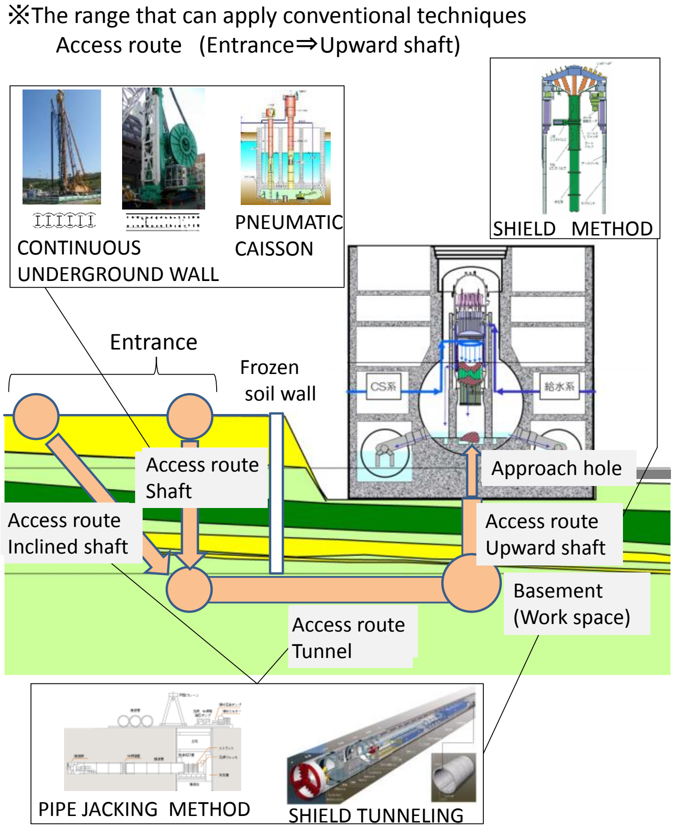

Figure 1. Outline of the bottom access route

References

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H02

A proposal of the New Method to Retrieve Fuel Debris with Geopolymer

Taichi Sakai, Takayuki Saimu, Shunichi Suzuki and Koji Okamoto

(The University of Tokyo)

Abstract

In order to retrieve fuel debris from 1F plants, we need to overcome many difficulties. In this paper, an alternative method where a variety of fuel debris are retrieved after grouting with geopolymer is proposed. This method simplifies the control items during fuel debris retrieval and also has advantages on the waste management.

1. Background

For decommissioning of 1F Plants, three methods to retrieve fuel debris such as a submersion method and in-air methods have been discussed [1]. These methods have their own merits and demerits, while the detailed planning have not been decided yet [1]. In this paper, an alternative method to solve these problems [2] is discussed.

2. Geopolymer Grouting Method

2-1. Outline of Geopolymer Grouting Method

First, the water-stopping technology being developed by IRID is applied for isolating PCV from S/C. Secondly, the grouting material, geopolymer is injected on the MCCI products at the bottom of the PCV. Then the radiation-shielding concrete is put on geopolymer to reinforce the radiation shielding ability. After that, a platform is constructed in the pedestal to retrieve fuel debris (Fig.1).

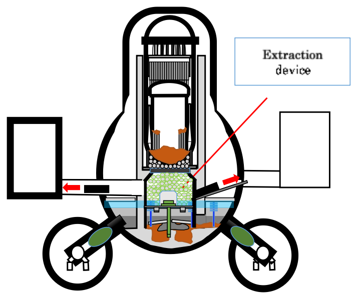

Fig 1. An Image of the Platform

2-2. Advantages

In this method, various effects are expected including stabilization of the MCCI products. For example, (a)isolation of PCV from the torus, (b)prevention of alpha-nuclides' dispersion, (c)reduction of operational control items and (d)long time storage because of less hydrogen generation are expected.

2-3 Research items

There are some issues to be considered in this method. One is the evaluation of the workability of geopolymer and another is the heat removal of fuel debris buried by geopolymer with or without water cooling. Researches on these items are currently going.

3. Conclusion

A new method to retrieve fuel debris is proposed, where there are multitudinous effectiveness and some accompanying issues such as the workability of geopolymer and the heat removal with heat pipes.

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J01 Practical Uses of the CW Single-Mode Fiber Laser Decontamination Device Technology

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LDD Corporation (Laser Decontamination and Decommissioning Corporation)

A new continuous- wave (CW) single-mode fiber decontamination device[1,2] has been developed to evaporate instantly with almost no temperature rise and to clean up the radioisotope (RI) contaminated stainless steel-, other metals- and concrete- made components, devices and major structural objects of nuclear power station, nuclear fuel reprocessing plants, accelerator facilities and the related ones. The laser decontamination device typically delivers the tightly focused laser light of multi- GW/cm2 just on the surface to clean up RI contained rust mold on and inside the stress corrosion cracks and corrosion pitting in the stainless steel-made components, devices and objects. The decontamination device is newly designed to measure 3-dimensional surface map very quickly, and successfully to peel the 3-dimensional irregular surface according to the measured map using the 3 dimensional fast scanner, displacement meter and laser system. In the cold tests, the device performed to peel off the surface of cans and multi-stepped plates very precisely, very uniformly and very quickly.

The laser cleaning trials over several years were performed to decontaminate the 60Co and others of RI heavily contaminated stainless steel samples cut from the pipes and plates in the primary cooling loop, and were successfully demonstrated to clean up using the decontamination device to be a few tens of Bq/kg or less. The heavily RI contaminated stainless-steel ones of 1MBq/kg were performed to clean up using the device, and were successfully reached to be not detected in the final trial year. The laser irradiated surface in the RI contaminated materials has the temperatures extremely higher than sublimation and boiling points, therefore the irradiated and contaminated ones are blown away by quick sublimation and instant evaporation, and steam explosion in the stainless steel, other metal alloys and concrete ones. Unlike the method using the CW single-mode fiber laser decontamination device technology, other conventional methods using sand blasting, wet blasting, pulsed laser and laser gouging have no abilities to clean up completely the surface of the RI contaminants so that some of the RI contaminants remain long time in the surface.

The CW single-mode fiber laser decontamination device technology has been developed over these 10 years in the Japan Atomic Energy Agency, ATOX Co., Ltd., Nishi-Nihon Create Co., Ltd., Wakasa Industrial Technical Engineering Co., Ltd., the Wakasawan Energy Research Center, and LDD Corporation. The CW single-mode fiber laser decontamination device will be manufactured and supplied in the first time in the world by LDD Corporation.

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J02 Direct decontamination technique by fiber laser

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The Wakasa Wan Energy Research Center

Abstract

A laser decommissioning technique was developed using focused continuous wave (CW) fiber laser light. The laser decontamination setup is designed to peel the surface using fast scanner. In cold tests, the surface of mortar test pieces with a depth of 0.1mm was peeled off at a rate of >1m^2/h. The details of the laser decontamination will be presented in the presentation.

1. Introduction

Laser decommissioning techniques have several advantages such as reduction of the generation of secondary waste materials and remote controllability, compared with the conventional techniques such as abrasive water jet, abrasive sand jet and mechanical peeling techniques. Further development of the laser decommissioning technique is indispensable for removal of contaminated stainless steel and concrete surface. The present research was undertaken to peel off mortar surface controlling laser power and scanning speeds.

2. Overview of our laser decontamination technique

Characteristics of our technique are irradiating focused laser light for surface. By focusing, laser light energy density will exponentially increases. This focused laser light causes various interaction instantaneously to peel off the surface of mortar. To scanning this laser light, we can take contactless peeling effect in plane as shown in Fig. 1.

The characteristics of laser light showing contribution for our decontamination technique are as drawing follows.

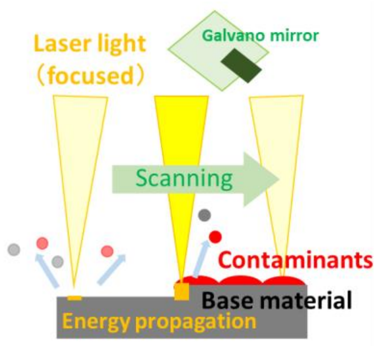

Fig. 1. Pattern diagram of laser decontamination

- Laser light is non-polluted.
- Easily take highly energy density by focusing.
- Restrictions by weight reactions and working distance are ignorable.

So our technique can decontaminate most targets in principle by these characteristics. To collecting peeled contaminants only, the volume of radioactive waste is reduced. Furthermore, our technique can design freely upon request of decontamination work site like miniaturization for narrow part decontamination and high-power laser (kW class) usage for high speed decontamination.

3. Conclusion

From our experiment by prototype laser decontamination setup, this technique can peel mortar test piece surface (as same as concrete surface) over 1 m^2/h (0.1mm depth, calculated). In the presentation, we will show our laser decontamination setup and peeling result by scanning laser.

References

J03

Sorting of contaminated soil based on radiological separation -experiences with a high performance mobile belt conveyor system-

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[1]NUKEM Technologies Engineering Services GmbH

Abstract

The existing, containerized, mobile belt conveyor system offers radiological characterization of soil with potential contamination. A set of gamma spectrometers is used to sort the material and to direct it to respective waste streams and containers, thus reducing the volume for subsequent treatment. The system also obtains information and generates documentation to accompany the characterized material in accordance with regulatory requirements.

1. Purpose of the belt conveyor scanning system

- Radiological characterization via gamma spectrometers
- Classification of contaminated bulk material
- Sorting and filling of the material
- Volume reduction for subsequent treatment
- Generation of sophisticated documentation per package
- Comparison with regulatory limits

Figure 1. Belt conveyor system on site

2. Achieved benefits

- Volume reduction regarding expensive disposal routes
- No secondary waste generated
- No need for process media
- Detection of Alpha-, Beta- and Gamma- emitters
- Evaluation of spatial activity distribution
- Proven toughness for construction site application
- Filling in containers according to customer's requirements

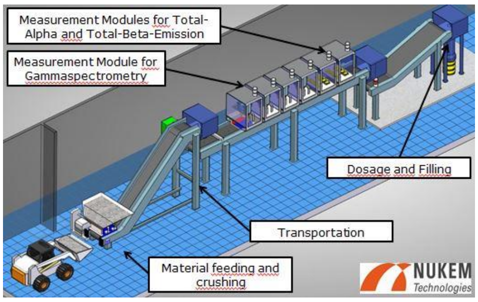


Figure 2. General layout

3. Technical Data

Throughput up to	100 tons per hour
Batch size	1000 kg
Detection limit	< 0.005 mSv/h
Installation size	3x 40' transport containers

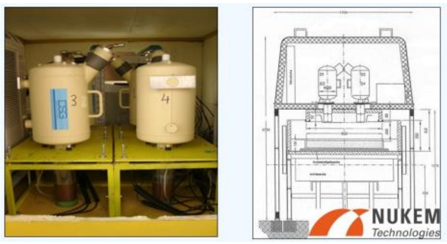


Figure 3. Detection system

3. Conclusion

This mobile belt conveyor system automatically sorts the soil into three different material streams (free release, limited release/utilization on site, radioactive waste) and can be optimized to customer's needs.

References: www.nukemtechnologies.com ; jochen.petermann@nukemtechnologies-si.de

K01

Development of Polymeric Aluminosilicate Agent for Cation Removal

Takenori Masada[1,2], Masahiko Matsukata[2] and Atsushi Yamazaki[2]

[1]Azmec Inc., [2]Waseda Univ.

Abstract

Polymeric aluminosilicate agent for cation removal was developed by applying geo-polymer technique. Novel adsorbent had approximately 400 cmol(+) kg^{-1} of cation exchange capacity, and high selectivity to Sr^{2+} ion.

1. Introduction

Geopolymer is a hardening body synthesized by reacting calcinated kaolin or fly ash in a highly concentrated alkali. Geopolymer is basically composed of poly-silicate network structure with SiO_4-AlO_4 tetrahedra crosslinked by oxygen. The network structure has nano-size pore system, and contains cation exchange site derived to compensate charge balance drived from 4-coordinated Al^{3+}. We tried to develop a novel agent by applying geopolymer to. This agent showed characteristics of ion exchange.

2. Characteristic of developed polymeric aluminosilicate agent

Developed agent was obtained by optimizing a wide variety of synthesis conditions. Generally, geopolymer should have silica-rich compositions to obtain sufficient mechanical strength. Our novel adsorbent has a wide range of aluminum-rich composition of SiO_2/Al_2O_3 molar ratio 2.0 to 4.4. In particular, suitable compositions for cation removal use was SiO_2/Al_2O_3 ratio < 3.0.

The agent developed showed approximately 400 cmol(+) kg^{-1} of cation exchange capacity being almost equal to that of synthetic zeolite, and a high adsorption selectivity to Sr^{2+} and several minds of heavy metal cation. The agent can be synthesized under low cost and energy saving conditions, at 20-100°C and atmospheric pressure.

3. Adsorption characteristics of Sr^{2+}

Adsorption test was performed to evaluate of the adsorption characteristics of novel agent. Test method was as follows: granule adsorbent in the range of 0.5 to 1.0mm was added into a strontium chloride aqueous solution or the artificial sea water (100%) with the solid liquid ratio of 1: 100 or 1: 500. The test results after 24 h of vigours strring was evaluated by using ICP-AES. Table 1 lists the test results, showing a high distribution coefficient of Sr even in the sea water containing high concentrations of Mg and Ca ions.

Table 1 Test Results of cation removal

Test solution	solid liquid ratio	Concentration of Sr［mg/L］		Removal Ratio［%］	Distribution coefficient［ml/g］
Strontium chloride solution	1:500	stock	**9.23**	**-**	
		After treatment	**0.005**	**99.9**	**9.2×10^5**
Artificial sea water (100%)	1:100	stock	**7.21**	**-**	
		After treatment	**0.10**	**98.6**	**7.1×10^3**

4. Conclusion

Developed adsorbent showed high cation exchange capacity and a high distribution coefficient of Sr^{2+} in solution, resulting in a high selectivity to Sr^{2+}..

References

[1] "Ion Exchange Characteristic of Aluminosilicate adsorbent", Takenori Masada, Masahiko Matsukata, Atsushi Yamazaki, SCEJ 80th Annual Meeting, March 2017

K02 Environmental Risk Analysis for Radionuclides Transported in Groundwater of Fukushima Daiichi NPS

CRIEPI* T. Koyama, Y. Tanaka, D. Tsumune, T. Hijikata, Y. Tateda, T. Hattori
NDF** M. Imazu, M. Kamoshida, A. Hasunuma, K. Hida, A. Ono, T. Fukuda
* Central Research Institute of Electric Power Industry
**Nuclear Damage Compensation and Decommissioning Facilitation Corporation

Preliminary radiological risk analysis was carried out for the radionuclides assumed to be transported through groundwater in Fukushima Daiichi NPS. The result shows radiation dose will be kept in very low, less than 1E-5 mSv/year, until 2111 even when contaminated PCV water is assumed to be leaked during debris retrieval.

Introduction

In many countries having contaminated nuclear facilities [1], "radiological risk assessment" has been developed as a key measure to decide actions for cleanup of contaminated sites and control of emissions to the environment. As a preliminary risk assessment, radiological risk analysis was carried out for the radionuclides to be transported through ground water.

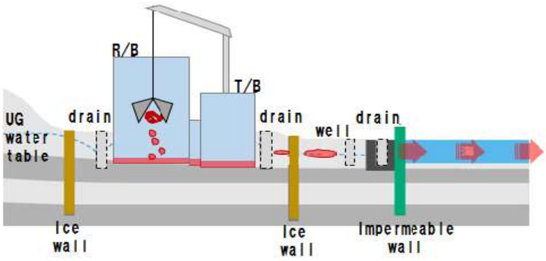


Fig. 1 Assumed pathway of contaminated water

Analytical model

Most of the current countermeasures to manage contaminated water were assumed to be continued during decommissioning. Source terms were the contaminated ground water currently existing around reactor buildings and the PCV water contaminated with cutting powder of fuel debris. Fig.1 illustrates the countermeasures and the assumed pathway.

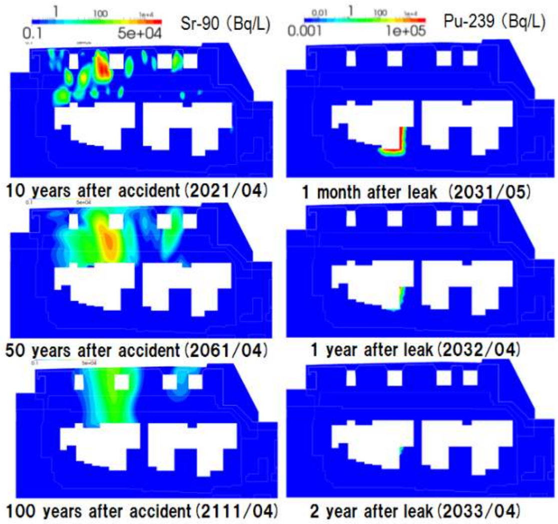


Fig.2 Behavior of radionuclides in ground water (left) reference case (right) risk case

Results & discussion

Fig. 2 (left) shows the future of Sr-90 distribution in groundwater around reactor buildings. As the water levels of drains around buildings are assumed to be kept below sea level during decommissioning, Sr-90 plumes move from sea side to buildings. Then the plumes move back to sea side because most of the countermeasures are assumed to be ineffective after decommissioning. Public radiation dose through ingestion of sea foods contaminated with radioactive nuclides permeated through impermeable sea wall was calculated to be kept very low, <1E-5 mSv/year. Because leaked radionuclides are collected by drains within few years as shown in Fig. 2 (right), similar low radiation dose is expected when contaminated PCV water leaked into groundwater.

References

[1] A. Clark, "A risk-informed approach to decommissioning and remediation", The 1st Int'l Forum on the Decom. of Fukushima Daiichi NPS.

K03

Continuous Challenges to Improve Performance, Availability and Operational Cost of Contaminated Water Treatment Systems for Fukushima Daiichi

Teruki Fukumatsu[1], Masaru Nishikubo[1], Masahiko Kobayashi[1], Keiji Ishikawa[2], and Kei Kobayashi[2]

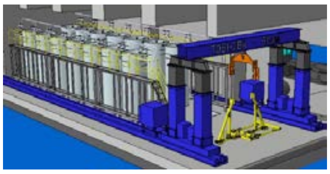
[1]Toshiba Corporation, [2]Tokyo Electric Power Company Holdings, Incorporated

Abstract

TEPCO and Toshiba have developed water treatment systems in Fukushima Daiichi to manage problems of contaminated water produced by fuel debris cooling and ground water intrusion to buildings. Water treatment systems consist of Cesium Reducing Device to utilize contaminated water as coolant of fuel debris, and Multi-nuclide Removal Facilities to remove radioactive nuclides except Tritium. Those devices and facilities have been operated to manage contaminated water, and also have been improved their adsorbing materials and operation condition to fit to changes of characterization of contaminated water.

Especially, the Second Cesium/Strontium Reducing Device (SARRY™) developed by Toshiba treated more than 80% of contaminated water to be treated by Cesium/Strontium Reducing Devices, and the improved SARRY™ is now planned to be installed as the Third Cesium/Strontium Reducing Device (SARRY™ -II). Also, the Multi-nuclide Removal Facility (MRRS™) and Improved MRRS™ developed by EnergySolutions and Toshiba have treated more than 90% of contaminated water to be treated by Multi-nuclide Removal Facilities. SARRY™ and MRRS™ use adsorbing process to simplify their process and operation. TEPCO and Toshiba continue to develop the materials, adsorbents for the systems and their processes in order to improve performance and availability, reduce the operational cost of the systems.

1. Outline of SARRY™



SARRY™ was developed and installed by Toshiba and it has been in operation from June 2011, which followed the Cesium Reducing Device installed by Toshiba, has treated about 170Million m^3 of contaminated water using less than 170 m^3 of adsorbent. It means the SARRY™ causes secondary waste of less than 1/1,000,000 of treated water in volume. SARRY™ has been improved to fit to changes of characteristics of contaminated water, by developing Cs/Sr simultaneous adsorbents, and by optimizing schedule of replacing columns, etc. Cs/Sr simultaneous adsorbents, also reduces dose rate on the border of Fukushima Daiichi due to water treatment systems. Improved SARRY™ is planned to be installed by Toshiba and in operation in 2017, to reduce contaminated water of turbine buildings.

2. Outline of MRRS™

MRRS™ has been developed and installed by Toshiba and it has been in operation from March 2013. MRRS™ has treated more than 600,000 m^3 of contaminated water and reduced the volume to less than 6000m^3 in 2,400 of High Integrity Containers. MRRS™ is a system consists of multiple adsorbents and effective pretreatment process to retrieve multiple nuclides. We have been developing and improving the materials, adsorbents and its processes.

3. Conclusion

SARRY™ and MRRS™ significantly contribute to manage water issues of Fukushima Daiichi. We will also try to improve performance and availabilities, minimize the operational cost of the systems, amount of secondary waste from waste treatment systems.

K04

Development of New Radioisotopes Selective Adsorption Media in EBARA

Takashi Sakuma[1], Makoto Komatsu[1], Tatsuya Deguchi[1], Kaoru Kikuchi[1], and Takeshi Izumii[1]

[1]EBARA Corporation

Abstract

EBARA has been developing radioisotopes selective adsorption media for treatment of contaminated water since 2011. During this period, 800 kinds of adsorption media were supplied from some manufacturers and the radioisotope removal efficiency was tested. These media have been successfully used at NPS in Japan to process radioactive contaminated water and contribute the settlement of severe accident occurred in March 2011. This paper introduces the media which has high removal efficiency of radioisotopes.

1. Radioisotopes Selective Adsorption Media

1-1. Advantages

These media have big advantages as follows, 1) large decontamination factor (DFs), 2) increases media troughputs, 3) reduction of waste generation, 4) reduction of radiation exposure to operators by reducing the frequency of media exchange.

1-2. Adsorption Media

EBARA media consist of organic or inorganic material. These media can remove Cs,Sr,I,Sb and Ru. EBARA also developed the media which can remove Cs and Sr at the same time.

1-3. Test Results

The batch test results are shown in Figure 1 and 2.

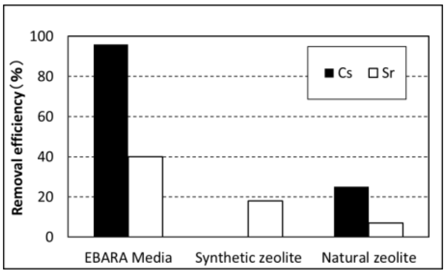


Figure 1 Cs/Sr Removal efficiency under seawater condition

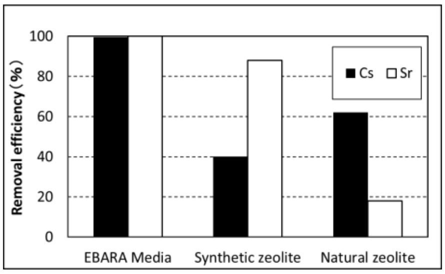


Figure 2 Cs/Sr Removal efficiency under diluted seawater condition

2. Conclusion

EBARA media removes specific ions from contaminated water efficiently and economically, are available in several process to accommodate the needs of any project. We are going to develop the radioisotopes selective adsorption media for farther waste water treatment such as decommissioning.

K05 Development of Decontamination Technologies for the Contaminated Water in Fukushima Daiichi Nuclear Power Station

Takatoshi Hijikata, Koichi Uozumi, Kenta Inagaki, Takeshi Tsukada and Tadafumi Koyama
Central Research Institute of Electric Power Industry (CRIEPI)

Abstract

CRIEPI has supported the operation of the decontamination system for high radioactively contaminated water in Fukushima Daiichi Power Station since the accident. Results of several tests and simulations clearly explained the several phenomena that occurred on the actual columns of the KURION system. Moreover, the permeable reactive barrier (PRB) of H4 tank area was installed using our recommended zeolite.

1. Introduction

CRIEPI has been studied the removal technologies of radioactive nuclides in molten salt by using zeolite. After large earthquake in 2011, these technologies were applied to the various decontamination of the high radioactive contaminated water in Fukushima Daiichi Power Station.

2. Decontamination system for the high radioactively contaminated water

The equilibrium capacity of KURION media to absorb Cs was determined by batch tests using mixtures of sea water and oils [1]. Adsorption kinetics in columns was verified by experiments of a small-scale zeolite column [2]. The code was developed to simulate the actual column system [3]. The kinetic parameters (film mass transfer coefficient and effective intra-particle diffusivity) in the actual column were estimated by combination of these column tests and simulation code. The DF (Decontamination factor) of the actual KURION system was examined by the simulation using the estimated kinetic parameter. As shown in Fig. 1, the calculated DF value of Cs agreed well with the measured value.

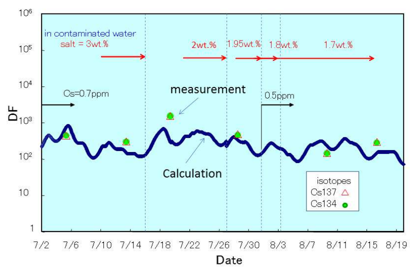


Fig.1 Simulation DF of Cs.

3. Permeable Reactive Barrier for the contaminated ground water (H4 Tank area)

PRB has been introduced in Hanford and West valley sites in U.S.A. to remove radioactive nuclides in the contaminated groundwater. CRIEPI revealed that the performance of Sr adsorption on natural zeolite was better than that on apatite as shown in Fig.2. The permeable reactive barrier (PRB) of H4 tank area was recommended the natural zeolite [4].

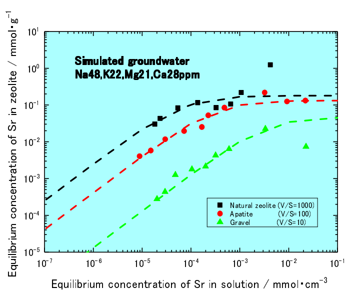


Fig.2 Absorption isotherm of Sr in simulated groundwater.

4. Conclusion

CRIEPI has supported to solve the various difficulties of the contaminated water in Fukushima Daiichi Power Station.

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[1] T. Tsukada, et al., J. Nucl. Sci. Technol 51, 7–8, 886–893 (2014).

[2] T. Hijikata et al., ibid ,51, 7-8, 894-905 (2014).

[3] K. Inagaki et al., ibid, 51 7-8, 906-915 (2014)

[4] Tokyo Electric Power Company Ltd., http://www.tepco.co.jp/nu/fukushima-np/roadmap/images/d140627_07-j.pdf.

K06 Installation of Land-side Impermeable Wall –Frozen-soil Walls at the Fukushima Daiichi Nuclear Power Station

Hiromitsu Kida[1], Atsuhiro Fukada[1], Isao Abe[1], Taichi Esaki[1], Shoji Seno[1] and Teru Yoshida[1]
[1]Kajima Corporation

Abstract

Artificial frozen soil walls have been installed, as a measure against the increase of contaminated water, surrounding four damaged nuclear reactor buildings at the Fukushima Daiichi Nuclear Power Station, Tokyo Electric Power Company (TEPCO). Purpose of the Frozen-soil Walls is to cut off the groundwater inflow to the buildings, which would become highly contaminated inside the buildings.

1. Background

At the Fukushima Daiichi Nuclear Power Station, approximately 600m^3 of groundwater has been pumped up every day and stocked in tanks by TEPCO. Almost half of the above (300m^3) is estimated to seep into the damaged reactor buildings. To cope with this issue, the Committee on Countermeasures for Contaminated Water Treatment, organized by the Ministry of Economy, Trade and Industry (METI), decided a basic policy in May, 2013, i.e. the installation of the Frozen-soil Walls.

2. Construction

To form seamless Frozen-soil Wall, approximately 30m long vertical freezing pipes were installed into the ground surrounding the buildings with an interval of 1m. As the freezing operation, brine solution, cooled down to -30 degree Celsius, has been circulated through the freezing pipes, since March, 2015. Grouting method was also applied partially to reduce the groundwater flow across the frozen wall being formed.

Total horizontal length of the completed wall is about 1,500m, which is definitely one of the largest artificial frozen soil body ever made in the world.

3. Monitoring

To grasp the freezing behavior, ground temperatures have been monitored. The temperature sensors (optical fibers) were installed inside vertical tubes, every 5m along the Frozen-soil Wall. In addition, discontinuity of groundwater level along the Frozen-soil Wall has also been checked, using observational wells, to confirm the completion of the wall.

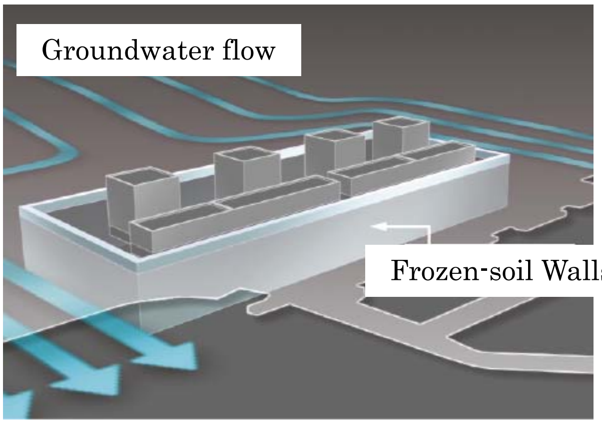

Figure 1. Concept of the Frozen-soil Walls

References

[1] http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/index.html

[2] http://www.tepco.co.jp/en/decommision/planaction/landwardwall/index-e.html

[3] http://www.kajima.co.jp/tech/c_frozen_soil_wall/index.html (in Japanese)

K07 Development of Micro-Polymeric Remover for Uranium Ion

Miki Abe[1], Michio Butsugan[2], Shukuro Igarashi[3], Yoshitaka Takagai[1]
(Fukushima Univ.[1], Hitachi Chemical Techno Service Co., LTD.[2], Ibaraki Univ.[3])

Abstract

Shiderophore chelate desferrioxamine B(DFB)-modified acrylic micro-polymer (MP) resins were synthesized and uranium (VI) ion adsorption properties on the resin were determined. The polymeric particles which have different functional groups and three size regions of the micro particle (less 7, 7-12 and 45-90 μm) were used as mother material. The synthesized resin showed good adsorption ability of uranium (VI) ion in weak alkaline solution. In addition, the investigation of absorbability of 61-elements on this resin was conducted. The result showed that it can collect some metallic elements of them.

Introduction

Since the Fukushima Daiichi nuclear accident, the contaminated water has been producing every day due to the melted-fuel refrigerating. The contaminated water contains high quantities of uranium ion which is eluted from fuel. Therefore, uranium remover for contaminated water has been required. In this study, we developed a micropolymers immobilizing desferrioxamine B(DFB) which has some hydroxamic acid groups in molecular structure. In addition, we investigated adsorption and desorption behavior of uranium ion for the polymeric resin.

Experiments

Five milligrams of DFB-MP were added to plastic centrifuge tubes, and then 1 ppb metal ions solution (i.e. sample solution) was added. The sample solution was adjusted to proper pH with buffer in advance of the use. After the addition of sample solution, it was shaken using shaker under 210 rpm for 10 min. Then, these were filtered using syringe filter and nitric acid was added. The solutions (filtrate) were measured by ICP-MS.

Conclusion

DFB-EG80-2(S) which is a series of small particle size (7～12 μm) showed sufficient U(VI) absorbability(96%). Optimum adsorption was under pH 9 and temp from 40 to 70ºC. Uranium(VI) was efficiently adsorbed compared with U(IV) in whole pH condition. In addition, highly adsorptions were shown regarding V, Co, Ni and Ga. The $Na_2B_4O_7$ buffer solution exhibited good adsorption efficiency as compared with acetate. Regarding the capacity factor, we are going on the progress; however we found that 533 μg and more. Desorption was successful using HCl solution (100%).

The project is supported by the MEXT, Human Resource Development and Research Program for Decommissioning of Fukushima Daiichi Nuclear Power Station

K08

Purification of accumulated waste water and groundwater in Fukushima Dai-ichi Nuclear Power Station

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Kenji Noshita[1], Shunsuke Miyake[1], Masahiro Ichino[1]
Yuko Kani[2], Toshimasa Ohashi[2], Yutaka Sangu[2]
Ken Yamaguchi[3], Kei Kobayashi[3], Yuichi Kurosaki[3], Keiji Ishikawa[3]
[1]Hitachi-GE Nuclear Energy, Ltd.
[2]Hitachi, Ltd. [3]Tokyo Electric Power Company Holdings, Inc.

Abstract

We developed three types of water treatment system and are contributing to reduce the radionuclides in contaminated water and ground water in Fukushima Dai-ichi Nuclear Power Plant Station. Here we developed the simulation code for Sr-90 behavior prediction that assists stable operation of the systems. Also, we established the technology to remove Sr-90 in RO-brine from the order of 10^8Bq/L to 1Bq/L under the existence of interfering substance.

We developed the facility "Sub-Drain Treatment System" (SDTS) to treat groundwater around the buildings called "Sub-Drain". The groundwater contains radionuclides such as Cs-137 and Sr-90 with relatively low concentration (100Bq/L). SDTS utilizes adsorption technology to reduces the level of Cs-137 and Sr-90 less than the control limit for ocean release. It is featured by the special adsorption media to remove both Cs and Sr at the same time. It has already treated and released 32,000m^3 of groundwater, and is still in operation.

Furthermore, Hitachi-GE applied this technology to purify the accumulated waste water (RO-brine generated from Reverse Osmosis (RO) system treating building water) stored in the yard of Fukushima Dai-ichi, which contains much higher Cs-137 (10^5Bq/cm^3), Sr-90(10^8Bq/L) and other nuclides. One is "Modified Sub-Drain Treatment System for RO brine treatment" (Sub-RO), which removes 99% of Sr-90 for the dose reduction of stored water. The other is "High performance multi-nuclide removal system" called "HERO", which removes Sr-90 almost completely into the level of 1Bq/L. These systems contributed the risk reduction of Fukushima Daiichi. In this report, we introduce the feature of those systems.

Also, we introduce the simulation code developed for the operation planning of SDTS and Sub-RO. It enables to predict the behavior of Sr-90 concentration at outlet of adsorption vessel. It shows operator when to exchange the vessel in advance, and contributes stable operation of the facilities.

In addition to those achievement, we also introduce the typical difficult feature of Sr-90, which was found in the operation of HERO. It was found that small content (0.1%) of Sr-90 exists as the chemical form not removed simply by adsorption media. Hitachi-GE researched the cause of this issue and found that Sr-90 forms some complex with the reagent used in RO system. Therefore, Hitachi-GE developed the way to dissolve the complex and remove the reagent so that Sr-90 stays the form of Sr^{2+} that can be removed by adsorption media. By the use of this technology, HERO achieved the reduction of Sr-90 less than 1Bq/L and contributed to reduce the risk accompanied by the storage of highly contaminated water in the yard of Fukushima-Daiichi.

K09

Fabrication of Porous Ceramics using Natural Minerals for Purification of Radioactive Water

Shuhei Toike[1], Katsumi Yoshida[1], Toyohiko Yano[1], Tadahiko Takada[2]

[1] Tokyo Institute of Technology, [2] Silica Material LLC

Abstract

After the accident of Tokyo Electric Power Fukushima Daiichi Nuclear Power Plant caused by earthquake on March 11, 2011, the treatment of radioactive water in the power station port has been a serious problem. We fabricated porous ceramic adsorbents using natural minerals for purification of radioactive water, and adsorption of Cs with the raw powders and the porous ceramics was evaluated. Porous ceramic adsorbents prepared in this study showed good adsorption performance for Cs.

1. Introduction

To converge the accident of Tokyo Electric Power Fukushima Daiichi Nuclear Power Plant, the treatment of radioactive water in the power station port has been a serious problem [1]. In this study, porous ceramic adsorbents for radioactive Cs and Sr were fabricated using natural minerals, which show higher adsorption for Cs and Sr, to improve handling ability during treatment of radioactive water and to simplify the immobilization process after treatment. In addition, effects of the raw materials used for the porous ceramic adsorbents on their adsorption ability for Cs were evaluated.

2. Experiment

Green compacts (ϕ20 mm, height: 10 mm) were formed by uniaxial pressing using natural porous silica (hereinafter referred to as A-WPS), natural zeolite (NKZ) and diatomaceous earth (TPS) with 10 wt% natural clay (NC). The compacts were pressureless-sintered at 500℃ and 700℃ for 2 hours in air. Surface microstructure was observed with a scanning electron microscope (SEM). Specific surface area and pore diameter distribution of the raw powders and sintered bodies were measured by nitrogen gas adsorption amount measurement method. Adsorption batch test of powders and sintered bodies for Cs was carried out using simulated radioactive water prepared by adding CsCl in pure water. Adsorption of Cs with the raw powders and the sintered bodies (porous ceramics) was evaluated.

Table1. Specific surface area of raw powders and sintered bodies

Sample	Specific surface area(m^2/g)		
	Raw powder	Sintered body (at 500℃)	Sintered body (at 700℃)
A-WPS	108.1	112.8	106.3
NKZ	19.8	27.5	19.8
TPS	39.0	39.7	34.5
NC	39.9	-	-

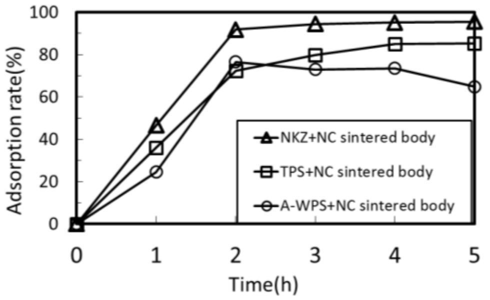

Fig1. Relation between adsorption time and Cs adsorption of porous ceramics sintered at 700℃.

3. Results

Table 1 shows the specific surface area of raw powders and sintered bodies obtained from BET plots. The specific surface area of A-WPS and porous ceramics with A-WPS showed the highest values. Specific surface area of the porous ceramics decreased with increasing firing temperature.

Figure 1 shows the relation between adsorption time and Cs adsorption of porous ceramics sintered at 700℃. In this test, pH was adjusted to be 7, liquid-solid ratio was 10, and initial concentration of Cs was adjusted to be 1 ppm. All samples showed Cs adsorption of 80% or more after 2 hours. These results indicated that the porous ceramic adsorbent fabricated in this study showed good adsorption performance for Cs.

References

[1] Tokyo Electric Power Company Press Release, November 19, 2015 "Current Status and Future Measures of TEPCO Fukushima Daiichi Nuclear Power Station"

L01

SIAL® :Geopolymer solidification technology approved by Czech / Slovak Nuclear Authority

Milena Prazska[1], Marcela Blazsekova[1] and Hisashi Mikami[2]

[1]Amec Foster Wheeler Nuclear Slovakia s.r.o., [2]Fuji Electric Co.,Ltd.

Abstract

We present the features and performance record of the geopolymer solidification technology, SIAL®, licensed for use by both the Slovakian (ÚJD SR) and Czech Nuclear (SUJB) regulators. An overview of its performance at Bohunice in Slovakia, where it has been used to successfully treat resins and sludge wasteforms will be provided along with references to other plants where it has been used. More recently, geopolymers have been noted as an immobilization technology which shows potential for resins produced by treatment of radioactive contaminated water at the Fukushima Daiichi Accident Plant. Reference will also be made to some of the activities being undertaken in Japan to demonstrate its performance.

1. Introduction

The Nuclear Power Plant A-1 located in Jaslovske Bohunice, completed in 1972 operated for 5 years until two accidents in 1976 and 1977. After the second accident in February 1977 (INES level 4) the Nuclear Power Plant was permanently shut down for decommissioning. Fuel assemblies and fuel cladding damaged in the accidents led to significant strontium-90, caesium-137 and transuranic contamination. As a consequence of the long-term corrosion of the barrier's material, highly contaminated sludge accumulated which could not be effectively immobilized using conventional methods such as cementation or bitumen treatment due to adverse physical-chemical properties and high specific activity of the waste (caesium-137). This challenge led to Amec Foster Wheeler developing and licensing the geopolymer, SIAL®. Today, SIAL® is one of the most proven widely used geopolymer for on-site solidification of radioactive materials such as sludge, resins, sorbents and organic liquids.

2. Features of Geopolymer solidification material

SIAL® can provide efficient and practical on-site treatment of radioactive waste streams at room temperature and can incorporate on average four times as much waste as a cement matrix equivalent. The equipment used to deploy SIAL® is also modular, flexible and versatile. It can encapsulate waste quicker than cementation and can even set under water. In addition, it is characterized by excellent mechanical and physical properties, compared with the earlier generation techniques. This includes higher mechanical strength, lower leachability, low volatility, posing a low fire risk and excellent physical stability in the presence of frost and water (no distortion or cracking).

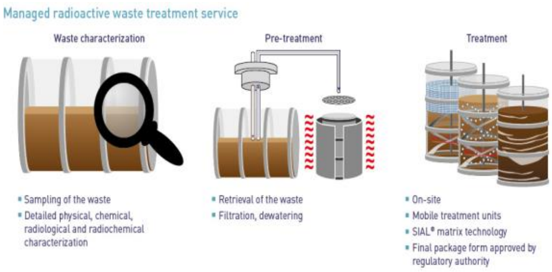

Figure 1　solidification process

Figure 2　SIAL® matrix with resins

3. Performance record exmaple

About 750 m^3 of radioactive waste (spent resins, sludge and borates) stored in 14 tanks situated in auxiliary building of the V1 NPP in Jaslovske Bohunice. The waste was characterized into two types of waste, namely resins and crystalline sediment and sludge. This comprehensive scope of work started with the licensing process, solidification and then was followed by the decontamination and cleaning of the workplace post clean up and transport of all equipment off site.

This is directly applicable to the conditions at Fukushima Daiichi (as well as other Japanese NPPs) where the waste streams are not well understood.

L02

Volume reduction and recycling of contaminated metal by melting

Satoshi Karigome[1], Masaru Kawamata[1], Takahiro Matsuda[1],
Toru Kikuchi[2] and Hiroki Shimoda[2]

[1]The Japan Atomic Power Company (JAPC), [2]JFE Engineering Corporation (JFEE)

Abstract

JAPC has an extensive record of nuclear power plant (NPP) decommissioning and assessments for clearance of materials from NPPs. JFEE contributed to disposal of disaster wastes in Fukushima Pref. following the Great East Japan Earthquake. Utilizing this experience, we will contribute to volume reduction and recycling of radioactively contaminated metals.

1. Background of JAPC

・First decommissioning of a commercial NPP (Tokai NPP) in Japan. (Figure 1)

・Assessment of contaminated wastes from decommissioned NPPs for clearance and recycling. (Figure 2)

Figure 1. Dismantling of Fuel handling Machine

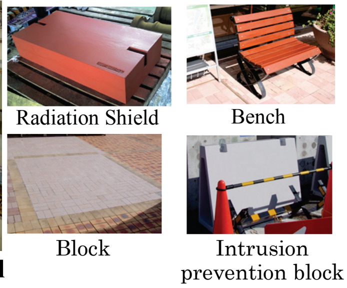

Figure 2. Recycled products

2. Background of JFEE

・Construction and operation of temporary incinerators for disaster waste, including radioactive substances, in Fukushima Pref. (Figure 3)

・Design and supply of ash melting furnaces for general waste incineration ash.

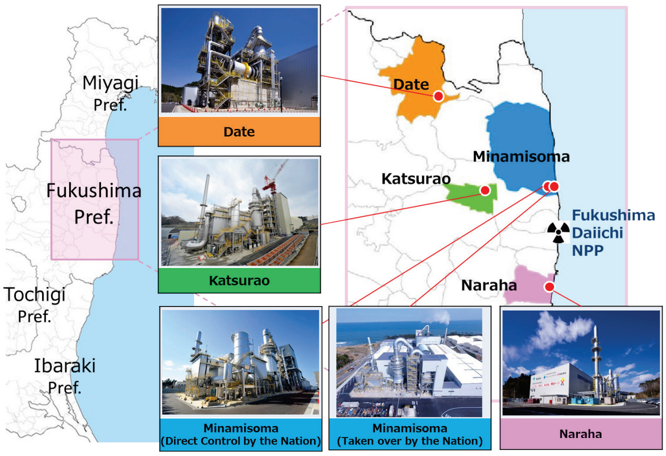

Figure 3. Incineration plants for radioactive disaster wastes in Fukushima Pref.

3. Melting of radioactive contaminated metal

・Volume reduction of scrap metal contaminated with radioactive cesium (Cs) by melting, and separation of radioactive Cs from the metal.

・Assessment of decontaminated metal for clearance and recycling.

- Radioactive Cs in metals is distributed to slag and dust
- Slag separation using difference in specific gravity
- Contaminated scrap metal with radiation level of less than approx. 1 mSv/h can be used as clearance metal

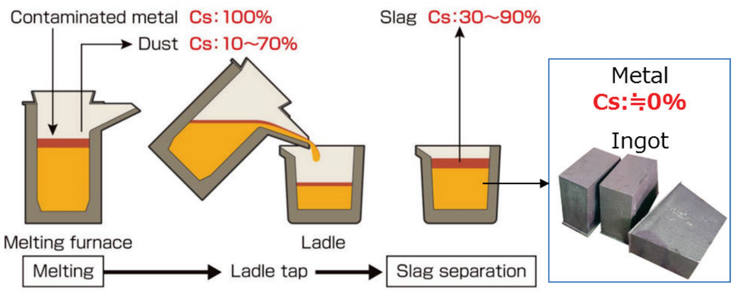

Figure 4. Process flow of radioactive Cs separation

- Enclosed structure to prevent dispersal of radioactive Cs
- Production of ingots for recycling use

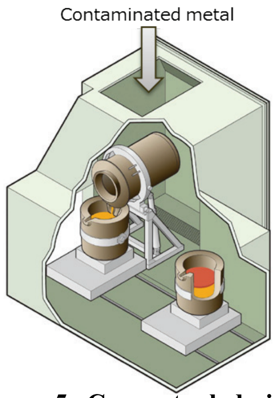

Figure 5. Conceptual design of the equipment

L03

Current status and issues about secondary waste from water treatment

Kosuke Sato[1]

[1]Tokyo Electric Power Company Holdings, Inc.

Abstract

There are many kinds of secondary waste from water treatment and they should be stabilized to reduce potential risks. It is necessary to solve technical problems for each waste but some of them have yet to be undertaken. In this poster, current storage management status and issues for stabilization treatment are summarized.

1. Recognition of risks

・Waste from water treatment is sometimes stored temporarily with its moisture content, and therefore, there is an potential risk of leakage of radioactive materials due to corrosion of the container or generation of hydrogen etc.

・It is necessary to keep risks low enough during long term storage in 1F until the period of disposal.

2. Current status

・Waste from water treatment is temporarily stored outdoors.

・The approximate amount of waste that needs to be treated is shown in Fig.2.

・Many kinds of media have been generated due to changes of media for improving Decontamination Factor.

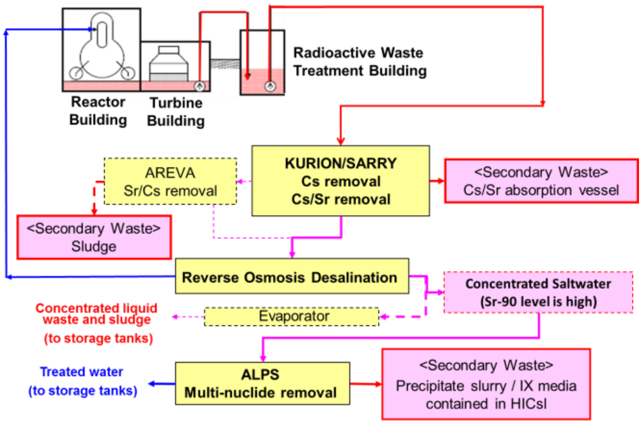

Fig.1 Overview of water treatment system

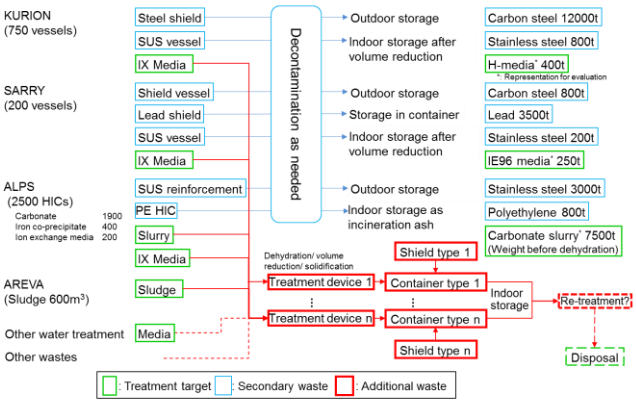

Fig.2 Quantity to be treated (quantity indicates rounded off figures for end of 2016, only major substances)

3. Issues

It is difficult to develop an optimal treatment strategy from the following reasons.

・Stabilization such as dehydration, drying and solidification is necessary but the applicable technologies are different depending on their radioactivity level, physical properties and chemical components.

・For rational treatment, it is necessary to think about a method of treating all waste with as few equipment as possible.

・The properties of secondary waste from water treatment are often unclear because sampling is difficult.

・Remote handling is necessary because of impossibility to approach high-dose secondary waste.

4. Introduction of effort

Our efforts to address these issues will be introduced on the day of the poster session.

L04

Examination of slurry stabilization technology

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1．Abstract

The Fukushima Daiichi Nuclear Power Plant treats the water including radionuclides by Advanced Liquid Processing Systems(ALPS).ALPS discharges the secondly waste called “slurry” and it includes a lot of water. Therefore , there are risks of leaking and pollution of the environment. This study researched and examined a dewater technology as a stabilization of the secondary waste.

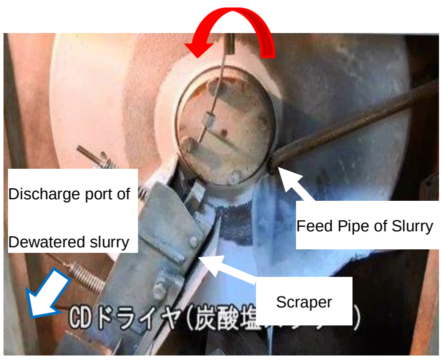


Photo 1 : CD (Compact disk） Dryer

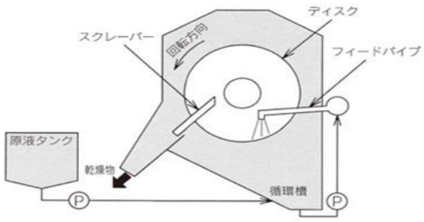


Figure1：Operational Overview（CD Dryer）

2．Introduction

1） Technical investigation

As basic study , simulated slurry was prepaired and dewater processes using it was evaluated in laboratory scale. The slurry particle size and moisture contents were evaluated after dewater tests.

2） Selection requirements

The requirements of treatment processes were examined based on the characteristics of the slurry and the restrictions such as throughput, treatment result, processing properties, dewatering performance, radiation reduction, scattering prevention, secondary waste generation, etc.

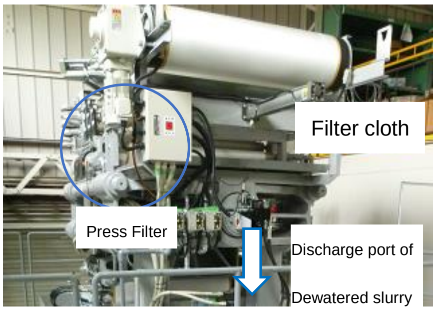


Photo2： Filter Press

3）Machine selection

Two type dewater machines in general industrious filed were selected from investigation results.

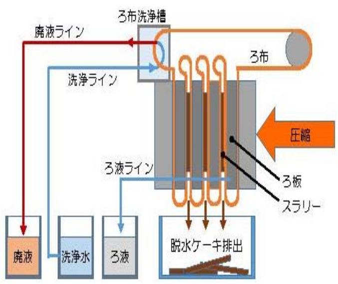


Figure2：Operational Overview（Filter Press）

3．Results and Discussion

As a dewater device of the general industry by the real scale cold test, CD (Compact disk)　dryer and Filter press (Photo2) were found to be suitable.

L05

High-frequency melting technology of radioactive metal waste

Takeshi Nishikawa[1], Nobutake Horiuchi[1], Naoto Sasaki[1], and Hirokazu Tanaka[1]

[1]Mitsubishi Materials Corporation

Abstract

Mitsubishi Materials Corporation has been developing technology concerning the high-frequency melting of radioactive metal waste, for the purpose of volume reduction, decontamination and recycling of metal waste contaminated with radioactive materials from NPP and nuclear facilities.

1. Introduction

In the melting of metal waste, a high volume reduction effect can be obtained. And radionuclides such as cesium (Cs), strontium (Sr) and α nuclides can be decontaminated from metals by melting using a high frequency induction furnace. In addition, the melting process is also suitable for the recycling of metal waste, because it can be homogenized and cast into any shape. We focused on these advantages of melting processes and have been developing technologies. The development results are shown below.

2. Development results

2-1. Volume reduction

By the melting, it is possible to make metal waste into a void free ingot, and it is confirmed that the volume of metal waste can be reduced to about 1/5 to 1/3.

2-2. Decontamination

The boiling point of Cs is lower than the iron melting temperature (1600deg-C), so iron-based metal waste can be decontaminated because Cs volatilizes during metal melting. Sr, uranium (U) and plutonium (Pu) are elements that are more stable as oxide than iron (Fig. 1). Therefore, in the electromagnetic field of the high-frequency induction furnace, the oxide (including nuclides) is ejected outward without the action of electromagnetic force, and can be decontaminated, while metal is moved to the center of the furnace by electromagnetic force (Fig. 2). In addition, the metal has good homogeneity because molten metal is stirred by electromagnetic force.

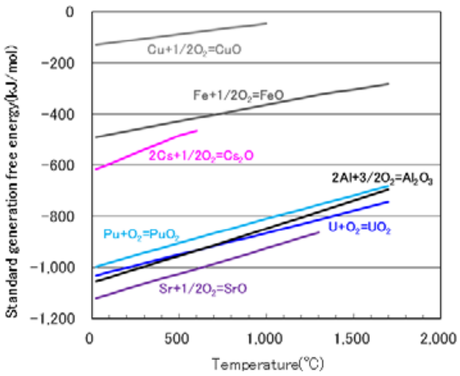


Fig.1 Oxide formation free energy of main metals

※The Japan Society of Thermometry
Calculated by thermodynamic data calculation software "MALT 2"

Melting decontamination test using real metal waste contaminated with radioactive Cs caused by nuclear accident was carried out using our small induction furnace (1 kg / batch). As a result, it was confirmed that real metal waste can be decontaminated to less than the detection limit (0.2 Bq / kg) [1]. In addition, melting decontamination tests using simulated nuclides (Cs [1] and Sr) were carried out using the small induction furnace and our demonstration scale induction furnace (1 ton / batch, Fig. 3). We confirmed the migration behavior of these simulated nuclides, and confirmed that decontamination is possible even on the demonstration scale. Furthermore, it was confirmed that U was decontaminable by melting decontamination tests using U [2] [3].

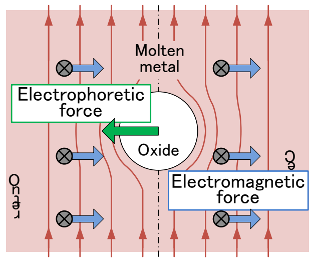


Fig.2 Behavior of oxide in high frequency induction furnace

2-3. Recycling

We have been developing technology to manufacture metal waste containers by centrifugal casting method, because this method has few secondary waste, is easy to manufacture, and is suitable for remote operation. By using the centrifugal casting method, it is possible to manufacture a cylindrical container without a core mold. It was adopted for advanced volume reduction facilities of JAEA.

If metal waste is made into ingots, they can be processed into various products later. Melting technology may be effective as a means to reduce and recycle radioactive metal waste generated at TEPCO's Fukushima Daiichi NPP.

Fig.3 Implementation status of demonstration scale test

3. Acknowledgments

The development of melting technology of radioactive metal waste introduced here was carried out under the guidance and cooperation of many people, demonstration project of MOE, Basic research programs for the next generation vitrification technology of METI, JNC, RWMC, effective use project of MITI, and so on, in addition to our own technology development. Thank you deeply.

References

[1] 2015, MOE, FY2010 decontamination / volume reduction technology selection and evaluation work.
[2] 2002, JNC, JNC technical report No.14.
[3] 2004, RWMC, Uranium waste decommission technology investigation.

L06

New Radioactive Waste Including Slurry Treatment Systems by Compact Disc Dryer

Hiroyuki Hayashi[1], Hirofumi Inagawa[1], Takashi Otsu[1],
Takashi Sakuma[1], and Takeshi Izumii[1]
[1]EBARA Corporation

Abstract

EBARA has been developing treatment System for radioactive waste by CD DRYERS. (Nishimura Work Co., Ltd.) With that system, radioactive waste including slurry is reduced in volume and separated into solid matter and water. CD DRYERS belong to the category of conductive heating dryers which indirectly heat and dry materials through conduction.

1. Construction

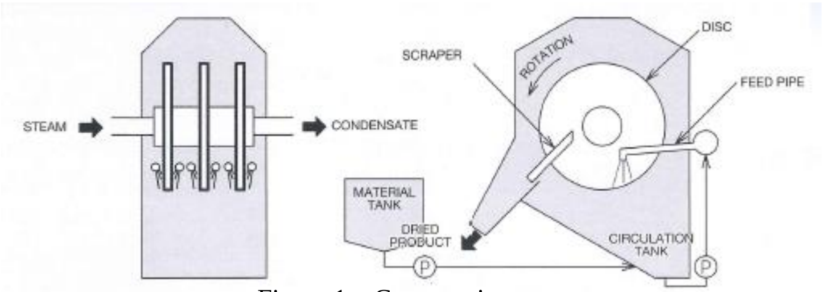


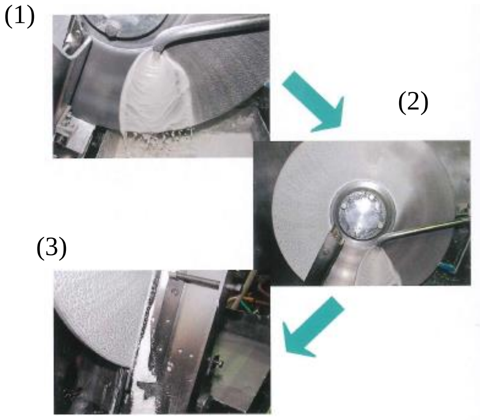
Figure 1　Construction

2. Flow of drying operation

2-1 The material in material tank is supplied to the circulation tank. (1)

2-2 The material in the circulation tank is sprayed over the disc surface by the circulation pump through the header. (2)

2-3 The material deposited on the disc surface is scraped off　by means of a scraper as it is dried while the disc is rotating. (3)



3. Features

3-1. High performance

3-2. Compact

3-3. Energy saving / High efficiency

3-4. Less thermal decomposition of material

3-5. Curtailment of process

4. Application

Radioactive waste, Waste resist, High concentrated salt water, Waste water-soluble oil and so on.

L07

Research&Development of Radioactive Waste Long-Term Storage Containers with Passive Autocatalytic Recombiners

Kazuyuki Takase[1], Nguyen Huy Hiep[1], Yota Suzuki[1], Yusei Tanak[1],
Isamu Kudo[2] and Ryutaro Hino[3]
[1]Nagaoka Univ. of Technology, [2]ADVAN ENG. Co., Ltd., [3]Japan Atomic Energy Agency

Abstract

In the decommissioning of Fukushima Daiichi nuclear power plant (1F), the long-term management of fuel debris is necessary. In this process, hydrogen which is the flammable gas is generated in storage containers by decomposition of water due to radiation. Then, in order to reduce the hydrogen concentration in a long-term waste storage container, use of passive autocatalytic recombiners (PAR) was considered.

1. Introduction

The objective of this study is to confirm experimentally that PAR functions effectively, even if the container which stores radioactive waste, such as the fuel debris, for a long period of time includes lots of water.

2. Experimental Plans

A high water concentration experiment was planned. In this experiment, the condition that much water is mixed with radioactive waste into a container was assumed. Two kinds of experimental devices with different size were set up in consideration of the TMI-2 results [1]. One is a large cylindrical container with a diameter of 35 cm and length of 200 cm, and another is a small cylindrical container with a diameter of 16 cm and 50 cm. Each container has simulated radioactive material and PAR in the inside as can be seen in Figure 1. Figure 2 shows appearance of the small cylindrical container. The inside can be confirmed in visible from the windows installed in the side wall. The procedure of the experiment is as follows: on the condition that water is enclosed in a container, hydrogen gas flows into the container from the bottom of that or the side; the oxygen in the container and the hydrogen gas changes to vapor by catalyzed reaction due to PAR; and, the experiment is repeated changing the amount of the accumulated water. That is, it is confirmed that PAR functions effectively, without depending on the amount of water and the water level in the container.

3. Conclusion

The present study is scheduled to be begun from the summer of 2017. The results will be reflected to the decommissioning of 1F.

References

[1] J. Henrie, et al., GEND 051, 1985.

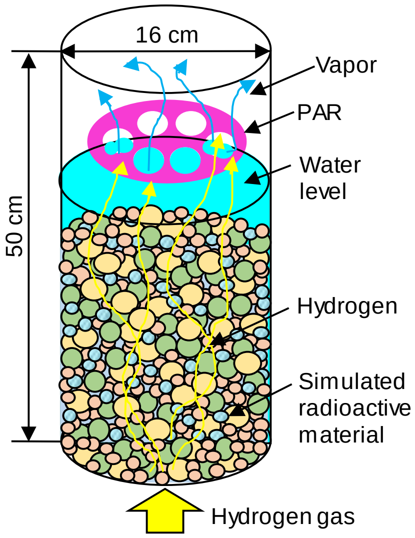


Figure 1. PAR and simulated radioactive material

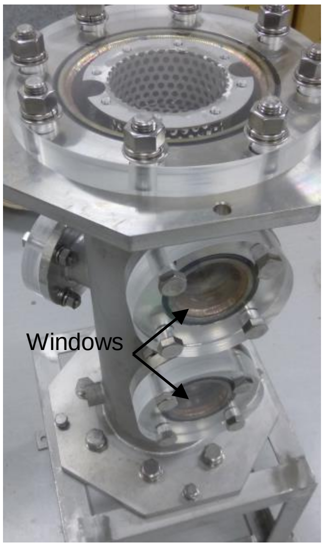


Figure 2. Small cylindrical container

L08

Study on Post-accident Waste Management Scenarios for Fukushima Daiichi Nuclear Power Plant

Subcommittee on Radioactive Waste Management
Study Committee on Decommissioning of the Fukushima Daiichi NPP
Atomic Energy Society of Japan

Abstract

In the decommissioning of the Fukushima Daiichi NPP, the radioactive waste management plan needs to be integrated with the plans for the series of activities from post-accident management to decommissioning and site remediation. Optimization of radioactive waste management (WM) scenarios is essential in preparing the decommissioning/remediation plans. This study aims to semi-quantitatively evaluate potential WM scenarios for multiple potential interim and final end-states of decommissioning/remediation. The outline of the study is presented in this poster.

1. Introduction

Atomic Energy Society of Japan has organized Study Committee on Decommissioning of the Fukushima Daiichi NPP consisting of several subcommittees, each focusing on a different area of expertise. One of the subcommittees, started in 2016, considers the management of radioactive waste generated from a series of decommissioning and site remediation activities. The objective of the subcommittee is to identify the requirements and constraints on decommissioning and remediation of Fukushima Daiichi NPP from the WM perspective.

2. Strategic Considerations

One of the first tasks is to review the reports published by international organizations on the experience of decommissioning and environmental remediation after nuclear accidents (e.g., [1] which emphasizes the importance of long-term strategies). Following the lessons from the past accidents, potential interim and final end-states in Fukushima Daiichi Decommissioning Roadmap [2] are discussed, as a basis to construct WM scenarios.

3. Scenario Analysis

The interim and final end-states define the goals for each step of post-accident clean-up, stabilization, decommissioning, and site remediation, and will facilitate the estimation of the quantity of waste generated in the process. Up to 2016 when post-accident clean-up and stabilization activities are in progress, more than 400,000 m^3 of wastes, including contaminated soil, trees, and rubbles, have been generated. A large amount of radioactive waste will be produced by dismantling the reactor facilities. There are numerous potential alternatives to manage this waste (e.g., treatment technologies, locations of storage and disposal sites). Choices of WM alternatives may influence the progress of decommissioning/remediation activities because, for example, storing waste on-site or constructing waste treatment facilities may limit the work area for decommissioning. The WM scenarios are being formulated as a combination of the possible alternatives.

4. Future study

The end states as well as the scenarios will be discussed and evaluated thoroughly and carefully in terms of factors such as feasibility, radiation safety, technology availability, consistency with the national framework.

References:

[1] IAEA, Decommissioning and Remediation after a Nuclear Accident, 28 January‐1 February 2013, Vienna, Austria.

[2] Inter-Ministerial Council for Contaminated Water and Decommissioning Issues, June 12, 2015.

L09 A pyrochemical treatment concept of combinding selective fluorination and molten salt electrolysis for fuel debris

Haruaki Matsuura[1], Takafumi Uchiyama[1], Takahiro Ono[1], Masatoshi Kajimoto[1], Yu Sakane[1], Tadayoshi Sato[1], Tatsuya Emori[1], Atsushi Nezu[2] and Nobuaki Sato[3]
[1]Tokyo City Univ., [2]Tokyo Inst. Technol., [3]Tohoku Univ.

Abstract

An on-site pyrochemical treatment process for fuel debris has been proposed. The procedure proposed is: 1) selective fluorination, 2) selective dissolution into molten salt, and 3) molten salt electrolysis. By the thermodynamic studies on HF fluorination of uranium - zirconium oxide mixtures and other structural materials, depending on composition and surrounding environment, fluorination condition should be selected.

1. Introduction

In the damaged reactors in the FDNPP, fuel debris is expected to exist in the variety of chemical form. After the struggling of taking out fuel debris from damaged cores, partitioning and stabilizing process would be required. We have focused on pyrochemical technology as one of the best solutions, because of its compact concept. The poster describes the concept in three steps and fundamental R&D studies performed for each step.

2. Concept of pyrochemical process in three steps

2-1. Selective fluorination

As the first step, fluorination treatment by dry hydrogen fluoride gas has been proposed, since uranium and trans uranium elements should not be vaporized as hexavalent form, but kept as tetravalent form. In this step, the best condition of selective fluorination of uranium must be found. According to thermodynamic studies on various composition of uranium – zirconium oxide under the treatment of dry HF gas, pre-treament by hydrogen gas reduction is considered to be very effective to selective fluorination of uranium. However, if the fuel debris contains some metallic compounds, to avoid the aggressive reaction with HF gas, pre-oxidation treatment should be added.

2-2. Selective dissolution into molten salt

Before the molten salt electrolysis, partially fluorinated fuel debris is introduced into molten salt, and dissolved selectively. In this process, selective dissolution of fluorinated uranium would be ideal. By using zirconium, dissolution behavior of its fluoride and oxide mixture into LiF-NaF-KF eutectic has been investigated. It is considered that coexisting oxide restricts the rate of dissolution of fluoride into molten salt.

2-3. Molten salt electrolysis

In the final step, dissolved uranium can be reduced electrochemically in the molten salt bath. According to the electrochemical studies on zirconium in various chloride, fluoride, and oxide systems, control of concentration of each anions is found to be the most important factor to deposit selectively targetted material.

3. Conclusion

These studies have been launched since 2013. We are planning to continue the studies using uranium in molten salt near future. This study has been performed by the JSPS Kakenhi JP 25630429 and 15K06665.

L10

Tailor-made solutions with proven technology to Waste Management

Motoki Nishibori
KOBELCO STUDSVIK Co., Ltd.

KOBELCO STUDSVIK Co., Ltd. was formed in Japan on July 1st, 2016, jointly by Kobe Steel Ltd. and Studsvik AB, focusing on delivering design, engineering and implementation to provide innovative radioactive waste management solutions to the Japanese nuclear industry. KOBELCO STUDSVIK will provide technology and processes to safely reduce radioactive waste and effectively recycle metals for the decommissioning of the Fukushima Daiichi Nuclear Power Station.

1.THOR treatment technology

THOR (**TH**ermal **O**rganic **R**eduction) is proven thermal treatment technology for processing of LLW and ILW, with pyrolysis and steam reforming mechanism. In Fig. 1, THOR process flow is shown.

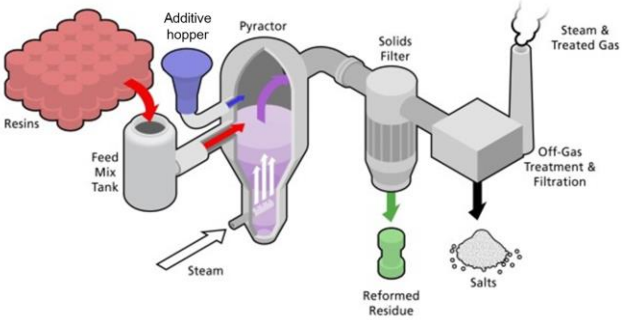


Fig. 1 THOR treatment process flow

(1) Wastes

Ion exchange resins, rubbers, activated carbon, plastics etc. are applicable wastes.

(2) Reformed Residue

Radioactive wastes are converted into dry and stable solid residue product (Reformed residue).

The reformed residue in which radioactive nuclides are captured is insoluble and leach-resistant.

(3) Volume reduction

When spent ion exchange resin is treated, its volume is reduced up to 1/15 , depending on waste type and final waste form.

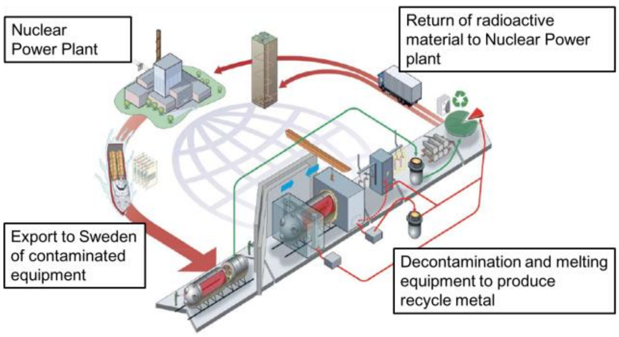


Fig. 2 Metal Recycle system flow

2. Metal Recycling

In Sweden, where the effective reuse of resources has socially taken root, metal materials of nuclear power equipment are safely recycled. The Studsvik model, which has been experienced in compliance with international rules and regulations since the mid-1980ies, will be able to respond to the increasing demand for metal recycling in Japan . In Fig. 2, metal recycle system flow and, in Fig. 3, photos of metal recycling system are shown respectively.

Fig. 3 Photos of metal recycling process

KOBELCO Studsvik

M01 Human resource development by creative robot contest for decommissioning

Shigekazu Suzuki [1]
[1] National Institute of Technology, Fukushima College

Abstract

For human resource development related to Fukushima Daiichi decommissioning, it was held to plan the first time the Creative Robot Contest for Decommissioning. It was held as robot contest of problem-solving and ability to identify challenges type. Naraha Summer School was held in September 2016 and the students visited Fukushima Daiichi and JAEA Naraha center. Human resource development through the robot contest is reported

1. Overview of Creative Robot Contest for Decommissioning

In order to get the young generation interested in the decommissioning, education through the creations of robots is believed to be effective. In addition, a variety of practices, such as PBL education and active learning lesson are offered in each technical college. This Robot contest is also carried out in PBL and active learning. If the main purpose is to interest students in decommissioning through the manufacturing of robot it also aims at cultivating the students and contributing to their "creativity education", "problem-solving ability" and "ability to identify challenges". Overview of the competition challenges are as follows.

1) Field

To select the playing field in each team from the two fields of the following assumes the reactor building.

a) Mock-up stairs b) Standard step field

2) Field environment

Mock-up stairs and standard test field both have the following environment features:

a) It is no darkness lighting

b) Not be able to face up to the body to operate the robot by remote

c) Radio wave does not reach because there is a thick wall of concrete

Fig. 1 Mock up stairs

3) Challenges of robot

a) Mock-up stairs

- Carry a 5 kg luggage up to the second floor from the first floor and return to the original location by placing the luggage.

- Examine the thing that is put on the second floor. It should be noted that the location is undefined.

Fig. 2 Standard step field

b) Standard step field

- Examine the field of shape (such as area and irregularities).

- Determine objects located in the field. It should be noted that their locations are undefined.

There were submitted from all over the country in the national and public technical colleges of the 13 colleges 15 team in this contest. Results of document screening, was observed participation of 15 teams.

M02 Advanced Research and Education Program for Nuclear Decommissioning

Toru Obara[1], Toyohiko Yano[1], Kenji Takeshita[1], Yukitaka Kato[1], Hiroshi Akatsuka[1], Hiroshige Kikura[1], Takehiko Tsukahara[1], Katsumi Yoshita[1], Koichiro Takao[1], Jun Nishiyama[1], Masayuki Harada[1], Nobuyuki Iwatsuki[1], Koichi Suzumori[1], Gen Endo[1], Kenji Kawashima[2], Noriko Asanuma[3], Tsuyoshi Arai[4], Naoyuki Takaki[5]

[1]Tokyo Institute of Technology, [2]Tokyo Medical and Dental University, [3]Tokai University, [4]Shibaura Institute of Technology, [5]Tokyo City University

Abstract

Advanced Research and Education Program for Nuclear Decommissioning has been started in 2014 for the sophisticated education and advanced research for the decommissioning of Fukushima Daiichi NPS.

1. Introduction

Advanced Research and Education Program for Nuclear Decommissioning (ARED) has been started by Tokyo Institute of Technology with the collaboration of Tokyo Medical and Dental University, Tokai University, Shibaura Institute of Technology, and Tokyo City University with financial support of the Mistry of Education, Culture, Sports, Science and Technology (MEXT). The purpose of the program is to perform sophisticated education of graduate school level for the decommissioning of Fukushima Daiichi NPS and to proceed advanced researches to solve the technical issues in the decommissioning.

2. Educational Activities

Some classes for the graduated school students have been offered by the program, which include laboratories using nuclear fuel and radioactive materials. The students perform experiments in radioactive hazard laboratories to obtain the fundamental and scientific knowledge of the materials and the method to tread them. In addition to that here is a class of laboratory for the robotics and remote sensing. The program includes lectures for the decommissioning of damaged cores and for the decommissioning of the reactors which are shut down by the life. The internships and seminars for the decommissioning are also offered.

3. Research Activities

Several advanced researches for the decommissioning are in progress including analysis method of contaminated material with microanalysis technique, decontamination and stabilization technology of contaminated materials, robotics and remote sensing technology, and criticality safety study in the reloading of the fuel debris. They are performed by the collaboration of the universities. Seminars about the research progress are held regularly to exchange information with nuclear industries.

4. Concluding Remarks

The educational activities and researches have been proceeded successfully. Some research topics have been moved to the phase of joint study with nuclear industry for the practical use. To continue the sophisticated education will improve the skill of researchers and engineers who involve in the decommissioning.

N01 Current Status of the JAEA's R&D Bases for the Decommissioning of the Tokyo Electric Power Company Holdings, Inc. Fukushima Daiichi Nuclear Power Station

Yoshihiro Tsuchida[1], Makoto Ooka[1], Toshiro Nakai[1] and Shinichi Nakayama[1]
[1]Japan Atomic Energy Agency

Abstract

The Japan Atomic Energy Agency (JAEA) is operating and constructing R&D bases at the coastal area of the Fukushima Prefecture for the decommissioning of the Tokyo Electric Power Company Holdings, Inc. (TEPCO) Fukushima Daiichi Nuclear Power Station (NPS).

1. Introduction

Restoration of the environment and decommissioning of the TEPCO Fukushima Daiichi NPS is positioned as Japan's national issues, and response to the accident is a prioritized mission of JAEA. In Fukushima Prefecture, JAEA has acting at the Collaborative Laboratories for Advanced Decommissioning Science (CLADS) in Tomioka Town and the Naraha Remote Technology Development Center in Naraha Town, and constructing the Radioactive Material Analysis and Research Facility in Okuma Town (Okuma Analysis and Research Center).

2. JAEA's R&D bases for the decommissioning of the Fukushima Daiichi NPS

2-1. Collaborative Laboratories for Advanced Decommissioning Science

CLADS is the core of JAEA's R&D on this research area, strongly linked with two infrastructural bases of Naraha Center and Okuma Center. CLADS began the operation in April 2017 of the Main Building in Tomioka Town, where the evacuation order was released in March 2017. CLADS is expected to be as both an international research hub and a symbol of the shared international interest in safely decommissioning the Fukushima Daiichi NPS.

2-2. Naraha Remote Technology Development Center

The Naraha Remote Technology Development Center, which began operation in April 2016, was established to conduct development/demonstration tests of remote controlled equipment and devices. The center provides test equipment for remote control devices such as Robot Testing Water Tank, Mock-up Stairs, and Motion Capture for external users.

2-3. Okuma Analysis and Research Center

The purpose of the Okuma Analysis and Research Center is to analyze and characterize the radioactive wastes and fuel debris for contribute to the establishment of treatment/disposal methods. The center consists of 3 buildings: an Administrative building, Laboratory-1 and Laboratory-2. The center is planning to start operation of the facility sequentially starting with the Administrative building in 2018.

N02

Overview of IRID R&D Projects

Naoaki Okuzumi[1]
[1]International Research Institute for Nuclear Decommissioning (IRID),

Abstract

Towards the decommissioning of the Fukushima Daiichi NPS, four entities cooperate closely to work together as one team. IRID is a complex entity consisted of eighteen organizations that play the leading role in R&D for the decommissioning of the Fukushima Daiichi NPS. IRID is conducting main three R&D projects; “Preparation of Fuel Debris Retrieval”, “Treatment and Disposal of Radioactive Waste”, and “Fuel Removal from Spent Fuel Pool”. In preparation for determination of fuel debris retrieval policy in 2017, IRID continues to develop technologies for; 1. Intensive investigation on the existence of fuel debris and damaged conditions inside the reactor, 2. Potential risk management and verification for nuclear safety, 3. Reliable remote operation under high radiation environments.

1. Progress of Research and Development

As R&D projects for the preparation of fuel debris retrieval, IRID is undertaking research based on three elements. Firstly, detection technology that enables to directly retrieve fuel debris in the PCV has been developed. In April 2015, a robot successfully entered the PCV at Unit 1. In FY 2016, the preparation of fuel debris investigation outside of the Pedestal is ongoing. At the same time, fuel debris investigation robots inside of the Pedestal, and remotely operated drilling device for the PCV penetration have been developed to reduce the exposure of workers at Unit 2. Additionally, investigation of fuel debris inside the Pedestal, an underwater swimming robot has been developed for Unit 3. When these robots remotely access fuel debris, it will enable to investigate a distribution and compositions of fuel debris. Severe Accident Analysis Code is upgraded to identify fuel debris inside the reactor, and investigations through the cosmic-ray Muon are ongoing. The distribution of fuel debris in the reactor is investigated from outside of the reactor building through the Muon at Unit 1. It resulted that the possibility is small that a large amount of fuel remains in the reactor core. The Muon investigation has conducted at Unit 2 since March 2016. Essential technologies such as access to fuel debris in the RPV or the PCV are ongoing. It is necessary to secure nuclear safety risks. Full-scale mock-up test facility of the lower part of the PCV at 1/8 sector was constructed for water leak blockage test at Naraha Remote Technology Development Center Test Building.

2. Future Development

With an aim to advance a very tough task of the decommissioning, IRID intends to proceed with R&D, collecting knowledge and expertise from around the world. Specifically, not only hardware support from oversea organizations is required for removal and storage of damaged fuel, but also experiences of safety management and process. We continue to build and maintain close cooperation between us for R&D on safe and steady decommissioning.

N03 Sorting Technology for Efficient and Safe Handling and Storage

Steve Rima[1], Jeffrey Lively[1], Masaru Noda[2], and Haru Hashizume[2]
Amec Foster Wheeler[1], Obayashi Corporation[2]

Abstract

Obayashi and Amec Foster Wheeler (AFW) have been working on the application of sorting technology for radioactively contaminated soil after Fukushima incident. That includes the adaptation and upgrade of well-proven system in the US to the scopes and specifications for Fukushima offsite remediation. **Its adaptability is further expected to extend into onsite work demands in any challenges.** This paper was submitted at ANS Joint Topical Meeting on Remote Control and Robotics in Pittsburgh in August 2016.

1. Introduction

Japan's national government commissioned the construction of waste consolidation facilities called Interim Storage Facility (ISF) which functions include waste consolidation, assay, segregation, volume reduction and engineered temporary storage. ISF must be efficient, technically & scientifically competent, and able to handle and segregate a variety of materials. Waste volume reduction is considered to be a key factor in ISF design.

2. Description of the Actual Work

Accelerating the processes of waste receiving, assay, segregation, and waste volume reduction are key factors not only for timely completion of the whole ISF project but for protecting workers from radioactive exposure. Obayashi has developed on ISF design that incorporates key measuring and sorting technologies to make the ISF process more efficient, productive, competent, and reliable. One of the technologies that is being integrated into the overall ISF process design is AFW's *ScanSort*^{SM} technology. To integrate the *ScanSort*^{SM} technology into the broader scoped and larger scale process train that Obayashi designed for ISF projects, it has become necessary to reengineer many of the electro-mechanical components of the *ScanSort*^{SM} system such that they work collaboratively and seamlessly with Obayashi's overarching ISF design.

3. Conceptual ISF Process Train Design

An appropriately scaled process train needed to be engineered with the overall electro-mechanical function so that the *ScanSort*^{SM} system does not function as "stand-alone". Obayashi designed for the ISF process train considering a number of factors in order to arrive at the design specification. Some of the constraining parameters included the limitations for material handling and feeding of 1 cubic meter bags, the desire for built in redundancy and flexibility of scale, as well as the expected volume of material and the proposed time line for ISF operations. Figure on the left shows the flow of fully integrated and automated soil processing train. The process train incorporates a cubic meter bag loading system, a container-bag shredder, a combustible-material separator, and the *ScanSort*^{SM} radiological measurement and sorting device supported with an engineering process to centralize, unify and integrate mechanical function, power supply and distribution, electro-mechanical control, and instrumentation and control systems into a seamless and fully automated process train with a single point of command and control.

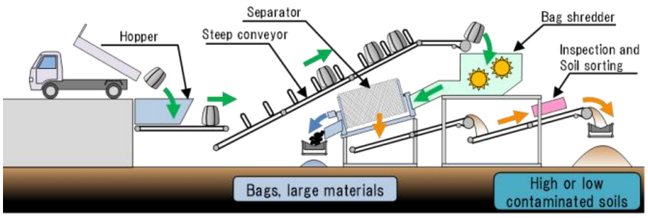


Figure: Conceptual Design of ISF Process Train

4. Generation II *ScanSort*^{SM} Design

AFW's reengineering for an endpoint of command and control falls into two major categories:

- Decoupling of the sensor systems from the electrical power distribution system, the I&C system, and the electro-mechanical control components, and
- Redesign of the *ScanSort*^{SM} operating system software to support the decoupling of the I&C system and the redistribution of command and control functions to non-dedicated electro-mechanical modules

In addition, the redesigned software will provide for the remote display of real-time system information to a centralized command and control station. Obayashi and AFW collaborated on the specifications for the engineering effort required to produce new standardized interfaces for electrical power, I&C signals, and modular mechanical attachment to the mechanical systems (conveyors and motors) sourced completely in Japan.

5. Benefits of the Generation II *ScanSort*^{SM} Design

The benefits of this design are many, including: 1) State of the art radioactive measurement using large volume scanning spectroscopy detectors and software algorithms, 2) Proven and reliable sorting technology, which will confidently segregate materials based on their radiological content thereby reducing the volume of materials, 3) High material throughput rates, 4) Built in redundancy using a multi-line process train configuration, 5) A higher degree of modularity than what exists in the current ScanSort^{SM} system, allowing for increased flexibility, redundancy, and reliability.

N04 Activities for fuel cooling at the Fukushima Daiichi Nuclear Power Station

Mitsuyuki Yamazaki[1] [1]Tokyo Electric Power Company Holdings, Inc.

Abstract

TEPCO is trying to review fuel cooling operation at Fukushima Daiichi Nuclear Power Station, because decay heat of fuel in reactor and spent fuel pool is declining gradually. The volume of water injected to cool the reactors was reduced from 4.5 to 3.0m³/h and moreover reduction is planning. At spent fuel pool Unit 1, it is confirmed that decay heat is released by only natural heat removal.

1. Reduction in volume of water injected into the Unit 1-3 reactor pressure vessel (RPV)

Water injected to cool the Unit 1-3 reactor falls into basement floors of building. The fallen injected water is treated by the contaminated water treatment facility with underground water flowed in buildings and accumulated water in buildings.

Reduction of the water injection volume is effective to mitigate the contamination facility load. The surplus capacity of the contaminated water treatment facility can be utilized to accelerate treatment of accumulated water in the buildings. Furthermore, the distribution of melted fuel would be estimated by comparing behavior of temperature measurements in RPV when the water injection volume is changed.

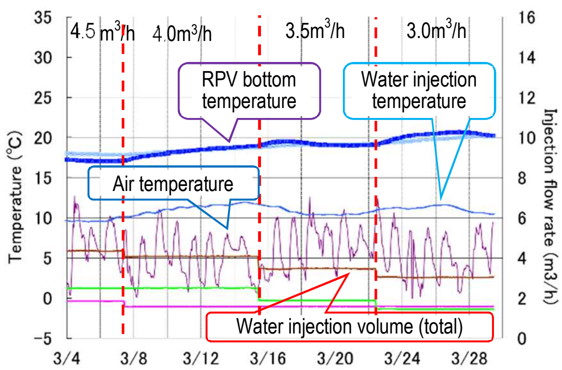


Figure 1. RPV Temperatures in Unit 2

TEPCO reduced the water injection volume to Unit 1-3 reactors steadily by 0.5m³/h from 4.5 to 3.0m³/h from December, 2016 to March, 2017.When reducing the water injection volume, monitoring parameters were confirmed, including the temperatures of the RPV bottom and inside the PCV, and PCV gas management facility dust monitors. Upon carrying out this activity, real time disclosure of plant parameters was started from February, 2017. For moreover reduction, cut down from two inlets to one inlet to RPV is in preparation.

2. Check of spent fuel pool (SFP) temperature while bypassing the Unit 1 SFP cooling facility

Decay heat in SFP had declined sufficiently, and less than 200kW (calculated value) at Unit 1-3 for each one. TEPCO made no heat removal condition by SFP cooling facility and investigated natural heat removal effect (such as evaporation, convection from surface of the water) at Unit 1 during the period April 5-26, 2017.

The results confirmed that the SFP water temperature was stable at around 30℃ and the trend was almost equivalent to the evaluation model including natural heat removal with a wind speed of 1.5m/s. It is anticipated that the SFP water temperature will remain stable at 35-40℃, even if the ambient temperature increases to 27℃(max. average monthly temperature over the past decade).

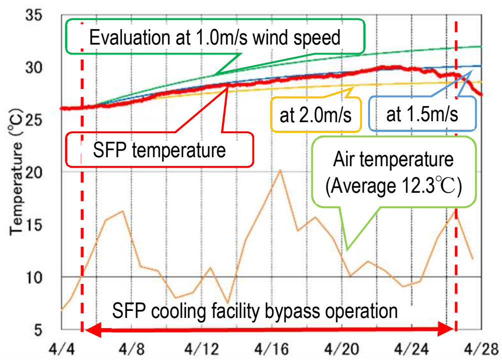


Figure 2. SFP Temperature in Unit 1

Continuously, natural heat removal effect will be investigated by similar bypass operation at Unit 2-3.

N05 The Overview of Project of Decommissioning and Contaminated Water Management

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[1] Mitsubishi Research Institute, Inc.
(Management Office for the Project of Decommissioning and Contaminated Water Management)

Abstract

For making decommissioning at Fukushima Daiichi NPS proceed in a safe and consistent manner, it is important for us to gather domestic and overseas wisdom for its research and development. Therefore, METI has set up the foundation in the FY2013 for carrying out the "Project of Decommissioning and Contaminated Water Management" which supports the R&D with the high level of technology.

1. Purpose

The purpose of this project is to advance the measures for decommissioning and contaminated water at Fukushima Daiichi NPS consistently, based on "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi NPS."

2. Overview of the Project

Not to mention the technologies for retrieving fuel debris, we are also working on the research and development of the internal investigation technology for Primary Containment Vessel ("PCV")/Reactor Pressure Vessel, the repair and water stoppage technologies for PCV and the criticality control technology which can improve the working environment.

In addition to the retrieval of fuel debris, the research and development of the long-term soundness evaluation on fuel assemblies taken out of the spent fuel pool, the processing and disposal technologies for solid waste, and the measures for the contaminated water have been implemented.

Owing to the past research and development, various technologies are highly developed. Therefore, the in-core state is gradually revealed and the information for making fuel debris retrieval policies is being gathered. Those achievements in the research and development are released on the website of the Project Management Office. (http://dccc-program.jp/)

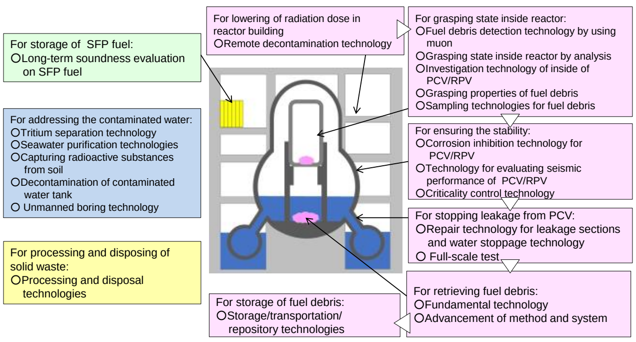

Figure 1. Main R&D Projects

3. Role of the Project Management Office

From the beginning of the subsidized project, Mitsubishi Research Institute, Inc. has been serving as the Project Management Office by gathering experts of nuclear energy, project management, etc. The Project Management Office is practicing a coherent project management which includes the solicitation of domestic and overseas subsidized project operating entities, the evaluation of proposal/presentation and the adoption, the work related to the subsidy grant, the management of project's progress, the settlement of subsidy amounts, making payment, etc.

N06

Power Assist Suit (PAS) to support heavy labor in radiological environment

Hirohisa Hirai, Yoshihiro Tamura
Mitsubishi Heavy Industries, Ltd.

Abstract

Mitsubishi Heavy Industries, LTD(MHI),in collaboration with The Japan Atomic Power Company (JAPC), developed a wearable robot ,Power Assist Suit prototype(PAS), to support heavy tasks in radiological environment(Figure 1). This PAS is expected the synergistic effect of the flexible correspondence by human and the high power by a robot. This presents such technical summary.

Figure 1 Image of PAS usage

2. Development

In development of PAS, it was considered as the specification with which the following concepts are filled.

1. An outer size of PAS is restricted to about 700 mm or less supposing passing the airtight door which is the minimum narrow part inside of a nuclear plant.
2. In order to make the calibration for any workers unnecessary, the sensors have to be able to gauge the physical quantity but not a biological signal.
3. The rate of a radiation shield which is considered as equivalent 40 to 50% to the conventional one, and the mechanical structure which can be assisted by PAS are adopted.

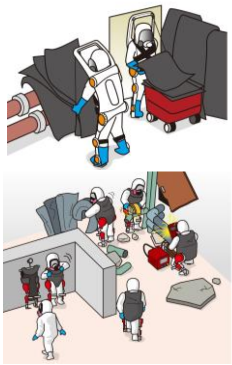

Figure 2 Tasks with PAS

After the basic functional test, to verify the performance at actual environment, PAS was tested using the mockup equipment.

Passing through the door | Walking through the stairs | Accessing to the instrument

Figure 3 the test using mockup equipment

3. Conclusion

The PAS system has been developed and verified for the purpose of supporting heavy labor in radiological environment, and is improving to apply to actual fields continuously.

The PAS is expected to accelerate decommissioning tasks which are continuing in the Fukushima Daiichi nuclear power plant. Furthermore the PAS shall become a utility tool which can be used for various heavy labor remained in normal maintenance of operating plants.

References

[1] [1]http://www.mhi.com/news/story/1512011943.htm (December 01.2015 No.1943)

N07

Veolia Nuclear Solutions Technologies for TEPCO 1F Decommissioning

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Kurion Japan K.K.

Abstract

Veolia Nuclear Solutions (VNS) has provided water treatment systems and remote access technologies for cleanup and decommissioning of TEPCO 1F. VNS has also proposed vitrification system named GeoMelt® for processing and solidifying radioactive wastes in the 1F site. Technologies provided and proposed by VNS for the 1F decommissioning are outlined briefly.

1. Introduction

A variety of technologies are required to respond to the decommissioning measures of TEPCO 1F site. VNS has provided water treatment technologies for selectively removing radionuclide in water as well as remote access technologies for inspection under high dose rate. In addition, VNS is studying application of vitrification system for reducing waste volume and stabilizing radionuclide in wastes.

2. Outline of Technologies

2-1. Water Treatment Technologies

VNS introduced selective adsorption systems called ISMS and KMPS at the 1F site to remove Cs and Sr from contaminated water. ISMS can process the contaminated water with a process rating of 1200 m^3/day and with decontamination factors of Cs for 10^5 and Sr for $3.5x10^3$. KMPS is the 5 skid-mounted assemblies used for at-tank mobile isotope removal to treat radioactive water stored in hundreds of water storage tanks on-site at 1F. The system is primarily used to remove Sr from the water with 300 m^3/day.

2-2. West Stabilization Technologies

VNS proposes the GeoMelt® vitrification process for immobilization of wastes generated from the 1F sites. The process has significant advantages below:

- High tolerance for debris such as concrete, metal, soil, etc.
- Commercially proven at large scale
- High degree of technical maturity at U.S. DOE sites for treatment of radioactive waste

2-3. Remote Access technologies

VNS has remote access technologies to support various initiatives including reactor inspection, repair and fuel debris removal.

Figure 1. Fukushima inspection Manipulator(FIM)

3. Conclusion

VNS offers unique value to customers, with a broad array of capabilities and offerings in nuclear clean up.

N08 Contribution to Environmental Remediation in Fukushima

Takao Ikeda, Wataru Kobayashi
JGC Corporation

Abstract

Incineration ash and removed soil from decontamination work will be stored in interim storage followed by final disposal outside Fukushima Prefecture in 30 years. To reduce the volume of the final disposal material, we developed and have been demonstrating a new pyro-treatment technology for removal of persistently adhering radioactive cesium from the object materials (incineration ash and removed soil). This demonstration project was entrusted to us by the Ministry of the Environment, and we are implementing it at a demonstration facility in Iitate village, Fukushima Prefecture, collecting object material from Iitate and its vicinity.

1. Dry Cesium Removal Technology

1-1. Treatment Process

The key technology of this treatment is to vaporize and remove radioactive cesium in the object materials using some reaction accelerant in a rotary furnace at high temperatures around 1,350°C. Through this treatment, the cesium content of the object materials is reduced to levels that allow unconditional recycling. The process flow diagram is shown in Figure1.

1-2. Treatment Facility

After some operational tuning, actual operations began in April, 2016. A perspective of the facility is shown in Figure 2.

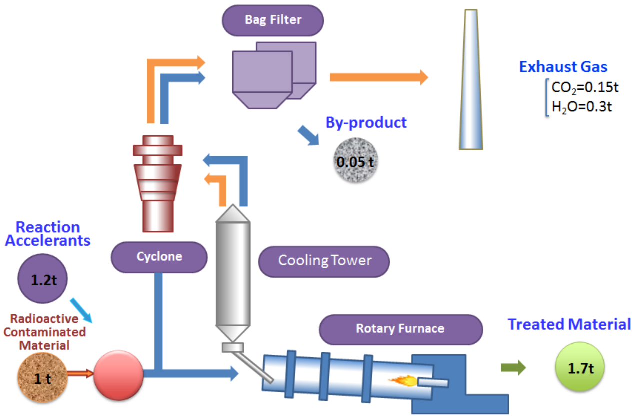


Figure 1 Process flow diagram of dry pyro-treatment process

Figure 2 Demonstration heat treatment facility

2. Conclusions

- The incineration ash and the removed soil containing tens of thousands Bq/kg of radioactive cesium were treated with the demonstration pyro-treatment furnace.
- The radioactive cesium contents of the treated materials were reduced to the IAEA clearance levels (<100 Bq/kg), which levels allow unconditional recycling use including road bed material, backfilling, banking or aggregate of concrete products.
- The pyro-process properly scaled up is expected to reduce the amount for final disposal of incineration ash and removed soil, thus contributing to the environmental remediation in Fukushima.

N09

Works for destroyed ChNPP Unit 4 conversion into an ecologically safe system as an experience in mitigation of Fukushima Daiichi NPP accident aftermath

Viktor Krasnov[1]

[1]Institute for Safety Problems of Nuclear Power Plants National Academy of Sciences of Ukraine (ISP NPP)

Abstract

In Chernobyl, New Safe Conferment (NSC) was designed and constructed by International Shelter Project and it was successfully installed in the design position in November 2016. The shelter implementation plan (SIP) was established in 1997 as internationally and the stabilization plans are implementing now.

1. Complex «New Safe Confinement - Shelter Object»

The NSC will bring to new quality complex – «New Safe Confinement-Shelter Object», which prevent temperature and moisture changes, and provide high radiation safety. The analysis of processes currently occurring in "Shelter" object (SO) has demonstrated that there is a high probability for appearance of factors capable destabilizing the existing conditions of nuclear and radiation hazard.

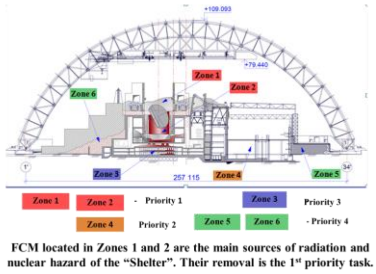


Figure 1. FCM location in NSC and SO

2. Shelter Implementation Plan (SIP)

The SIP shall be achieved through implementation of 3 stages. Stage1 (Done) is "Stabilization" which stabilize the existing facility, enhance its operational reliability and longevity of structures. Stage 2 (Done) is "Preparation for Conversion" which create additional protective barriers, primarily the NSC, and ensure the personnel, public and environment safety. Stage3 (Progessing) is "Conversion" which remove the fuel containing materials and long-lived Radio Active Waste (RAW) from the SO, perform its conditioning with the following storage and disposal in the RAW storage facilities in accordance with the effective standards; complete the SO decommissioning. The SIP has a mandatory of "Early deconstruction", which shall be implemented by the end of 2023, taking into account design life time of the SO reinforcement structures.

Table 1. Shelter Implementation Plan (SIP)

F01

Development of Laser Cutting and Dust & Fumes Collection technologies for Fuel Debris Retrieval

D. Roulet[1], C. Georges[2], C. Chagnot[2], C. Journeau[2], E. Porcheron[3]

[1] ONET Technologies, France, [2] CEA, French Alternative Energies and Atomic, [3] IRSN

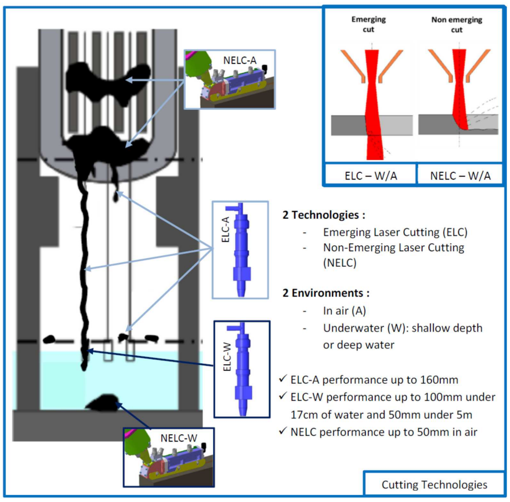
Abstract

Among the numerous challenges towards the decommissioning of Fukushima Dai-ichi reactors, removing fuel debris is for sure on of the tougher ones. A French consortium “ONET Technologies, CEA and IRSN” is developing laser cutting technologies for fuel debris with the implementation experience in UP1 French reprocessing plant. In addition to laser cutting development in air and underwater, key aspects of fuel debris cutting are the representativity of fuel debris simulants to reflect the quantities of aerosols, gas and dusts released during the debris laser cutting and their collection.

1. Cutting Technologies

The variety of fuel debris location, material and shape will need various cutting techniques to be developed. Laser cutting technologies are capable to overcome many configurations with proven performance, and great benefit with regards to remote application. Research for application to Fukushima environment is on-going with promising results.

Cutting trials have been conducted on melted fuel debris simulant (inactive but heterogeneous with representative simulant of all fuel debris elements, except Uranium and Ruthenium).

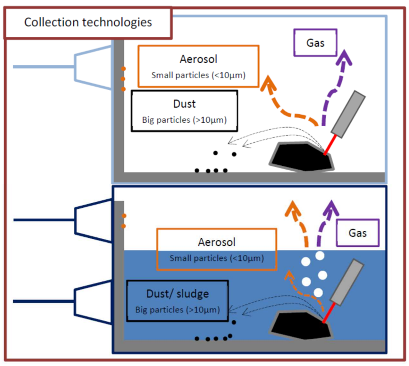


2. Knowledge of dust and fumes generated during cutting

Laser cutting being a thermal cutting method, aerosols, gases and particles are emitted during the process and the characterization of such secondary outlets is of paramount importance. The conducted trials have enabled the first estimation of released radioactive elements, aerosols size and gases, which are an important input data for collection and treatment systems definition and estimation of release to environment.

3. Collection Technologies

In parallel to cutting technologies, collection systems are being developed to capture the dust and fumes generated during the cutting. Such technologies are to be deployed remotely, either embedded with cutting system either by separate means.



Conclusions

Laser cutting technologies associated with collection technologies are key processes for fuel debris retrieval, but could be also used for other systems cutting as part of Fukushima-Daiichi decommissioning as CRD or RPV internal structures.

F02 Chemical-free Water treatment by Hydrodynamic Cavitation (HDC) and Electrocoagulation with sacrificial Ferrous anodes.

Gilbert Peronnet[1], Tristan Cerosky[2] and Christian HONNORAT[2]
[1]Optimum Water System, a company of ISB Water., [2]NUVIA France

Introduction

Ferrous Anodes Galvano-in Electro-Precipitation HDC Reactors can be applied as pretreatment before the SARRY's and ALPS systems. In this solution, ferrous iron hydroxides are electrically produced directly in the bulk fluid, and cavitation enhances the adsorption capacity of the produced iron hydroxide for a better removal of radioactive pollutants before polishing by existing columns, resulting in reduction of waste volume.

Principle

After injection of air microbubbles, the water to be treated is passed through a reactor in which an electric current flows through sacrificial electrodes. This results in electrochemical reactions taking place between them. The sacrificial electrodes dissolve, releasing their metal ions, and metal hydroxide flocs are produced in the process. These generated metal hydroxide flocs have a high adsorption capability and can thus bind the finely dispersed radioactive particles. The ferrous ion is specifically added to the water to be treated, and in the formation of hydroxide flocs there are also co-precipitation and occlusion precipitation reactions, in which undesirable substances are precipitated. The co-precipitated substances can then be separated mechanically by sedimentation or by filtration.

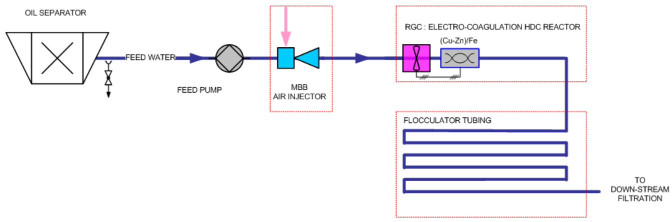


Figure 1; P&ID of typical system

The water passing through the reactor is also subject to hydrodynamic cavitation. When a liquid flow passes through the constriction, the velocity of the liquid increases and the local pressure is consequently reduced. In HDC reactors, throttling is sufficient to cause the pressure around the point of lowest local pressure to fall below the threshold pressure for cavitation which is usually around the vapor pressure of the medium at the operating temperature, cavities are generated. Subsequently, as the liquid jet expands, the pressure recovers and this results in the collapse of the cavities. This phenomenon of generation, growth and rapid collapse of the cavities has been described as hydrodynamic cavitation. When pressure increases, the cavities cannot sustain the surrounding pressure, and consequently collapse, creating numerous localized points of extreme high pressure and temperature. The intense mixing forces around the collapsing bubble will lead to more complete adsorption of contaminants inside the floc material.

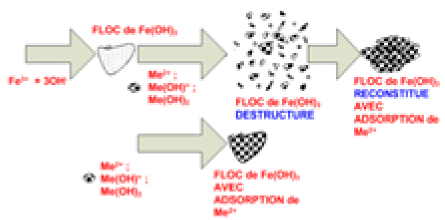


Figure 2: Floc with Contaminant Embedment

F03

Hydrodynamic Cavitation (HDC) application to existing Reverse Osmosis Systems.

Gilbert Peronnet[1], Tristan Cerosky[2] and Christian HONNORAT[2]
[1]Optimum Water System, a company of ISB Water., [2]NUVIA France

Introduction

Zinc Anodes Galvano-Chemical-Precipitation HDC Reactor units applied for scale mitigation in front of membrane filtration units. The "brutality of collapse" of the cavitation bubbles maximizes the supersaturations of ions in the vicinity of the bubbles, and create bulk precipitation of carbonates, sulfates, phosphates or other salts present in the water to be treated. RO Membranes are protected with better output.

Principle of treatment

The water passing through the reactor is subject to hydrodynamic cavitation. Hydrodynamic cavitation can simply be generated by the passage of the liquid through a constriction such as orifice plates, nozzles, or throttling valves. When a liquid flow passes through the constriction, the velocity of the liquid increases and the local pressure is consequently reduced. If the throttling is sufficient to cause the pressure around the point of lowest local pressure to fall below the threshold pressure for cavitation which is usually around the vapor pressure of the medium at the operating temperature, cavities are generated. Subsequently, as the liquid jet expands, the pressure recovers and this results in the collapse of the cavities. This phenomenon of generation, growth and rapid collapse of the cavities has been described as cavitation and in this case, ‘’ hydrodynamic ‘’ cavitation.

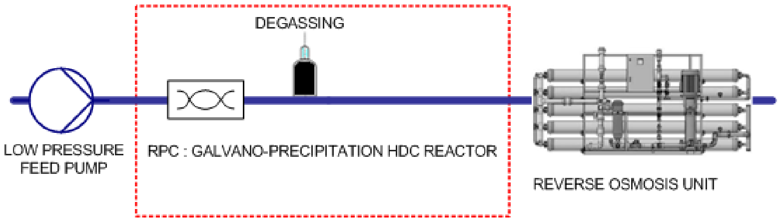


Figure 1 P&ID of typical system

When pressure decreases to low values, cavities are formed in the liquid. When pressure increases, the cavities cannot sustain the surrounding pressure, and consequently collapse, creating numerous localized points of extreme high pressure and temperature. The bubble will eventually collapse to a minute fraction of its original size, at which point the gas within dissipates into the surrounding liquid via a rather violent mechanism, which releases a significant amount of energy. At the point of total collapse, the temperature of the vapor within the bubble may be several thousand Kelvin, and the pressure several hundred atmospheres. This is resulting in numerous chemical reactions settling in, and release CO2 and other dissolved gases from the solution. When properly designed and run, this technology can lead to very high sur-saturations levels in the surrounding of the collapsing bubbles and to the precipitation of calcium carbonate and other salts.

This early precipitation nuclei are also the seed for further precipitation to take place on the “concentrate side” of the RO membrane and thus protecting it.

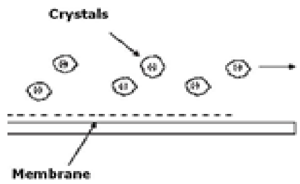


Figure 2: Non-Clogging Solid crystals

F04

Froth flotation process for remediation of contaminated soil

S. Faure [1], A. Ben Said [1], A. Grandjean [1], F. Charton [1], C. Georges [1], T. Prévost [2], D. Grange [3], J.P. Spanu [3], F. Maneglia [4]
[1] CEA, French Alternative Energies and Atomic Energy Commission, Nuclear Energy Division, [2] AREVA NC, Business Unit Recycling, [3] VEOLIA, [4] ANADEC

Abstract
Soils with large clay fraction are difficult to decontaminate because of clay affinity with Cesium 137 in a nearly irreversible way, resistant to washing.
Froth flotation process demonstrated its ability to extract contaminated clay, without destroying its organic part, allowing to reduce the volume of the contaminated waste soil to store and to reuse part of the decontaminated soil.

1. Introduction

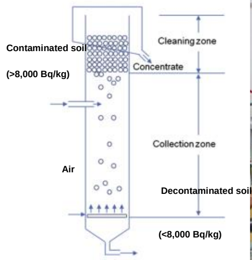
Despite the numerous existing soil decontamination technologies such as soil washing, magnetic separation, electro kinetic processing, and phytoremediation methods [1, 2, and 3], there is a need for environmentally friendly process limiting the production of secondary waste and able to treat high volumes of contaminated soil.
Based on the fact that the finest particles <20 µm contain 60 to 90% of the cesium radioactivity, solutions were searched to separate them with the objectives:

- To minimize the amount of radioactive wastes to be disposed in the intermediate storage centers (>8000 Bq/kg)
- To provide an eco-friendly decontamination process accepted by the population
- To provide a complete and transportable compact solution compatible with the disposal of radioactive waste
- To use emerging proven technologies in partnership with Japanese entities

Micro-filtration being un-adapted because of different limits (problems of cake resistance, clogging of the membrane, limited flowrate, variable cut-off, and cost), CEA developed a solid-liquid process based on froth flotation , in partnership with AREVA and VEOLIA in the frame of a project supported by the French Research Agency (ANR), called DEMETERRES [4].

2. Process Description

Contaminated soil is continuously introduced in a column where it generates a ground suspension in water and forms a flotation froth of the clay particles under the effect of a dispersed air bubbling and addition of a surfactant.
The foam volume evacuated by vacuum at the top of the column is transferred to two storage containers. The slurry is discharged continuously from the bottom of the column into a decanter. Sedimented particles of decontaminated soil are isolated in plastic containers. 50 to 80% of water is recycled in the process.



3. Results within project Demeterre

Several soils, presenting various textural characteristics, were floated and compared. The effects of processing parameters, including surfactant/soil ratio, froth residence time, suspension concentration and air flow rate, upon fine particles extraction performance to determine the most significant variable that affect flotation and obtain the operating conditions which led to the best performance. Finally, the selectivity of the process on the fine particles was investigated and scale-up studies were performed at pilot scale. Flotation results showed that fine particles extraction from soil is feasible thanks to attachment to air bubbles and exhibits excellent floatability and selectivity. The results obtained at lab and pilot scales evidenced good agreement which provides valuable evidence to support the technical viability of the soil flotation process for future exploitation at industrial scale.
The flotation column is the heart of the process. Additional independent skid which includes the soil preparation functions, recovery of the treated soil and recycling and recirculation of water is connected to the flotation column. Integrated pilot allows an overall process scheme "Preparation-processing-recycling" suspensions of soil.
This pilot unit was successfully tested in France and in Japan over hundred hours on 5 different soils.

4. Conclusion

Froth flotation is a proven technology, already widely used in industrial plants e.g. for the extraction /purification of minerals. It tends to be an innovative and cost-effective alternative to decontaminate radio-contaminated soils by selectively extracting the fine clay particles containing the majority of contamination and thus minimize volumes of waste to be stored (15-30% of initial weight). In addition a new demonstration campaign should occur soon, with main objectives to asses and consolidate the foam flotation process performances on radioactive cesium 137 contaminated clay soils from Fukushima area

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F05

IN CAN MELTER for the conditioning of high and medium-level and long-lived waste from decommissioning operations

Christophe GIROLD [1], Christine GEORGES [1], Stéphane CATHERIN [2], Thierry PREVOST [3], Guillaume LECOMTE [4]

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[3] AREVA NC, Business Unit Recycling, [4] ECM Technologies

Abstract

”IN CAN MELTER” process is the solution developed by CEA for its own waste coming from D&D operations, including legacy waste management, when “glass-like” encapsulation is required for further disposal but when cost reduction is an aim.
A specific melting tool was designed to be implemented In Situ, close to D&D workshops, and to match the requirements and constraints of D&D projects.

1. Introduction

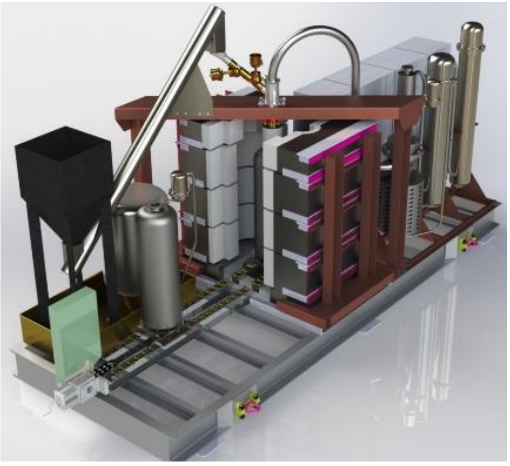
Some waste streams from decommissioning operations are identified as an issue in terms of handling, transportation, adapted conditioning matrix or evacuation outlet within the existing regulations. The numerous constraints associated with the management of such waste led CEA to investigate the implementation of an in situ conditioning treatment able to produce a waste package complying with existing evacuation routes and/or on-site storage facilities.

2. Specification

In this context, glasslike matrix brings a satisfactory answer as the glass material and the vitrification process demonstrated long ago to be well adapted to high level waste and to be flexible enough to accommodate to variable waste streams.
Specification for a vitrification process adapted to D&D was then:

- to be adapted to high or medium level waste,
- to be flexible enough to accommodate uncertainties on waste composition and however produce a confinement with quality description, with source term calculation methodology for long term storage,
- to be adequately designed and compact enough to be installed and operated inside a decommissioned cell,
- to be designed for a short duration of use as a decommissioning tool aimed to be dismantled just after the treatment operation,
- to produce a small amount of secondary waste,
- to generate minimum investment and operation costs.

2. Developments



To rapidly deliver a high TRL and provide all the basic data necessary to start an industrial application, “IN CAN MELTER” process took as a basis a previous development already fully qualified for specific CEA needs in facilities with alpha contaminants [1, 2].
In this process, the container is used as a crucible ("in can"), renewed with each batch, which greatly simplifies the equipment and makes it very robust: there is indeed no need to drain the glass and corrosion problems are limited by the batch limited time.
Secondary waste are limited to the heater as no components with molten glass remains after use. Thanks to its small size, the crucible can be easily heated by a simple and robust resistance heated furnace, inexpensive, easy to maintain, easy to implement and offering a great homogeneity to the melted mixture. This heating mean allows to have a metallic fraction in the canister and allow an excellent control of the treatment temperature, with low temperature steps if needed,
The process shown considerable flexibility as it will for example for the CEA application be operated only with two shift teams and no operator during night shifts,
The compactness and basic technology of the IN CAN MELTER makes it a relatively low investment.

3. Conclusion

“IN CAN MELTER” with low temperature glass (900 °C) is presently under qualification for the vitrification of high active deposits and sludge from French shut down facilities, containing fission products and alpha components.
Another field where low temperature solidification without additives would be of great interest is the encapsulation of mixed effluent waste such as zeolite, co precipitation sludge or powder of fuel debris, etc.

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F06

Potentialities offered by New Binders in conditioning of problematic low- and intermediate-level radioactive waste

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CEA, French Alternative Energies and Atomic Energy Commission,
Nuclear Energy Division,

Abstract
It has long been common practice to solidify and stabilize low- and intermediate-level radioactive waste with calcium silicate based cements (Ordinary Portland Cement). However, some wastes produced by decommissioning operations may chemically react with cement phases or mixing water, affecting hydration and eventually resulting in the deterioration of the waste form in storage or disposal, for instance by swelling and cracking. In order to avoid pretreatment or increased volumes of waste, three kinds of alternative inorganic binders offering better chemical compatibility with these problematic wastes are of great interest: (i) calcium aluminate and sulfo-aluminate cements, (ii) magnesium and calcium phosphate cements, and (iii) alkali-activated binders and more specifically geopolymers.

1. Calcium Sulphoaluminate Cements (CSAC)
CSAC clinker are produced by firing mixtures of limestone, gypsum and bauxite.
Foreseen applications of CSAC for waste conditioning ranges from Cementation of borate or heavy metals such as lead, cadmium, zinc, and trivalent chromium or to immobilization of Aluminum.
Due to the different cement chemistries, the rate of hydration of CSAC may be less affected by strong retarders of OPC such as heavy metals or borate ions and its mineralogical structure is favorable for waste immobilization, offering possibilities of ion substitutions.

2. Magnesium Phosphate Cements (MKP)
Phosphate cements are the main representatives of acid-base cements. Waste immobilization results from two processes: precipitation of many contaminants, particularly actinides, as phosphates with very low solubility, and physical encapsulation in a dense phosphate matrix. Good results have been reported for several types of wastes, e.g. low-level debris wastes contaminated by 137Cs, highly saline effluents or metallic aluminum [1].

3. Geopolymer: an alkali-activated binder
Alkali-activated binders are made by mixing solid aluminosilicates, such as fly ash, metakaolin, various clays usually activated by heat or blast furnace slag, with an activating solution comprising high concentrations of alkali hydroxide (NaOH, KOH) and / or polysilicate ($Na_2O.nSiO_2$, $K_2O.nSiO_2$). The reaction product, formed according to a dissolution/polycondensation process, exhibits an X-ray amorphous network structure and is usually called geopolymers [2].
By selecting appropriate starting materials and by varying the conditions of processing and curing, it is possible to vary the properties of the produced alkali-activated binders over a wide range, and to tailor them to specific requirements like high compressive strength, low permeability, low shrinkage.
Geopolymers offer great potential to stabilize/solidify hazardous wastes like heavy metals, alkali-earth, alkali ions and magnesium alloy encapsulation (Figure 1).
Geopolymers present a new way for direct organic liquid waste encapsulation by stabilizing emulsion of oil in an alkali silicate solution and being directly solidified by addition of metakaolin (Figure 2) [3].

Figure 1: Encapsulation of Mg cladding in geopolymer

Figure 2 : Oil/ geopolymer composite

3. Conclusion
New binders offer great opportunities for the management of problematic waste besides, understanding the chemistry of cement – waste interactions, and their consequences on the physical properties of the solidified waste forms, including their long-term evolution, will have to be further considered for the acceptance of these alternative binders in nuclear waste conditioning. Particular attention will also have to be paid to their possible interactions with the near-field environment.

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GB01 UK and Japan - Natural Partners in Nuclear Decommissioning

1. UK-Japan Collaboration

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

[1]British Embassy Tokyo, [2]Sellafield Ltd., [3]Oxford Technologies Ltd, [4]National Nuclear Laboratory, [5]NUVIA, [6]James Fisher Nuclear Ltd, [7]CREATEC, [8] Cavendish Nuclear Ltd, [9] WS Atkins, [10]Amec Foster Wheeler, [11]International Nuclear Services

Abstract

The home of the World's first full scale Nuclear Power station at Calder Hall, the UK nuclear industry is well over 60 years old, and has developed a mature and capable decommissioning sector. This industry has a history of successful collaboration and this series of posters demonstrates the benefits of this collaboration, and how it has been used to support the work at Fukushima Dai-ichi.

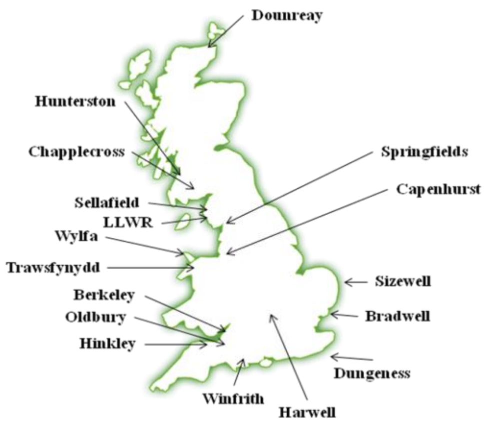
Figure 1. UK-Japan Collaboration

NDF/NDA Agreement　　TEPCO/Sellafield Agreement　　Japan/UK Government MoC

1. UK-Japan Collaboration

The UK and Japan have recognised the benefits of sharing experience in decommissioning through a series of collaboration agreements (Figure 1).

Figure 2. NDA Decommissioning Sites



2-1. The NDA

Decommissioning in the UK is the responsibility of the Nuclear Decommissioning Authority (NDA). This allows sharing of information and learning across all sites, leading to cost savings and more efficient decommissioning.

2-2. Technical Challenges

The technical challenges faced at UK decommissioning sites such as Sellafield, Magnox and Dounreay, have similarities to those at Fukushima Dai-ichi. This series of 8 posters show how this experience is proving valuable in Japan.

3. Conclusion

Collaboration, whether between companies or between nations is the key to successful decommissioning.

GB02 UK and Japan - Natural Partners in Nuclear Decommissioning

2. Sellafield and Fukushima Daiichi - the challenges of stakeholder engagement

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

Sellafield has been a key part of the of the UK's nuclear industry since the 1940's. It deals with many challenging nuclear wastes, and over the years has learned important lessons about waste management and decommissioning complex facilities. The site has learned the benefits of working with local, national and international stakeholders, and is now sharing this experience with TEPCO.

1. Sellafield-TEPCO Agreement

Since 2014 Sellafield Ltd and TEPCO have been supporting each other's decommissioning programmes

2. Fukushima-West Cumbria Study on Stakeholder Engagement

TEPCO and Sellafield have a joint project looking at how each company engages with the local community surrounding their sites. This has included TEPCO staff attending the local stakeholder meetings in West Cumbria, which is where Sellafield is situated.

3. Conclusion

Sellafield and Fukushima Dai-ichi are sites with similar issues which cannot be tackled without the support of the local community. Sharing how best to engagement with local stakeholders is an important part of ensuring successful decommissioning at both sites.

INS INTERNATIONAL NUCLEAR SERVICES British Embassy Tokyo Sellafield Ltd oxford technologies CREATEC NUVIA cavendish nuclear NATIONAL NUCLEAR LABORATORY James Fisher Nuclear Fisher ATKINS amec foster wheeler

UK and Japan - Natural Partners in Nuclear Decommissioning

3. Waste Retrieval – Magnox Reactor Sites and Dounreay

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

The final UK Magnox reactor completed power generation in December 2015, the last of 11 Magnox reactor sites which started operation in 1956. In addition, the breeder reactors at the Dounreay site in Scotland are also shut down and the site is being decommissioned. An on-going decommissioning programme in the UK across multiple Magnox sites and at the Dounreay site is addressing many varied decommissioning challenges. Significant progress is being made across all of these decommissioning sites with lessons being learned that are applicable to decommissioning and waste management projects at Fukushima Dai-ichi.

1. Retrieval and Management of Radioactive Wastes

Retrieving highly radioactive waste that is difficult to access, and storing it safely, is a challenge currently facing Fukushima Dai-ichi, as well as at the Dounreay and the UK Magnox sites. Technologies and methods have been developed in the UK decommissioning programme for retrieval of radioactive wastes and the subsequent processing, packaging and storage of these wastes.

Figure 1. Retrieval of waste at Hunterston A

Figure 2. Interim storage facility at Berkeley

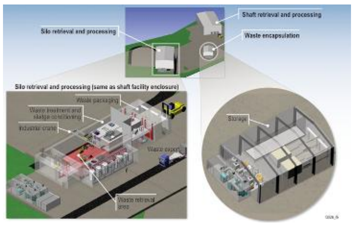

Figure 3. Retrieval of wastes at Dounreay shaft

2. Conclusion

Innovative work is taking place at Magnox stations where operational waste that was in concrete bunkers above or below ground, is being retrieved and placed into interim storage. Work is also taking place at Dounreay where operational wastes are to be recovered from a 64m deep shaft. These technologies and methods are relevant to the challenges at Fukushima and are being applied to the development of the fuel debris retrieval methodologies.

GB04

UK and Japan - Natural Partners in Nuclear Decommissioning

4. Waste Retrieval – Sellafield

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

Material stored in ponds at Sellafield for many decades have given Sellafield a waste retrieval and disposal challenge which is in many ways similar to the challenges facing Fukushima Daiichi.

1. Waste Retrieval

Water, radioactive sludge and swarf must all be monitored, categorised, retrieved and packaged for future disposal. Remote handling both in and out of water are key to the effective and efficient delivery of this work.

Figure 1. Removal of waste from a Sellafield Pond

2. Regulator Involvement

Close engagement with the UK regulator is key to a successful project. The UK has developed methods to deal with challenging retrievals without the need to vastly expensive and time-consuming new facilities.

Figure 2. Fuel Debris at Sellafield

3. Innovative Technology

Innovative technologies have been developed and are UK organisations are working with Japanese partners to apply these to the challenges at Fukushima Dai-ichi and elsewhere.

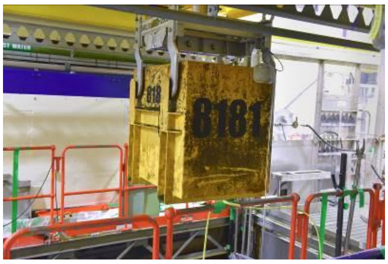

Figure 3. Metal Fuel removal from a Sellafield pond

4. Final Disposal

All retrievals consider the final disposal option for the material. Wherever possible the waste is packaged with this in mind which saves cost further down the line.

5. Conclusion

Working together Sellafield and Fukushima Dai-ichi experience can accelerate the decommissioning process and reduce the hazards on both sites.

GB05 UK and Japan - Natural Partners in Nuclear Decommissioning

5. Programme Management

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

The UK's Nuclear Decommissioning Authority (NDA) utilises a programmatic approach to effectively delivery best value for the UK tax payer. The structured approach is deployed throughout the NDA's 17 sites enabling consistent decision making, delivery and reporting. Projects, programmes and portfolios become common terminology.. The UK has many organisations skilled in managing complex decommissioning projects. They are working with Japanese organisations to ensure the lessons learned from the UK programme can benefit Japan. Figure 1 shows the NDA's strategic themes.

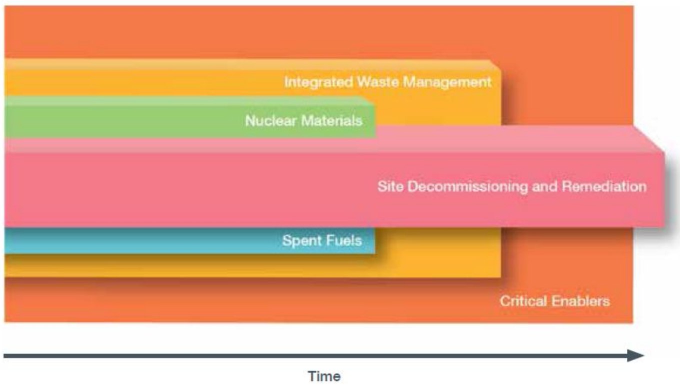

Figure 1. NDA's Strategic Themes

1. Principles

Effective and efficient delivery across a range of missions within a complex multi facility and multi-site estate requires a structured framework. By utilising established portfolio, programme and project structures the UK nuclear decommissioning sector lead by the NDA has been able to give a higher degree of clarity to UK Government. The framework enables relative priorities to be understood, assessed, prioritised and delivered. UK industry has been able to work with these arrangements as a site licence company, a Management and Operations (M&O) organisation or as a supplier.

2. Conclusion

NDA has established a programme management framework that has delivered benefit to the UK and they have been very pleased to be able to share this with NDF. UK companies have been working with TEPCO to share the approaches used, their strengths and the successes this brings as well as the areas where the UK has gained significant learning.

6. Decommissioning Technology

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

Technology and innovation are key to delivering safe and affordable energy at each stage of the nuclear lifecycle. Particularly in decommissioning where legacy challenges require 'first of a kind' solutions. However, entirely new technology is often not required, and UK companies have often been able to adapt technologies from other industries to provide 'fit-for purpose' solutions.

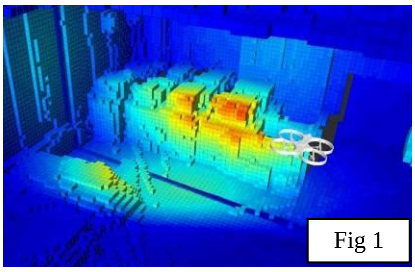

Fig 1

1. Examples of Technology

Figure 1. 'RISER', a3D Laser scanning and radiation mapping mounted on an Unmanned Air Vehicle (UAV) developed in the UK by Createc and BlueBear now deployed at Fukushima Dai-ichi.

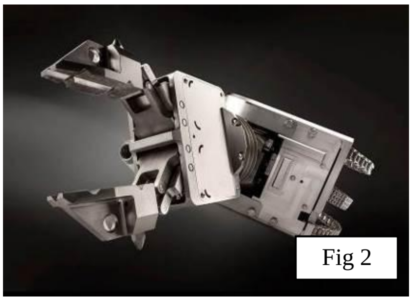

Fig 2

Figure 2. Advanced robotic equipment developed by Oxford Technologies for retrieving complex waste from Dounreay facilities.

Fig 3

Figure 3. Underwater remotely operated vehicles with specialist tooling developed by James Fisher Nuclear are tested before deployment at Sellafield.

Figure 4. The GROUNDHOG Evolution 2 and Synergy developed in the UK by Nuvia for real time detection of particles to carry out beach monitoring surveys both at Sellafield and Dounreay.

Fig 4

2. Conclusion

In addition to new innovations, Nuclear Decommissioning technologies can often be adapted from other industries. UK firms have successfully applied this methodology to solve decommissioning challenges at many sites in the UK and also at Fukushima Dai-ichi.

7. Needs Based Research and Development

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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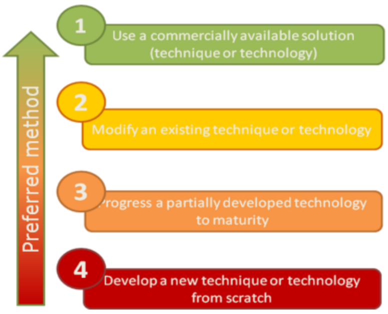
Abstract

Nuclear decommissioning at sites such as Fukushima Dai-ichi and Sellafield can throw up a series of unique challenges. In order to solve these challenges it is important that research matches the needs of the decommissioning industry.

Figure 1: Research Hierarchy



1. Needs based research

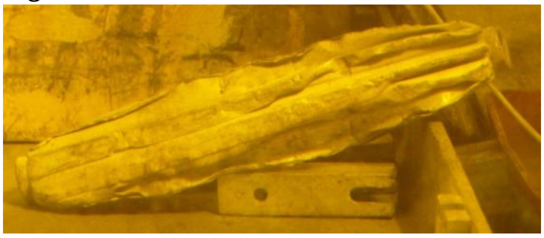
The philosophy of needs based research has spawned a number of innovations to address decommissioning challenges in the UK. This methodology is being shared with Japan through collaborations with organizations such as CLADS.

2. Examples of Research Successes

- Detailed studies of hydrogen evolution has enabled a significant reduction in cost and schedule at Sellafield.
- Development of waste forms has allowed difficult wastes at Sellafield to be immobilised for long term storage and disposal.
- Studies to understand long term waste behaviour has allowed increased waste loadings in containers saving time and cost.

Figure 2: Nuvia development rig

Figure 3: Windscale fuel characterisation



3. Conclusion

The UK has many years of applying needs based research to accelerate or de-risk decommissioning plans. By UK and Japanese organisations working together, there is the opportunity to find solutions to the challenges faced by both countries through coordinated needs based R&D.

GB08 UK and Japan - Natural Partners in Nuclear Decommissioning

8. Waste Management

Keith Franklin[1], Roger Cowton[2], Mark Sharpe[3], Kat Lennox[4], Jorge Weir[5], John Falch[6], Matt Mellor[7], Chris Carter[8], Linda Ashton[9], Steve Caley[10], Sarah Groves[11]

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Abstract

Successful Waste Management is the key to any decommissioning project, and is a large proportion of the cost. The UK has a national integrated waste management strategy, which is designed to minimise both the amount of waste and the cost of treating it. It provides broad categories for waste, and defined disposal routes, reducing the costs and uncertainties in decommissioning projects.

1. Waste Hierarchy

By using the waste hierarchy, the amount of waste which has to be treated and stored is significantly reduced. This is achieved through careful management of the activities which produce waste, and treatment processes which allow waste to be disposed of safely or reused.

Figure 1. The Waste Management Hierarchy

Figure 2. Dounreay Store

2-1. Waste Storage

A range of waste storage facilities have been built in the UK, after full consultation with local communities.

2-2. Waste Treatment

Treatment processes have been designed to minimise radioactive wastes

3. Conclusion

Using an integrated waste management strategy, combined with proven treatment processes and appropriate storage facilities the UK has been able to provide solutions to many of the waste issues, and this learning is being shared with Japan in order to tackle the task of managing the wastes produced as part of the Fukushima Dai-ichi clean-up process.

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GB09

Decommissioning and Waste Management

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Abstract

Nuvia has over 40 years' experience in the decommissioning and waste management of Nuclear power plants in UK and other parts of the world from planning to demolition and site remediation. Nuvia's leading edge consultancy services, engineering services and technologies continue to be used throughout the decommissioning lifecycle and waste management of NPSs in UK and globally, providing a unique opportunity to deal with the challenges faced with decommissioning and waste management at the Fukushima Daiichi Nuclear Power Stations (NPS).

1. Introduction

This paper summarises features requiring consideration for design of decommissioning, some of the key challenges and how Nuvia's experience can be utilised.


Fig -1


Fig -2


Fig -3


Fig -4


Fig -5


Fig -6

2. Lifecycle of Decommissioning and Waste Management

In line with IAEA guidance [Ref 1], Nuvia's waste management & decommissioning projects proactively aim to follow a set of design features relevant to international best practice:

- Characterisation and minimisation of activated products;
- Contamination control and decontamination facilities;
- Segregation of contaminated items;
- Ability to segment large items in-situ;
- Minimisation of operational and decommissioning waste;
- Adequate rad waste packaging and storage facilities;
- Management of records for decommissioning.

3. Dealing with key Fukushima challenges

In order to deal with Fukushima effectively, prior knowledge and experience of decommissioning and waste management is essential. Below is a numbered list of some of Nuvia's projects (in line with Figures 1 to 6) each one followed by a challenge faced at Fukushima [Ref 2]. The aim is to show how Nuvia's experience can support the management to deal with some of the Fukushima challenges.

Fig-1. B204 Contaminated Stack Decommissioning and design of Stack Climbing Platform (SCP).
- o Fukushima Daiichi Unit 1&2 Stack Dismantling.

Fig-2. Decommissioning of the Steam Generating Heavy Water Reactor (SGHWR).
- o Fukushima Daiichi decommissioning and waste management.

Fig-3. External Active Sludge Tank (EAST) Treatment Plant (WETP).
- o Fukushima Daiichi radioactive waste characterisation, treatment, reduction, storage and disposal measures.

Fig-4. Modular Active Effluent Treatment Plant (MAETP)
- o Fukushima Daiichi contaminated ground water processing.

Fig-5. Nuclear Safety & Design Support Chernobyl's New Safe Confinement (NSC) Dome, Ukraine.
- o Fukushima Daiichi radioactive waste storage facilities.

Fig-6. Radiation monitoring using Groundhog & Hi-Ram.
- o Fukushima Daiichi seawater and land monitoring.

4. Conclusion

This paper presented an overview of Nuvia's unique experience throughout the lifecycle of decommissioning and waste management. A number of decommissioning project examples were presented highlighting how this experience would be useful in dealing with key Fukushima challenges.

References

[Ref 1] IAEA, "Design Lessons Drawn from Decommissioning of Nuclear Facilities, "IAEA TECDOC No. 1657, 2011.
[Ref 2] TEPCO CUUSOO Website, "An open innovation platform for energy related technologies and ideas," Feb. 1st, 2016.

GB10 Decontamination and Decommissioning with Radiation Imaging Solutions

Mike Anderson, Kazushi Watanabe and Victoria Anderson
Innovative Physics Limited

Abstract
Effective decontamination and decommissioning of radio activity for post event clean-up operations and dismantling of Nuclear Power Plants. Innovative Physics (IPL) have developed a range of radiation imaging solutions for Fukushima Prefecture following the Dai-ichi Power Plant incident in 2011. Rapid visual representation of radioactive areas makes these radiation cameras a key tool for decontamination and decommissioning teams worldwide.

GB11

International case studies applicable to the decommissioning and waste management challenges at Fukushima Daiichi

Jenna McIntyre[1], Nick Bold[1]
[1]DBD International

Abstract

Whilst the Fukushima Daiichi (1F) site is unique, there are a number of relevant worldwide decommissioning projects and related learning from experience that can be utilised to benefit the site. DBD are well positioned to apply this knowledge to the issues faced on 1F in order to accelerate a reduction in hazard levels on site.

1. Introduction

This poster summarises some international case studies that are relevant to the range of technical and strategic issues that face the Fukushima Daiichi site. The poster focusses on four prominent case studies which highlight the range of projects DBD has previously been involved in and how this knowledge and learning from experience could be applied to further the work and assist strategic decommissioning on the 1F site.

2. Poster and Case Study Summary

2-1. Support to the 1F site (see the top photo in Figure 1)

This section highlights DBD's work on the Fukushima site where DBD's D_2O optioneering process was used to assist with current issues facing the 1F site.

2-2. WRPS (see the middle photo in Figure 1)

This example summarises work DBD carried out to assist a US client in establishing a waste form development program to address performance needs and understand waste form characteristics of Solid Secondary Wastes.

2-3. MSSS (see the bottom photo in Figure 1)

DBD has been part of an integrated client team, providing a range of strategic and technical support, this section highlights key support DBD has provided to MSSS.

Figure 1 – Fukushima site, Hanford site, MSSS - UK (top, middle & bottom, respectively) [1]

2-4. Strategic Modelling

DBD produced a new effluent treatment strategy model for a highly complex chemical facility, providing the client with a tool that predicted multiple scenarios for reducing risk on site.

2-5. DBD's Core capabilities

The centrepiece of the poster is DBD's five core capabilities (Figure 2). Each case study refers to these key capabilities.

Figure 2 - DBD's Core Capabilities

3. Conclusion

This poster represents a portion of the wide range of work that DBD carries out internationally and the applicability of this work to problems currently faced on the 1F site.

References

[1] Publicly available images from online search engine – Google, sourced June 2017

R01 Fuel debris management system

Main technologies and approaches for fuel debris treatment.

Oleg Bagryanov, Senior Project manager, TENEX

Abstract

To detect the localization of fuel debris inside the PCV, to implement the sampling of fuel debris inside the PCV and also to develop recommendations for removing of fuel debris inside the PCV and RPV.

1. Introduction

Rosatom develops and applies modern control system neutron-physical characteristics of reactor units of type VVER, RBMK and BN, as well as points of SNF storage that allows to create neutron detectors of small dimensions for the detection of fuel debris within any geometry. Rosatom is also developing a remote controlled robotic systems for repairs and sampling of metalwork inside the RPV that allows to create sampling system for implementation of sampling inside the PCV of Fukushima Daiichi NPP.

2. Main steps in fuel debris treatment

2-1. Detection of fuel debris

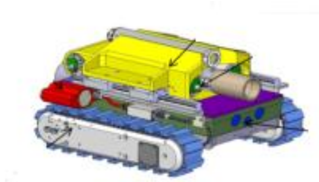
Detection of fuel debris plays one of the most important role in developing of debris removal technology. Rosatom's technologies (by using of small-size neutron detectors with automatic tuning) allow to accurately determine the localization of fuel debris.

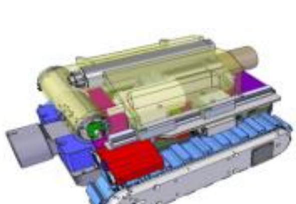
2-2. Developing of sampling technology (inside the PCV). Implementation of sampling (inside the PCV). Studying of the characteristics of the samples

Debris sampling will allow to obtain data on the properties of the debris and also allow to formulate the initial data for development of equipment for the debris removal.

Based on the experience in the development of robotic tools for conducting manufacturing operations at the RBMK type reactors (without fuel unloading) the enterprises of Rosatom are ready to develop and deliver a robotic system for sampling (inside the PCV) of fuel debris.

2-3. Developing of safety justification of debris removal (inside the PCV) technology. Developing of debris removal technology (inside the PCV). Developing of safety justification of debris removal (inside the RPV)technology. Developing of debris removal technology inside the RPV





Safety justification will allow to pick up equipment for dust suppression when performing cutting. At the enterprises of Rosatom has extensive experience in the development of safety justification and perform cutting of SNF in a variety of environments (under water, in air).

2-4. Packaging of fuel debris

Packaging for fuel debris samples plays an important role in ensuring the safe and efficient preparation of waste for interim storage or disposal.

3. Conclusion

Fuel debris sampling, removal and packing should be highly technical, effective and safe. Rosatom enterprises at each step ready to provide own, tested and unique technologies and solutions to overcome the challenges of different complexity.

R02

Options for Fukushima-Daiichi Liquid RW Management Improvement

Sergei Semin, Sector Head, TENEX

Adamovich Dmitrii, PhD, Head of Department, NIKIMT

Abstract

To improve current Fukishima-Daiichi liquid RW management, to reduce secondary waste generation, to reduce operative cost for liquid RW treatment.

1. Introduction

Well known, that liquid RW (LRW) treatment contains not only water decontamination phase but secondary waste conditioning phase too. And the main problem is how to prepare these secondary waste for disposal requirements. In this case, you there are several points of costs: capital, operating and service costs.

During decades, ROSATOM develops and applies effective liquid RW treatment solutions in the different cases like a legacy liquid RW treatment or new generated liquid RW treatment. ROSATOM has the modern cheap and effective solutions.

2. Current status

The main disadvantages of this scheme are the large volume of secondary waste generation and conditioning issues. ROSATOM offers to improve some part of basic scheme, which contain exclusion number of retrogradation steps.

3. Proposed improvements

The following points showed proposed scheme:

1. Special reagents added with highly dispersed flock generation for Sr capturing;
2. Flock separation on ceramic and ultrafiltration membrane;
3. Cs decontamination by finely divided sorbent and extra Sr sorbtion on flock;
4. Special containers with ferrocyanides sorbents disposap;
5. Sludge and slurry solidification into cement matrix or calcination;
6. Sludge and slurry solidification into cement matrix or calcination/

ROSATOM proposed improvements base on selective Sr isotopes concentration with inorganic collector and Cs isotopes sorbtion on finely divided sorbent. Sr and Cs isotopes codeposition occurs when special chemical reagents A and B are applying. Moreover, there is Sr-isotopes retrogtadation on highly dispersed flock. We note that maximum effect is achieved with the optimum ration of A and B reagents. And next step is extra Cs-isotopes decontamination.

Varying reagents volume and number of decontamination steps, you can achieve your own decontamination requirements with minimal secondary waste volume.

For Cs isotopes decontamination, finely divided (50-200 μm) inorganic sorbent is added. This sorbent captures Sr-isotops too. Only 5% of initial LRW volume is a secondary waste (sludge).

Thus, this proposed scheme allows reduce of Sr and Cs activity 725 and 7800 times respectively.

For extra Cs isotopes decontamination we offer to use ferrocyanides sorbents contain into the special containers, which could be disposal immediately. The column volume of this sorbent is 7000-8000 for seawater.

5. Conclusions

Offering scheme allows reduce secondary waste volume and reduce treatment cost by using cheap reagents and sorbents.

R03 Solid RW management system
Main technologies and approaches for solid RW treatment.

Oleg Bagryanov, Senior project manager, TENEX

Abstract

To reduce the release of radioactive and other toxic materials into the environment requires safety and effective treatment methods. Treatment of solid radioactive waste involves the application of several steps: decontamination, fragmentation, conditioning, rehabilitation and packaging. Each step must meet not only the safety criteria but also the effectiveness criteria.

1. Introduction

Rosatom applies progressive approaches to overcome the challenges associated with decommissioning, radioactive waste management, territory rehabilitation and elimination of accident consequences. During Russian nuclear industry development to overcome these challenges were designed various technologies that were tested in real conditions.

2. Main steps in solid RW treatment

2-1. Decontamination

Radioactive contamination of the working areas and equipment may result from normal operations or from accidental release. Decontamination, therefore, form an essential part of a radiation protection, serving to ensure clean and safe working conditions.

2-2. Fragmentation

For implantation of work in high radiation fields to minimize dose to personnel and to reduce the potential impact on the environment for distance fragmentation remotely controlled equipment should be used.

2-3. Conditioning

Before packaging radioactive wastes should be conditioned or to be brought in a convenient form for storage. Volume of radioactive waste arising from decommissioning process or from accident also should be reduced.

2-4. Rehabilitation

To significantly reduce a huge amount of radioactive soil and rehabilitate the territory arising from decommissioning process or from accident, it is necessary preliminarily segregate a waste stream by activity and separate by size particles.

2-5. Packaging

Packaging for radioactive wastes plays an important role in ensuring the safe and efficient preparation of waste for interim storage or disposal.

3. Conclusion

Radioactive waste treatment arising from regular decommissioning process or accident should be highly technical, effective and safe. Rosatom enterprises at each step ready to provide own, tested and unique technologies and solutions to overcome the challenges of different complexity.

US01 "Effective design and assurance for permanent geologic storage of contaminated liquids: site selection, surveillance, and safe operations"

Ahmed Abou-Sayed[1], JC Rogiers[2], Satoshi Mochizuki[3], Omar Abou-Sayed[1]
[1]Advantek Waste Management Services LLC, [2]Oklahoma University, [3]Consultant

Abstract (60 words)

The proposed solution of subsurface injection has been reviewed (June 2016) by the Tritiated Water Task Force. Their concerns were: no suitable geological structure, lack of monitoring technology and regulatory hurdles. However, our well-established technology today in oil and gas industry would address these issues .

1. Introduction

The present efforts and technologies currently deployed to manage contamination at Fukushima site, workers are exposed to radiation up to 8 times higher than the acceptable limit. It is also unavoidable to consider the radioactive water discharge to ocean during emergency. The accidental and planned diluted radioactive water discharges continue to contaminate the ocean and land. The concentration level increases through the entire food chains over the foreseeable future (500 to 1000 years). The challenge is to find a sustainable solution that spans many generations of mankind for such a long-term risk issue. We believe that our proven technology of geologic disposal is, so far, the only technology that meets the challenge. We have more than 30 years of experience of such application and would like to share our proven practice in oil, gas and chemical industries. Specifically, we refer to how we select the site, monitor, and operate safely through modeling, testing and real time surveillance for process integrity assurance.

2. Technology

The site selection involves the detailed study of geological structural column at the selected location. This requires seismic images, logging, core samples and modeling fluid and slurries flow in subsurface layers to guarantee containment and prevent any potential fault activation (breach or earthquakes), and to achieve controlled fracture propagation, if any. Pre-injection tests (fall-off test and step rate test) are performed to calibrate simulation models. We have established this workflow over 30 years for many fields around the world. Injection fluids and slurries (viscosity, density and particle size).are designed to optimize the injection and safety

The monitoring is done at the surface and near the injection point (fiber optics pressure gauges). The pressure response from the injection is continually analyzed to ensure the safe operation. Our industry-leading proprietary modeling technology plays the key role in interpreting data and taking actions.

We have worked with many governmental agencies on the legal framework around the world to apply this technology. We believe our experience would help formulate regulations in Japan.

3. Conclusion

The cesium contamination is spread to nearly entire Pacific Ocean. The dilution to legal limit is not the ideal solution because it concentrates through the entire food chain. Our technology is considered “risky” among some experts, but the damage that the current solution provides is extensive, and not sustainable for thousands of years. Our technology can provide much safer, economical and sustainable long-term solution.

US02 Nuclear Decommissioning and Risk Management from 30 Years of Experience

Tim Carraway, Stan Hodges, Gavin Winship, and Max Ehrhardt
AECOM

Abstract

This poster illustrates AECOM's decommissioning and dismantlement (D&D) program and approach. This approach includes all necessary elements to estimate and execute a complex D&D project. AECOM's proven approach is based on 30+ years of experience at commercial reactor and high-hazard decommissioning sites.

1. Introduction

In addition to selecting the appropriate D&D technology, an accurate cost estimate and schedule is a crucial factor in completing large, complex D&D projects. AECOM's database of experience guided by a proven project management approach with an integrated ISO 31000-compliant Risk Management program produces accurate estimates and allows efficient execution throughout a D&D project.

2. Decommissioning Project Management - Elements of an effective project execution plan

2-1. Baseline Development

By analyzing past performance and lessons learned, critical quantities and characteristics (labor, materials, equipment, D&D production rates for various hazard levels, etc.) are estimated. Key personnel within AECOM and the Site Owner with an essential base of knowledge are identified as the project management team.

2-2. Cost Estimating

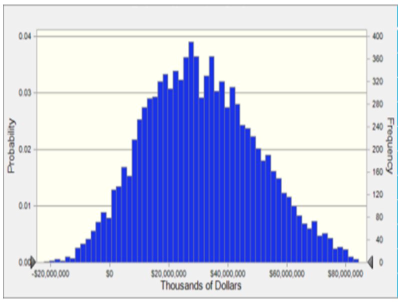
Costs are estimated based on the Work Breakdown Structure identified during the baseline analysis and then integrated into customized D&D estimating software. The estimate is supported by input from D&D Subject Matter Experts and validated by comparison with prior estimates in AECOM's D&D Database of Knowledge.

2-3. Scheduling

Combining AECOM's Database of Knowledge with commercially available scheduling software, the entire work scope is logically sequenced. The activities and cost estimates are shared between the schedule and cost software, creating a fully integrated cost and resource-loaded schedule.

2-4. Risk Management

Experienced Subject Matter Experts identify risks in the performance baseline and determine their likelihood and impact to the D&D project. Methods to mitigate or avoid each risk are developed. Using a Monte Carlo analysis of the risks, an appropriate amount of reserve funding (contingency) is calculated for emergent work.



Percentile	Forecast values
0%	-$24,455,177
10%	$7,390,419
20%	$14,169,276
30%	$19,812,358
40%	$25,116,259
50%	$29,875,858
60%	$35,163,772
70%	$40,879,659
80%	$47,418,606
90%	$56,609,780
100%	$97,003,368

Figure 1. Monte Carlo analysis for contingency funding

3. AECOM employs this project management approach on every large D&D project

3-1. AECOM's D&D Database of Knowledge is the foundation of AECOM's D&D program

With 30+ years of accumulated knowledge in procurement, design, fabrication, and operations in all stages of D&D projects at both Commercial Nuclear Power Plants and DOE/NDA facilities, AECOM incorporates actual results from completed projects to develop each element of the D&D execution plans.

3-2. AECOM's D&D Approach is integrated into the ETTP and San Onofre projects

AECOM's project management system (via its affiliate UCOR) was used to construct a Level 9 WBS with over 2000 activities at the East Tennessee Technology Park (ETTP) site. This approach has been proven in executing the Oak Ridge Reservation projects on-time and under budget. It is also used as the baseline for the SONGS D&D project.

UCOR's Project Performance			
		$M	¥B
Budgeted Cost of Work Scheduled	BCWS	$1,212.8	¥145.42
Budgeted Cost of Work Performed	BCWP	1,244.9	149.27
Actual Cost of Work Performed	ACWP	1,113.4	133.50
Cost Variance	CV	131.4	15.76
Schedule Variance	SV	32.1	3.85
Cost Performance Index	CPI	1.12	
Schedule Performance Index	SPI	1.03	

Figure 2. Contract performance at ETTP 2011-2015

4. Conclusion

AECOM's project management approach along with access to several decades of nuclear D&D experience can produce a cost estimate and schedule that properly accounts for and minimizes project risk. AECOM's strong proven resume and confidence to share risks with the site owners is a key feature that distinguishes AECOM from other D&D companies.

US03 Energy*Solutions* Nuclear Power Plant Decommissioning Experience

Colin Austin[1] and Makoto Kikuchi[2]
[1] Energy*Solutions*, [2] MKC Consulting

Abstract

EnergySolutions (ES) is an international leader in commercial nuclear power plant (NPP) decommissioning. It has developed this experience over a period of 30 years performing NPP decommissioning and related nuclear waste management services in the USA and Europe. This presentation will provide some background on ES, some specific examples of its decommissioning experience in the USA, and identify benefits that this experience brings to NPP decommissioning projects.

Scope of Work and Experience

ES was formed 10 years ago and is now made up of over 10 different companies that have been integrated to provide the complete value chain of services necessary to successfully perform NPP decommissioning projects. The companies that make up ES have a rich history in the industry going back as far as 60 years. The scope of work that ES has been involved in includes everything necessary to successfully perform NPP decommissioning including:

- Regulator compliant estimates for decommissioning funding,
- Detailed decommissioning planning and license application,
- Spent fuel management, handling and storage,
- Decontamination and dismantling,
- Equipment, facility and site survey and characterization,
- Waste packaging, transportation and logistics,
- Waste treatment and disposal, and,
- NPP site and waste management facility operating license holder.

This experience allows ES to understand and optimize the NPP decommissioning strategy to ensure projects are performed safely, in full compliance with all regulatory and permitting requirements and at the lowest cost. The company has developed different technical, contracting, business and licensing models to minimize both owner and contractor risk. Examples include:

- Transfer of the nuclear licenses at Zion and La Crosse from the nuclear utility to ES the D&D contractor,
- The first and only successful dismantlement of two NPP at the same time,
- Largest and fasted spent fuel transfer campaign, and
- First segmentation of large NPP reactor vessel in the USA, completed in 1 month.

Many of the lessons involve cultural change from that of a nuclear operator or an engineering project company to that of a nuclear facility dismantling and waste management project. The key is to recognize that a NPP decommissioning project is primarily a nuclear waste management project. The ES approach significantly reduces project risk and ensures safe and compliant performance for the lowest cost.

ES hopes to work with JAPC and the Fukui Prefecture to ensure safe compliant and effective execution of the Tsuruga-1 project, and to make available its experience to ensure the effectiveness of the NPP decommissioning program in Japan.

List of Organizations