The outline of Japan Atomic Energy Agency's Okuma Analysis and Research Center (1) - The total progress of Labolatory-1 and Labolatory-2 -

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Abstract

The JAEA is currently constructing the Okuma Analysis and Research Center near the TEPCO's Fukushima Daiichi Nuclear Power Station site based on the Japanese Government's "Mid-and-Long-Term Roadmap". The Okuma Analysis and Research Center consists of three buildings; Administrative building, Laboratory-1 and Laboratory-2. The hot laboratories; laboratory-1 and Laboratory-2 handle and analyze the radioactive samples from 1F site. Laboratory-1 is for radioactive analysis of low and medium level radioactive rubbles and secondary wastes. The construction began in April 2017 and plans an operational start in the spring of 2020. Laboratory-2 is planned for the radioactive analysis, mechanical and physical and chemical characterization, of fuels debris and high-level radioactive rubbles and secondary wastes. The detail design began in summer of 2016. Radioactive analysis in the hot laboratories will provide the data needed to establish the strategy and methodology for treatment and disposal of radioactive rubbles, and for the removal methods of fuel debris in the reactors. Laboratory-1 and Laboratory-2 are designed with reference to a generally accepted knowledge base on design of post-irradiated examination (PIE) facilities with enhancements that are discussed below.

1. Introduction

Tokyo Electric Power Company (TEPCO), Fukushima Daiichi Nuclear Power Station (1F) was hit by the 2011 Tohoku Earthquake off the Pacific coast of and the tsunami associated with the earthquake. Since the power supply equipment was lost by these natural disasters, the cooling function of reactor core was lost [1]. In the reactor of loss of coolant system, fuel pellets were heated and melted firstly. Secondary, the molten fuels fell to bottom of RPV (reactor pressure vessel) and penetrated through. These molten materials consist of the fuels assembly and reactor component materials, and were called "Fuel debris". Units 1, 3 and 4 caused explosion by generated hydrogen gas with fuel assembly melting progress. As a result, reactor rubble and radioactive materials were scattered around outside of the reactor building. Now, for cooling the damaged reactors (spent fuel assembly, fuel debris, and so on), contaminated water has been generated day by day. This contaminated water has been treated through water processing systems such as KURION, SARRY and ALPS. Radioactive wastes generated through these systems are referred to as secondary wastes from water processing. To treat and dispose these fuel debris and radioactive wastes they are issued towards decommissioning [2, 3].

In 1F, various efforts have been done towards the decommissioning based on the "Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station" (Revised June 12, 2015). The Japan Atomic Energy Agency (JAEA)

works on various missions for decommissioning of the 1F plant periphery, and the research and development facility "Okuma Analysis and Research Center" is designed and has been constructed near 1F as part of the efforts. The Okuma Analysis and Research Center will be used for research and development to ascertain characteristics of radioactive wastes, and technological development to treat and dispose fuel debris.

Figure 1 shows the expected completion drawing of the Okuma Analysis and Research Center [4]. The Okuma Analysis and Research Center consists of an administrative building, Laboratory-1 and Laboratory-2. The administrative building provides researcher's office spaces, meeting rooms and a workshop. The laboratory-1 will perform radioactive analysis, chemical and mechanical characterization of low and medium level radioactive rubble and secondary wastes. The laboratory-2 will perform radioactive analysis, mechanical and chemical characterization of fuel debris and high level radioactive rubble and secondary wastes.

In this paper, the basic design, activities, and the progress of the Okuma Analysis and Research Center are reported.

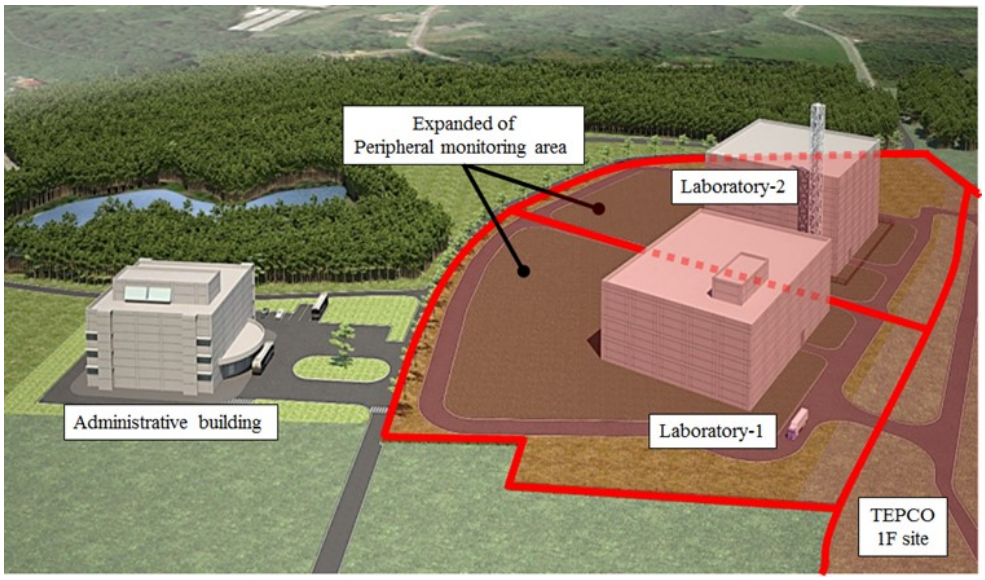

Fig. 1. Okuma Analysis and Research Center (expected completion drawing).

2. Mid-and-Long-Term Roadmap and the schedule of the Okuma Analysis and Research Center

The Mid-and-long-Term Roadmap for the decommissioning of Fukushima Daiichi Nuclear Power Station is shown in Fig.2, and the construction schedules of the Okuma Analysis and Research Center are in Fig.3. The objective of fuel debris removal will be determined in middle 2017, and the beginning of the fuel debris removal will be planned in September 2021 on the Mid-and-Long-Term Roadmap. The fuels debris removal method and transport route will be decided based on the observation of the 1F reactor's internal supervision.

The hot laboratory; Laboratory-1 is designed and in construction, and Laboratory-2 will be designed and constructed based on the Roadmap. The detail design of Laboratory-2's transport equipment will be decided on the fuels debris removal and transport methods, which have an impact on the selection of top-loading transport or side-loading transport methods.

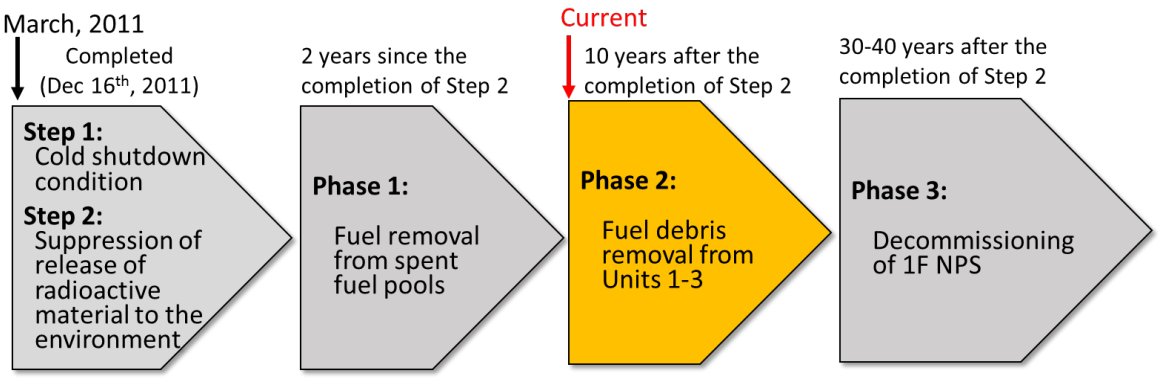

Fig. 2. The Mid-and-Long-Term Roadmap for the decommissioning of 1F NPS.

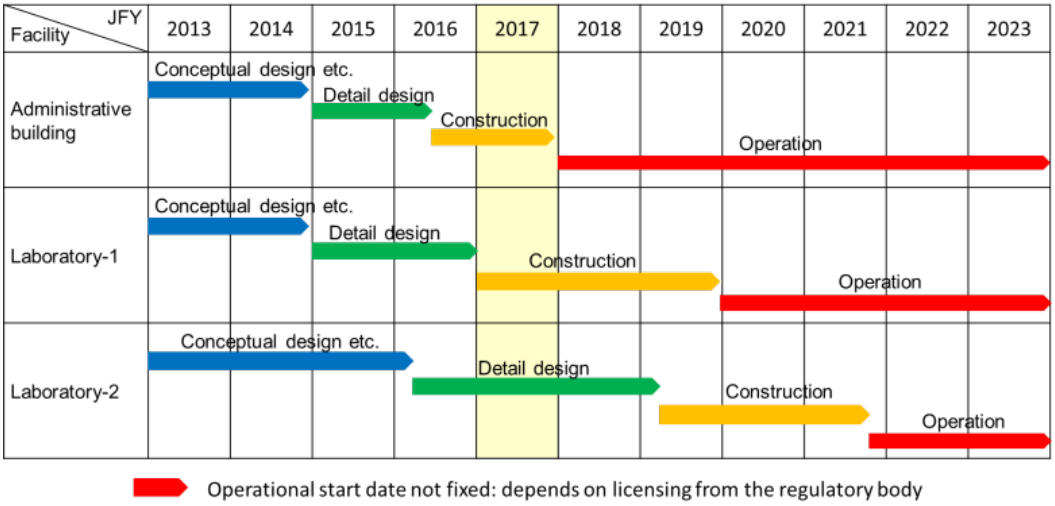

Fig. 3. Okuma Analysis and Research Center construction schedule.

3. Concept, design and current situation of the Okuma Analysis and Research Center

The Administrative building provides office space and meeting rooms for the researchers, and an apparatus mock-up space “Workshop”. The construction began in October 2016, and plans an operation start in the spring of 2018. Laboratory-1 and Laboratory-2 have hot cell, glove boxes, and hoods for handling and analyzing radioactive materials. Transport equipment; an airlock, overhead traveling cranes, and carriages are installed in the facilities. These transport utilities will be used for analysis samples from the 1F site. The license of the Laboratory-1’s implementation was approved by The Secretariat of the Nuclear Regulation Authority and the construction started in April 2017, it is planned an operational start in 2020.

The Laboratory-1 and Laboratory-2 are designed with reference to a generally accepted knowledge base of existing post-irradiated examination facilities in Japan and other countries [5, 6]. Laboratory-1 is for radiometric analysis of low (< 1 mSv/h) and medium (< 1 Sv/h) level radioactive rubble and secondary waste. Laboratory-2 is for radiometric analysis of high (≧ 1 Sv/h) level radioactive rubble and fuel debris. The main specifications of Okuma Analysis and Research Center are in Table-1. Table-2 shows the design of main analysis items and

preparation items and so on. Proven analysis equipment and procedures were considered and selections were made at a review meeting organized by qualified and key members [7]. Special equipment for analysis of fuel debris will be installed at Laboratory 2. This equipment includes X-ray CT. In selection of the analysis equipment, proven past results are given priority over the latest experimental devices. The equipment will have resistance to radiation from the fuel debris and high level radioactive samples.

Table 1 Buildings specifications

	Administrative building	Laboratory-1	Laboratory-2
Building design	4 floors	3 floors	4 floors (TBD)
Total floor area	4,786m^2	9,671m^2	9,200m^2 (TBD)
Analysis materials	- (Researcher's Residential and Office room)	・Rubble and Secondary wastes (low and middle levels)	・Fuel debris and highly contaminated materials ・Rubble and Secondary wastes (high levels)
	-	β-γ specimen	α-γspecimen
Main equipment	-	Steel cell, Glove Box, Fume hood	Concrete cell, Steel cell, Glove Box, Fume hood
Others	Workshop		

Table-2 The design of main analysis items in Okuma Analysis and Research Center

	Laboratory-1	Laboratory -2 (TBD)
Main Analysis items	Radioactivity Elemental analysis Salinity Organic matter Surface analysis Chemical analysis Hydrogen gas Mechanical characteristics Specific surface area / Particle size distribution	Radioactivity Elemental analysis Salinity Organic matter Surface analysis Chemical analysis Hydrogen gas Mechanical characteristics Specific surface area / Particle size distribution Density Thermal property Calorific/Heating value Others (High-temp. properties, etc)
Main Preparation	Cutting machine Polishing machine Electric discharge machine	Cutting machine Polishing machine Electric discharge machine
Main Pretreatment	Alkali dissolution units Acid dissolution units	Alkali dissolution units Acid dissolution units
Others		X-ray computed tomography scanner Pneumatic carrier system

3.1. Laboratory-1

Laboratory-1 will provide the data needed to establish the strategy and methodology for treatment and disposal of the wastes. In Laboratory-1, the radioactive samples will be analyzed mainly on the second floor. The schematic layout is shown in Fig. 4. Laboratory-1 is equipped with 10 glove boxes, and 56 fume hoods for low level radiochemical analysis. For

the handling of medium level samples, a sealed room and steel cells will be installed. The crushing and division of the samples are carried out at that space. If additional analysis equipment is purchased and additional technicians are hired, the lab capability can be expanded to process up to 800 samples/year, and equipment is installed for this sample level. The number of samples for analysis is expected to be a maximum of 200 samples/year, which is estimated for the necessary number of waste disposal treatment. There will be 120 samples/year of concrete, metal and secondary waste with medium level contamination [4]. The maximum size of low and medium level samples is less than 300kg and 2kg, respectively. The 2kg size is limited by manipulator capacity. The 300kg size is due to the capacity of the transporter.

It is expected that for safe disposal of 1F wastes that 38 nuclides should be assessed. Pre-processing by alkali dissolution and acid dissolution is done before the radiochemical analysis is done. Acid dissolution produces acid vapor and the acid vapor negatively affects piping and equipment. The fume hoods outflow goes through a scrubber to remove the acid vapor. Operational experience of Laboratory-1, will be applied for improving Laboratory-2's method of analysis.

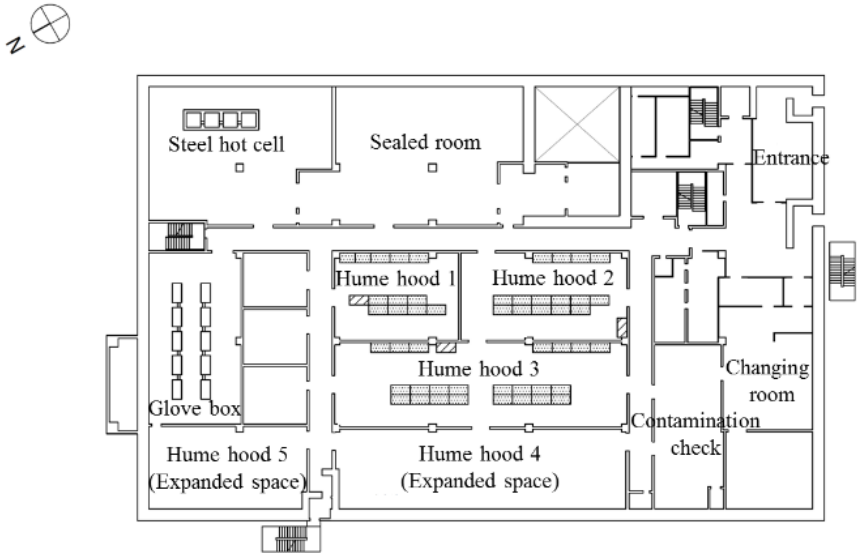

Fig. 4. Schematic layout of Laboratory-1 (Second floor plan).

3.2. Laboratory-2

Concrete cells, steel cells, glove boxes and fume hoods, will be installed at Laboratory 2 for the analysis of fuel debris and high level radioactive rubble, and will be used to determine the basic design for the high level radioactive waste disposal method. The fuel debris samples will be about 5kg and there will be up to 12 samples/year. Laboratory-2's concrete and steel cells will be designed to be filled with nitrogen, to prevent the samples from oxidizing, and to suppress fire when cutting samples containing Zry-2. The facility will be equipped with 14 concrete cells, and 12 steel cell for the high level radiochemical analysis, located mainly on the first floor. The facility services will be in the first basement level. The first floor schematic layout is shown in Fig. 5. These cell and the glove boxes will be connected by pneumatic carrier system, for convenient transportation of high level radioactive samples. The design concept of glove boxes and fume hoods specifications are similar to that of Laboratory-1, because the same analysis methods will be used after the sample size is reduced to minimize the radioactivity dose at the cells.

The main feature of Laboratory-2 is heavy concrete and steel cells, where the samples of high level waste and fuel debris are treated and prepared. At first, the analysis samples from the 1F site are transferred by transport cask (top loading cask or side loading cask (TBD)),

and are brought into the receiving-concrete cell, where dosimetric measurement (γ-ray measuring), non-destructive inspection by visual examination and X-ray transmission tomography are done to confirm the safety of the transportation. Secondarily, the sample will be moved to the preparation-concrete cell and will be cut, polished, modified or dissolved as necessary for pretreatment. It will be necessary to use special corrosion countermeasures when the fuel debris is dissolved by acids. To reduce radioactivity dose, the sample size will be lowered before. The handling within glove boxes and fume hoods is similar to that of Laboratory-1, since the dose rate of the fuel debris and high level radioactive rubble activity will be reduced to a low enough level.

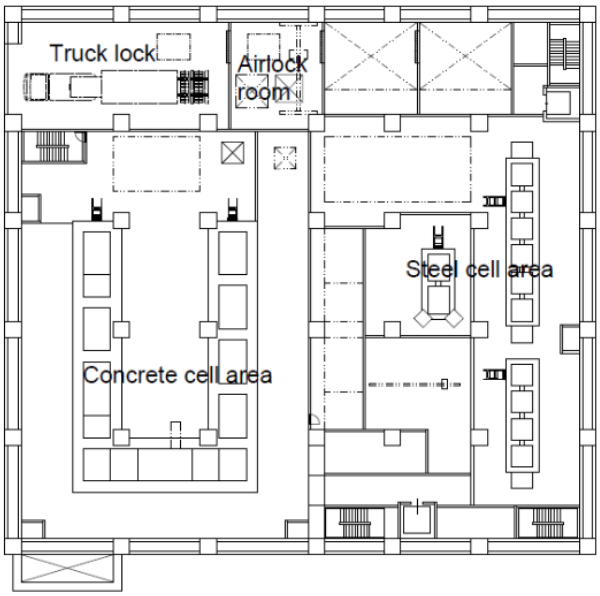

Fig. 5. Schematic layout of Laboratory-2 (First floor plan).

4. Hot laboratory operation; operator resources and framework

When the Okuma Analysis and Research Center starts up, many operators and analysts will be necessary. The operators will need particular skills including safety knowledge and experience about radiation and radioactive materials in a radiation controlled area. The analysts will need highly specific skills, such as the handling work, transport, and analysis methodologies of radioactive specimens in a radiation controlled area.

Related to the training of the operators and analysts, young JAEA staff will be posted in existing and operating post irradiated examination (PIE) facilities, this way they will learn the different analysis techniques and have an experience of dairy checkup in PIE facilities for a few years. With their experience they will become the leading member of the facilities at the startup of the Okuma Analysis and Research Center.

5. Summary

According to the Roadmap, JAEA is moving forward with the design and building of the Okuma Analysis and Research Center accordingly. JAEA's buildings will be constructed first with consideration for safety. JAEA will promote a design for the laboratories based on the latest knowledge to be able to safely perform the analysis of the fuel debris. JAEA will be reporting the progress made at the laboratories at a future time.

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