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Experience of Integrated Safeguards Approach for Large-scale Hot Cell Laboratory

N. Miyaji[a], Y. Kawakami[a], A. Koizumi[a], A. Otsuji[b], K. Sasaki[b]

[a]Fuels Monitoring Section, Fuels and Materials Department,
Oarai Research & Development Center, Japan Atomic Energy Agency (JAEA),
Ibaraki, Japan

[b]Japan Safeguards Office (JSGO),
Ministry of Education, Culture, Sports, Science and Technology (MEXT),
Tokyo, Japan

miyaji.noriko@jaea.go.jp

Abstract. The Japan Atomic Energy Agency (JAEA) has been operating a large-scale hot cell laboratory, the Fuels Monitoring Facility (FMF), located near the experimental fast reactor Joyo at the Oarai Research and Development Center (JNC-2 site). The FMF conducts post irradiation examinations (PIE) of fuel assemblies irradiated in Joyo. The assemblies are disassembled and non-destructive examinations, such as X-ray computed tomography tests, are carried out. Some of the fuel pins are cut into specimens and destructive examinations, such as ceramography and X-ray micro analyses, are performed. Following PIE, the tested material, in the form of a pin or segments, is shipped back to a Joyo spent fuel pond. In some cases, after reassembly of the examined irradiated fuel pins is completed, the fuel assemblies are shipped back to Joyo for further irradiation. For the IAEA to apply the integrated safeguards approach (ISA) to the FMF, a new verification system on material shipping and receiving process between Joyo and the FMF has been established by the IAEA under technical collaboration among the Japan Safeguard Office (JSGO) of MEXT, the Nuclear Material Control Center (NMCC) and the JAEA. The main concept of receipt/shipment verification under the ISA for JNC-2 site is as follows: under the IS, the FMF is treated as a Joyo-associated facility in terms of its safeguards system because it deals with the same spent fuels. Verification of the material shipping and receiving process between Joyo and the FMF can only be applied to the declared transport routes and transport casks. The verification of the nuclear material contained in the cask is performed with the method of gross defect at the time of short notice random interim inspections (RIIs) by measuring the surface neutron dose rate of the cask, filled with water to reduce radiation. The JAEA performed a series of preliminary tests with the IAEA, the JSGO and the NMCC, and confirmed from the standpoint of the operator that this system could be used for verification purposes under the ISA. It is clear that application of the system under the ISA would improve the transparency of the material shipping and receiving process and the system established by the IAEA with the JSGO, the NMCC and the JAEA would successfully contribute to strengthening the effectiveness and efficiency of JNC-2 safeguards. Short notice RII will be also applied to material transfer between the FMF and the prototype fast breeder reactor, Monju.

1. Introduction

Figure 1 shows a bird's-eye view of the Oarai Research and Development Center (JNC-2 site) of the Japan Atomic Energy Agency (JAEA). The site consists of the experimental fast reactor Joyo, the Fuel Monitoring Facility (FMF), the Alpha Gamma Facility (AGF), the Material Monitoring Facility (MMF), the Irradiation Rig Assembling Facility (IRAF), the Deuterium Critical Assembly (DCA) and other facilities.

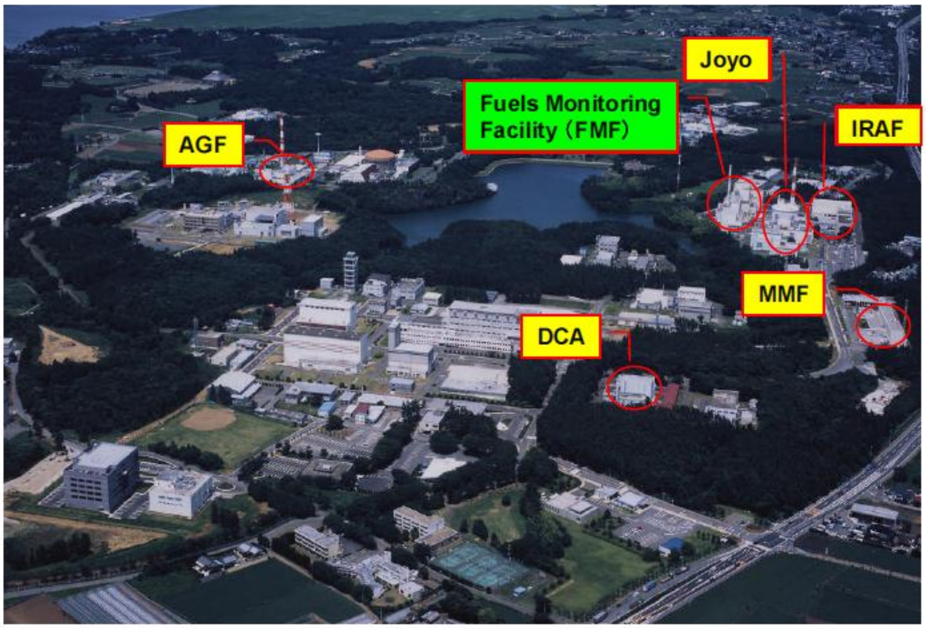

Fig.1 Bird's-Eye View of JNC-2 Site

The FMF plays the key role in the receiving of assemblies from Joyo. In this facility, the received assembly is disassembled and non-destructive examinations are carried out. Some of the disassembled pins are cut into segments and destructive examinations are performed. Then, some of the segments are shipped to the AGF and/or the MMF for detailed examination. In the AGF, physicochemical and metallographic examinations of the irradiated fuels are conducted. In the MMF, mechanical strength and metallurgical examinations of the irradiated core and structural materials are conducted. After PIE, the tested materials are shipped back from the AGF and the MMF to the FMF. Finally, they are shipped back form the FMF to a Joyo spent fuel pond. In some cases at the FMF, the fuel assemblies are shipped back to Joyo core for further irradiation after reassembling of the irradiated fuel pins that are transferred from the other assembly. The spent fuel flow is shown in Fig.2.

Fuel irradiation rigs and material irradiation rigs for Joyo are assembled in the IRAF. And, the DCA is under decommissioning.

The application of safeguards system to Japan started in 1977 in accordance with the safeguards agreement between the IAEA and Japanese government. The original safeguards system was strengthened by the additional protocol in 1999. This conventional safeguards system has been applied to Japan including the JNC-2 site.

The IAEA carried out conversion of the applied safeguards system from the conventional approach to the integrated safeguards approach (ISA) at the JNC-2 site from October 2010 per a March 2010 agreement between the IAEA and the Japanese government.

The conventional safeguards approach consisted of one Physical Inventory Verification (PIV), one Design Information Verification (DIV), several Interim Inventory Verifications (IIVs) and certain other verification procedures per year. The PIV is a verification activity focusing on the facility inventory based on the list of inventory items prepared by the operator. The activities of the DIV are carried out to verify that the facility design has not been tampered with. IIV is for purpose of timely detection. These activities were performed according to the schedule. Each facility at the JNC-2 site had a different IIV times because the timeliness detection goal depended on the types of material handled at each facility.

Meanwhile, under the ISA, a new verification system for the material shipping and receiving process between Joyo and the FMF is required to improve the effective and efficiency. Therefore, the IAEA has established a new verification system under technical collaboration among the Japan Safeguard Office (JSGO) of MEXT, the Nuclear Material Control Center (NMCC) and the JAEA.

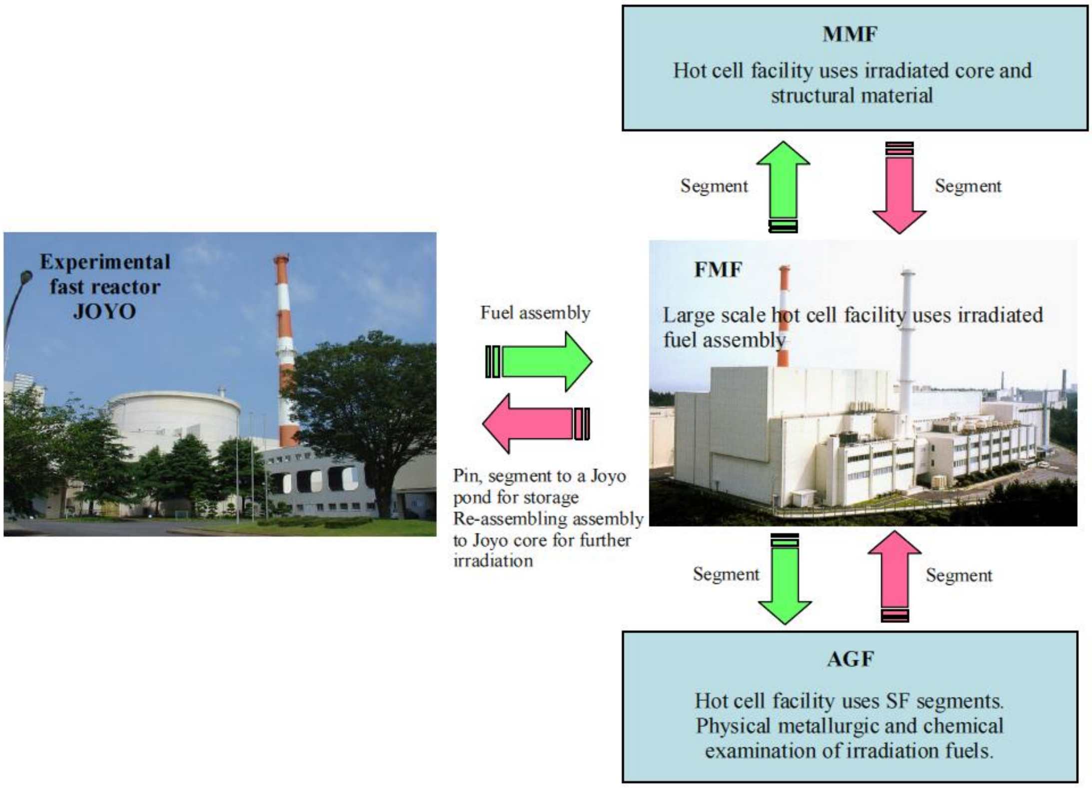

Fig.2 Materials flow between Joyo and the FMF, the FMF and the AGF, the MMF

In this paper, the new verification system for material flow between Joyo and the FMF is described, including experience applying the ISA to the FMF.

2. Development of the ISA to the FMF

2.1 Outline of the ISA to the FMF

The designed ISA consists of Containment and surveillance (C/S) measures with remote monitoring (RM) and short notice Random Interim Inspection (RII). Under the ISA, the FMF is treated as a Joyo-associated facility, i.e., sector, in terms of its system of safeguards because it deals with the same spent fuels. And, the C/S measures and the RII are to be applied to the receipt and shipment process between Joyo and the FMF. The annual PIV is also to be carried out to verify the facility inventory. Additionally, the IIV is not required because the timeliness detection goal of material handling at the FMF has been relaxed from three months under the conventional safeguards approach to one year. The details of the C/S measures and the RII are described below.

2.2 C/S measures with RM

The verification of the material shipping and receiving process between Joyo and the FMF is applied only to the declared transport routes and transport casks. The C/S measures are provided by the following C/S systems: the Server Digital Image Surveillance (SDIS) system which consists of cameras, a server computer with an uninterruptible power supply system, and a data transmission system which utilizes the Internet. The cameras are placed at key measurement points according to the material flow of the declared transport casks. The monitoring data obtained from the cameras are automatically gathered into the server computer, and also automatically transmitted to the IAEA HQ in Vienna, Austria, via the Internet. This could provide the Continuity of Knowledge (CoK) concerning the material flow.

2.3 RII with short notice

The nuclear material contained in the transfer cask is verified with the method of the gross defect at the time of short notice RII. The verification could be performed through measurement of the surface neutron dose rate of the cask. Since the application of a verification procedure using the neutron dose rate measurement method was a new concept at the JNC-2 site, the IAEA has developed a neutron measurement system for the nuclear material contained in the transferred cask under technical collaboration among the JSGO, the NMCC and the JAEA. Under the condition of maintaining the CoK obtained by the SDIS system, the RII on shipping from the FMF to Joyo can be conducted the day before shipping in accordance with the convenience of the operator. The details of the system are described below.

Additionally, the above-mentioned short notice RII will be also applied to nuclear material transfer between the FMF and Monju, located in Tsuruga, Fukui.

2.4 Validation of the developed verification system

In developing the verification system, reduction of the radiation exposure level of the inspector and operator during the RII inspection work was an important issue. Accordingly the system was designed to measure the surface neutron dose rate of the cask before draining the water contained in the cask. In order to confirm the system, the JAEA performed a series of preliminary test measurements of the surface neutron dose rate of the cask with the IAEA, the JSGO, and the NMCC. In the tests, the surface neutron dose rate measurements were carried out both before and after draining the water from the cask using a common BF_3 proportional counter. The measurement point of the vertical position was fixed at an approximately 400mm height from the bottom of the cooling fins of the cask because the nuclear materials were positioned around that area in the declared transfer cask. The schematic diagram of the cask is shown in Fig.3.

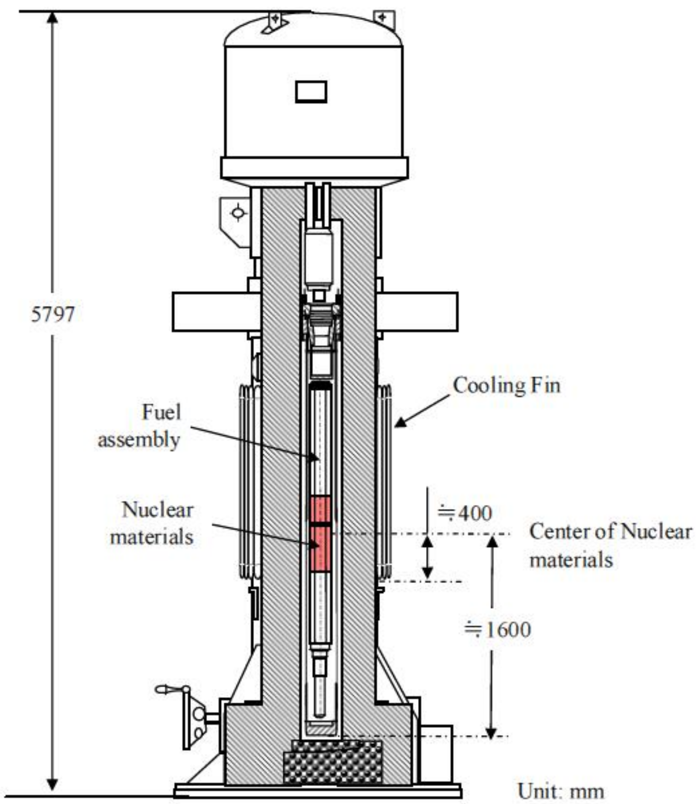

Fig.3 The schematic diagram of the cask

The test results are shown in Fig.4. It is shown that, although the surface neutron dose rate of the cask after draining the water is higher than the dose rate before draining, it is possible to confirm the existence of the nuclear materials from the measurement results obtained before draining, i.e., when filled with water. Therefore, it is concluded that the newly developed neutron measurement system for the cask when filled with water is sufficiently accurate. Additionally, in the actual RII, a ^{3}He proportional counter is employed, because it is fairly sensitive compared with a common BF_3 proportional counter.

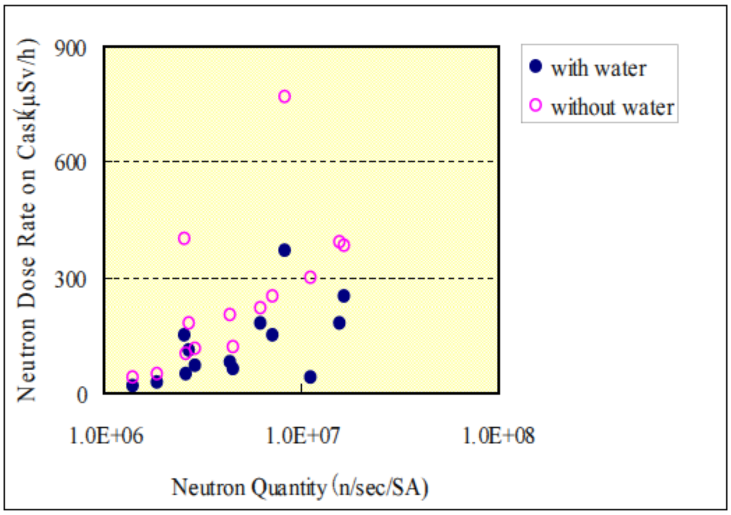

Fig.4 Relation of neutron quantity per assembly to neutron dose rate on SF cask

3. Effects of ISA implementation to the FMF

Under the conventional safeguards approach, one PIV, one DIV, and three IIVs were performed every year in accordance with the published schedule. The DIV could be combined with the PIV, and 1PIV/DIV required 2 Person-Day-Inspection (PDI). Each IIV required 1 PDI, and 5PDIs were required per year. Also, the operator was required to make an effort to ensure smooth PIV and IIVs, such as transferring nuclear material from its storage to display it in front of cell windows and so on. For the operator, an average of 52 work-days per IIV and PIV were required, which had a significant impact on facility operation.

Under the ISA, the RII and providing monthly facility information in advance as Advance Site Information (AI) is newly required work for the FMF. AI is a system of providing the facility operation schedule to the IAEA. Such information includes material transfer, facility maintenance with restrictions to access, and activities for C/S review. RII is performed not only for the material transfer but also for the detection and deterrence of undeclared activities. One PIV and one DIV per year are performed in the same manner as the conventional safeguards approach.

The expected number of RII for material transfer between Joyo and the FMF is 3, meaning that this type of RII requires 3 PDIs per year. The expected number of RII for the detection of undeclared activities is at least 1, which means that this requires 1 PDI. The PIV as well as the DIV are performed once and require a total of 2 PDIs. Therefore, the expected total workload is an average of 6 PDIs per year. For the operator, there is no need to prepare for the verification, such as providing a display of the material on the RIIs. Operator effort for the PIV and the AI is expected to be 52 work-days and at least 24 work-days, respectively.

Table 1 shows the inspection times and days under the ISA compared with the conventional safeguards approach to the FMF. Although the number of inspections and workload for AI provision under the ISA increases, operator effort per year is reduced to less than half of that required under the conventional safeguards approach. This is the result of IIV not being performed under the ISA. Furthermore, since the facility operation is not disturbed by the IIV, the efficiency of the PIE work would improve. It should be noted that the standby work-days are not taken into account in the above evaluations.

It is also clear that application of the system under the ISA would improve the transparency of the material flow and successfully contribute to strengthening the effectiveness and efficiency of safeguards.

Besides, in terms of amount of PDI, the number of PDI on the FMF slightly increases under the ISA as cited above. However, it is confirmed that the total number of PDI on the whole of the JNC-2 site under the ISA should decrease to approximately two-thirds of the conventional safeguards: for example, on Joyo, the number of PDI decreases almost by half. Therefore, the application of the ISA should fairly reduce the total workload on the JNC-2 site.

Table.1 Comparison of Operator's work-day with Conventional and IS approaches

	Conventional safeguards		Integrated safeguards	
	PDI	Operator's work-day	PDI	Operator's work-day
IIV	3	156 (3time×52work-days/time)	---	---
RII for material transfer	---	---	Average 3	Average 12 (3times×4work-days/time)
RII for detect undeclared activities	---	---	At least 1	At least 3 (1times×3work-days/time)
PIV/DIV	2 in total	52	2 in total	52
AI	---	---	12 (---)	24 (12times×2work-days/time)
Total	5PDIs	208work-days	6PDIs+12AI	91work-days

4. Conclusion

A new verification system on the material shipping and receiving process between Joyo and the FMF was established by the IAEA under technical collaboration with the JSGO, the NMCC and the FMF. As a result, it is clear that application of the system under the ISA would improve the transparency of the material flow and successfully contribute to strengthening the effectiveness and efficiency of safeguards.

Although FMF PDIs under the ISA, having one PIV, one DIV, several short notice RIIs, and no IIV, increase compared with the conventional safeguards approach, the total workload on the JNC-2 site is fairly decreased.

The short notice RII will be also applied to material transfer between the FMF and Monju, defined as the same sector under the ISA, and due to this, PDIs and operator effort will be increased as in, for example, the performance of transfer RIIs between Joyo and the FMF.

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