Analysis on approach of safeguards implementation at research reactor handling item count and bulk material

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1. Introduction

KiJang research reactor (KJRR) will be constructed to produce the radioisotope such as Mo-99 etc., provide the neutron transmutation doping (NTD) service of silicon, and develop the core technologies of research reactor [1,2].

Different from other research reactor in Korea, KJRR has a process using nuclear material for fission Mo production and physical/chemical changes of nuclear material are occurred during the process. Therefore it is necessary to analyze the approach of safeguards and nuclear material accountancy for KJRR.

In this paper, the features of the process and nuclear material flow are reviewed and the material balance area (MBA) and key measurement point (KMP) are established based on the nuclear material flow. Also, this paper reviews the approach on safeguards and nuclear material accountancy at the facility level for Safeguards-by-Design at research reactor handling item count and bulk material.

2. Features of KJRR

KJRR mainly consists of reactor area and fission Mo production area. The reactor area and FMPA area are separated by a wall and there is a transfer elevator installed between the spent fuel storage pool and the hot cell of FMPA to move the targets.

2.1 Reactor Area

KJRR is an open-tank-in-pool type research reactor with 15 MWth and the design features are shown in table I [3]. Reactor area consists of fresh fuel storage, reactor core, service pool and spent fuel storage pool.

Table I: Design features for KJRR

Parameter	Value
Reactor type	open-tank-in-pool
Reactor power	15 MW
Max. thermal neutron flux	> 3.0×10^{14}n/cm^{2}s
Coolant	H_2O
Reflector	Be, Graphite, and Al
Absorber	hafnium

The fuel assembly is a box-type fuel with flat fuel plates and U-7Mo dispersion fuel with an enrichment of 19.75% will be used. Two different types of fuel assemblies, 16 standard fuel assemblies (SFA) and 6 follower fuel assemblies (FFA) which is attached with Hf absorber, will be loaded in the core [2,3]. Figure 1 shows the flow of fuel assemblies in the facility.

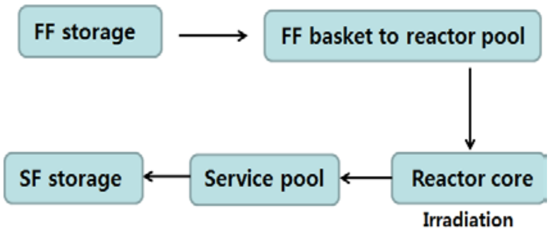

Fig. 1. Flow of fuel assemblies in KJRR

2.2 Fission Mo Production Area

Fission Mo production area (FMPA) produced Mo-99 from irradiated FM target. FMPA consists of concrete hot cells, U filter cake storage, and hot labs.

FM target assembly consists of 8 plates with 19.75% enriched UAlx-Al target and 6 FM target assemblies will be loaded in the core [4].

After irradiation in the core, FM targets will be transferred to hot cell in the FMPA using transfer elevator and dissolved in NaOH solution to extract Mo-99. The precipitated uranium during the process will be collected in a U filter cake and the U filter cakes are transferred to U filter cake storage after packaging and welding. Figure 2 shows the flow of FM target in the facility.

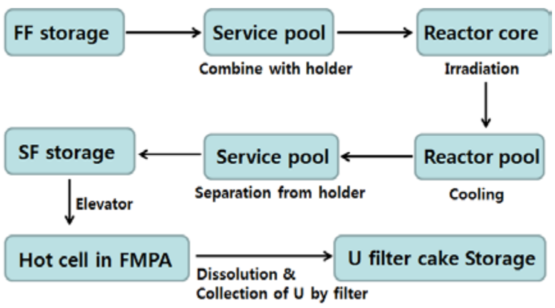

Fig. 2. Flow of FM targets in KJRR

3. Approach on safeguards and nuclear material accountancy

3.1 Establishment of MBA

The material balance area (MBA) is an area inside or outside of a facility such that the quantity of nuclear material in each transfer into or out of each MBA can be determined. The MBA is the nuclear material accounting area for reports made to the IAEA and nuclear material accounting is the activities carried out to establish the quantities of nuclear material present within defined area and the changes in those quantities within defined periods [7].

The reactor area and FMPA are exists within a building at KJRR and the irradiated FM targets will be frequently transferred from reactor area to FMPA. If the KJRR has 2 MBAs, the number of nuclear material accounting reports will be increase due to the nuclear material transfers from reactor to FMPA and it can disrupt FM production activities during IAEA inspection. Thus, 1 MBA for KJRR is determined through discussion with the IAEA considering the effective and efficient safeguards measures such as the nuclear material accountancy and the Agency's inspection.

3.2 Establishment of KMPs

The key measurement point (KMP) is a location where nuclear material appears in such a form that it may be measured to determine material flow or inventory. The flow and inventory KMPs at KJRR are established considering the features of process, the location of inventory, measurement point and nuclear material flow as shown table II.

Table II: Flow and inventory KMPs in KJRR

KMPs		Description
FKMP	KMP 1	Receipt, de-exemption, accidental gain
	KMP 2	Shipment, exemption, accidental loss
	KMP 3	Transfer to/retransfer from retained waste, nuclear production/loss
	KMP 4	Shipper/receiver difference
	KMP 5	Measured discard, termination
	KMP *	Rebatching plus and minus
IKMP	KMP A	Fresh fuel/FM target storage
	KMP B	Reactor core
	KMP C	Spent fuel storage
	KMP D	FMPA hotcells
	KMP E	U filter cake storage
	KMP F	FMPA hot labs
	KMP G	Other location

3.3 Approach on safeguards implementation

The safeguards implementation for fuel assemblies of KJRR can be applied the same approach with existing research reactor.

On the other hand, for the fresh FM target, it is not determined that the FM target assembly will be received to KJRR or FM target plates will be received and assembled in KJRR. Also, dummy target plates may replace part of FM target plates to adjust the FM production plan. Therefore, the amount of nuclear material included in a FM target assembly is very important for the verification. It could be necessary to discuss with IAEA to apply the safeguards approach on the FM targets.

For the irradiated FM target, it is not easy to measure the amount of the nuclear materials in hot cells. The collected uranium from resolved targets is more than 99.97% and very tiny amount of nuclear material will be remained in intermediate level liquid wastes which are filtered by U filter cake.

Thus the amount of remaining in the intermediate level liquid waste has to be analyzed. According to the analysis result, all uranium dissolved can be regarded as the uranium collected in U filter cake or the remaining uranium in the liquid waste could be treated MUF/loss through the discussion with IAEA.

4. Conclusions

In this paper, MBA and KMPs are established through the analysis on facility features and major process at KJRR handling item count and bulk material. Also, this paper reviews the IAEA safeguards implementation and nuclear material accountancy at KJRR. It is necessary to discuss the safeguards approach on the fresh FM target assemblies and remaining uranium in the intermediate level liquid wastes.

REFERENCES

[1] I.C.Lim, et al, "Strategy for the effective utilization of new research reactor", KAERI/TR-4519/2011, 2012.
[2] C.G.Seo, et al, "Conceptual Nuclear Design of the Kijang Research Reactor" RRFM 2013, Saint Petersburg.
[3] C.Park, et al, "Current Status of the KJRR Project and its Design Features", 16^{th} IGORR, 2014.
[4] K.H.Lee, et al, "Depletion and Decay Analyses of a KJRR Fission Moly Target", KNS 2013.
[5] IAEA, "Management of radioactive waste from ^{99}Mo production", IAEA TECDOC-1051, 1998.
[6] IAEA, "Production and supply of Molybdenum-99", IAEA 54^{th} General Conference Documents, 2010.
[7] IAEA, "IAEA Safeguards glossary", 1987.