Dose Rate Calculation of TRU Metal Ingot in Pyroprocessing - 12202

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ABSTRACT

Spent fuel management has been a main problem to be solved for continuous utilization of nuclear energy. Spent fuel management policy of Korea is "Wait and See". It is focused on Pyroprocess and SFR (Sodium-cooled Fast Reactor) for closed-fuel cycle research and development in Korea.

For peaceful use of nuclear facilities, the proliferation resistance has to be proved. Proliferation resistance is one of key constraints in the deployment of advanced nuclear energy systems. Non-proliferation and safeguard issues have been strengthening internationally. Barriers to proliferation are that reduces desirability or attractiveness as an explosive and makes it difficult to gain access to the materials, or makes it difficult to misuse facilities and/or technologies for weapons applications. Barriers to proliferation are classified into intrinsic and extrinsic barriers. Intrinsic barrier is inherent quality of reactor materials or the fuel cycle that is built into the reactor design and operation such as material and technical barriers. As one of the intrinsic measures, the radiation from the material is considered significantly. Therefore the radiation of TRU metal ingot from the pyroprocess was calculated using ORIGEN and MCNP code.

INTRODUCTION

Spent fuel management is the main problem to be solved for continuous utilization of nuclear power. There are three options for back-end fuel cycle in general; reprocessing, once-through (direct disposal) cycle and wait and see (deferred decision). Spent fuel management policy in Korea is “Wait and See”. In general, factors for fuel cycle assessment are environmental impacts, economics, public acceptance and proliferation resistance. Especially proliferation resistance is important for peaceful use of nuclear energy by impeding the diversion or undeclared production of weapon-usable material. It is also one of key constraints in the deployment of advanced nuclear energy systems.

There are many factors for fuel cycle assessment such as environmental impacts, economics, proliferation resistance, etc... Proliferation resistance is one of key constraints in the deployment of advanced nuclear energy systems. It is also important for peaceful use of nuclear energy by impeding the diversion or undeclared production of weapon-usable material. Non-proliferation and safeguard issues have been strengthening internationally.

DOSE RATE CALCULATION

The radiation from metal ingot in pyroprocess has been assessed. As it is mentioned before, SF management policy in Korea is “wait and see”. For the reprocessing of SF dry type reprocessing so called pyroprocess is considered and the long-term interim storage and direct disposal of high-level waste are also major issue in radioactive waste management in Korea.

Proliferation Resistance and Barriers

Proliferation resistance is defined as that characteristic of nuclear energy systems that impede the diversion or undeclared production of nuclear material, or misuse of technology, by States intent on acquiring nuclear weapons or other nuclear explosive devices [1].

Barriers to proliferation can be described as those elements of the system that reduces desirability or attractiveness as an explosive, or make it difficult to misuse facilities and/or technologies for weapon applications. Barriers to proliferation resistance can be divided into intrinsic and extrinsic barriers. Intrinsic barriers are those inherent to technical and related elements of a fuel cycle, and its facilities and equipment [2]. Extrinsic barriers are an institutional or other external barrier that lowers the risk of proliferation of nuclear materials, such as physical security measures, monitoring techniques and IAEA (International Atomic Energy Agency) inspections. Material and technical barriers are categorized as intrinsic barriers. Material barriers depend on the intrinsic physical qualities of the materials such as isotopic composition of the material, chemical property, radiation hazard, detectability etc... One of the material barriers, radiation from the material is the focus on in this paper. Because highly radioactive materials can be “self-protecting”, it is important to understand the nature of the radiation from various reprocessing schemes. Therefore, this paper presents the results of analyses that describe the radiation from TRU (trans uranium) metal ingots produced in the pyroprocessing of irradiated fuel from Pressurized Water Reactors (PWR).

Pyroprocessing Cycle

Pyroprocessing is a technology that recovers valuable resources such as Uranium from spent fuel of nuclear power plant, and recycles those resources as fuel for the next generation sodium fast reactor, resulting in increase of Uranium usage efficiency, decrease of radiotoxicity and significantly reduces the amount of radioactive waste. The basic concept of pyroprocessing is group recovery (Pu is not extracted with TRU and minor actinides), which enhances the proliferation resistance significantly. This is because Plutonium is not able to be separated as a pure product (Korea Atomic Energy Research Institute). The input for ORIGEN is the typical (the most representative) PWR spent fuel at a burnup of 55000 MWd/tone, 4.5% of uranium enrichment with 10 years cooling [3]. ORIGEN is irradiation and decay simulation code which was developed by Oak Ridge National Laboratory. ORIGEN code is used for analyzing spent fuel composition and characteristics such as activities, decay heat, radiation sources..

Modeling and Assumptions

For the dose rate calculation, the TRU metal ingot (with rare earth and fission product) in pyroprocessing was considered. Because the TRU metal ingot is considered as the most radioactive material in pyproprocessing. The metal ingot is cylindrical shape and 15 kg which is considered for 1 batch size in pyroprocessing. And the detection point is 1 m away from the material, which is applicable to IAEA self-protection value (1 Sv/hr at 1 m). The radiation from the metal ingot was calculated using MCNP (Monte Carlo N-Particle transport) code. MCNP is a general purpose Monte Carlo Neutron Particle code that is used to calculate coupled neutron-photon-electron transport. MCNP is a general purpose, three-dimensional general geometry, time-dependent, continuous energy Monte Carlo N-Particle code. MCNP has always had fully three-dimensional surface-sense geometry capable of modeling any space bounded by first and second degree surfaces [4]. There are wide variety of applications for which MCNP can be used including shielding, criticality safety, nuclear well logging, health physics, medical physics, aerospace, and more. For many years, MCNP has provided important modeling and simulation capabilities for radiation transport. For the source term input for MCNP program the ORIGEN code was used and only the photons are considered. In ORIGEN code, ORIGEN 18 group gamma spectrum was chosen. And the conversion coefficient factor for MCNP code, the ICRP-21 and ANSI/ASN data which are the most generally used were adopted and compared.

RESULT AND DISCUSSION

Table I. Dose Rate from Metal Ingot (mSv/hr)

	Conversion coefficient	
	ICRP	ANSI/ANS
15 kg TRU metal ingot	673	759
15 kg TRU metal ingot (w/o Y-90)	578	646
15 kg TRU metal ingot (w/o Eu-154)	97	146

Table I shows the dose rate from metal ingot with ICRP and ANSI/ANS. And also the dose rate from metal ingot without Y-90 and Eu-154 which are major nuclide for gamma source were calculated and compared.

The dose rate from the metal ingot for 1 batch in pyroprocess was calculated using ORIGEN and MCNP code. The composition of material for 1 batch material can be differed and need to be studied in the future.

References

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