Preliminary Safety Assessment for the Disposal of Neutron Activated Concrete Waste

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1. Introduction

On the 9th of June 2017, the Korean Nuclear Safety and Security Commission (NSSC) approved the permanent shutdown of Kori unit 1 (Kori-1), which is the first commercial nuclear power plant (NPP) in Korea. In accordance with the 5th Comprehensive Nuclear Energy Promotion Plan, Kori-1 will be decommissioned by means of an immediate dismantling strategy. Including two years of preparation period, decommission of NPP would be completed within 15 years.

For safe and efficient decommissioning of NPP, not only appropriate decontamination/decommissioning techniques but also radioactive waste management strategy are needed. In particular, the disposal method for the concrete waste, which is expected to be the predominant radioactive waste that will be generated during decommissioning [1], should be prepared.

There are two major types of decommissioned radioactive concrete waste: contaminated concrete and activated concrete. Activated concrete may contain various kinds of radionuclides [2], which are difficult to be removed, while contaminated concrete is relatively easy decontaminated [1]. Therefore, activated concrete waste might be directly disposed of in a repository without decontamination process. In this study, the preliminary post-closure safety assessment is conducted for the LILW silo repository which is disposed of activated concrete waste (biological shield).

2. Model Description

2.1 Radionuclide inventory of activated concrete waste

During the operation of NPP, various radionuclides are produced within the biological shield through the neutron-induced activation process. The sort of radionuclides, which can be produced during the NPP operational period, and its inventories were calculated by the ORIGEN-S code [3]. Impurities (i.e. europium and cobalt), which might be present in concrete, were also considered in the calculation. The assumed elemental composition of concrete by weight in percentage is listed in Table 1.

Table 1. Elemental composition of concrete

Element	Weight %	Element	Weight %
H	1	K	1.3
C	0.1	Ca	4.4
O	52.9	Fe	1.4
Na	1.6	Eu	1×10^{-3}
Mg	0.2	Co	1×10^{-2}
Al	3.4	**Total**	**100**
Si	33.7		

In the calculation, the neutron flux and the irradiation time were assumed as 1×10^{10} n/cm^2·s and 40 years, respectively, and the results are summarized in Table 2.

Table 2. Radionuclide inventories in activated biological shield (cooling time: 0.01 year)

Radionuclide	Activity Concentration (Bq/g)	Radionuclide	Activity Concentration (Bq/g)
Ar-39	5.72×10^{4}	Mn-54	1.71×10^{4}
Fe-55	1.11×10^{5}	C-14	1.69×10^{2}
Eu-152	4.59×10^{3}	Ca-45	6.56×10^{4}
Co-60	4.14×10^{3}	Na-22	5.18×10^{1}
Eu-154	8.29×10^{2}	Cl-36	7.13
Ca-41	3.90×10^{2}	H-3	4.41

2.2 Safety assessment model

Basic template of the safety assessment model, used in this study, is identical to that used in the previous study [4]. Only the source-term modeling was modified to apply changes in inventory according to the disposal of activated biological shield.

3. Modeling Result

Prior to assessing the safety for the disposal of an activated biological shield, the safety assessment was conducted for the silo repository system, where only ordinary radioactive waste is disposed without activated concrete waste, as shown in Fig. 1 (base case). The maximum annual dose rate is dominated by C-14 and isotopes of iodine and technetium appeared as important radionuclides in view of the long-term safety.

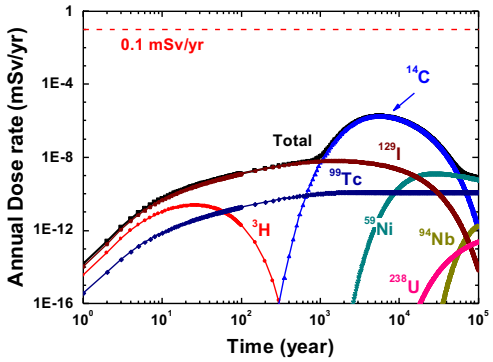

Fig. 1. Annual dose rate from the base case.

The safety assessment for the disposal of activated concrete waste in a silo repository is shown in Fig. 2. In comparison with the base case, Cl-36 and Ca-41 additionally appeared to be predominant radionuclides with respect to the long-term safety. However, no significant difference in the maximum annual dose rate is observed. In addition, the maximum annual dose rate is calculated as 1.6×10^{-6} mSv/yr, only 0.0016% of regulatory criteria.

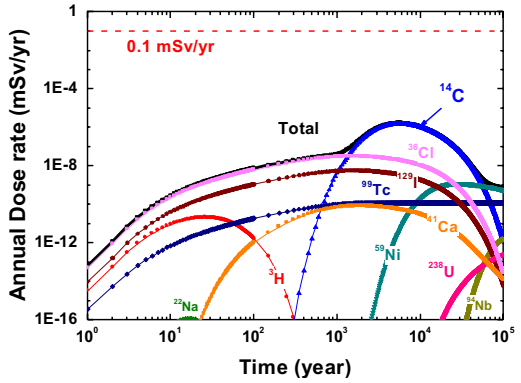

Fig. 2. Safety assessment results for the disposal of the activated biological shield.

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