Preliminary Radioactive Contamination Assessment for Decommissioning on Kori-Unit 1 Bioshield

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INTRODUCTION

Republic of Korea has started to take part on nuclear D&D project industry with the beginning of Kori unit 1 nuclear power plant reactor decommissioning. For adequate design of project, the gravity of radioactive source term characterization could not be underestimated. Due to its concentrated neutron absorption on bioshield region under long period of operation, the structural radioactive contamination degree is relatively higher than that of other components. However, there is a limitation on specific source term for its lack of geometric and operation information. On behalf of insuring worker safety, efficient economical and engineering resource consumption, the specific contamination source term characterization on bioshield through modeling is required. For preliminary approach on evaluation, major impact radioactive nuclides (^{60}Co, ^{152}Eu, ^{154}Eu) which have been chosen on Trojan nuclear power plant decommissioning project, have been selected for the research.

Physical Model

MCNP6 (general purpose Monte Carlo N-Particle computing code) has been used for Kori-unit 1 description and nucleus concentration of each regional component. Although the ultimate goal is to analyze bioshield, for designing neutron flux distribution that requires on source term characterization, it is necessary to evaluate whole regional information from the reactor core.

The targeted regions follow as Fig. 1, reactor core (baffle), barrel (stainless steel), bypass (H_2O), thermal shield (stainless steel), downcorner (H_2O), pressure vessel (carbon steel), air and bioshield (concrete) [1].

Editing nuclides concentration before there neutron absorption and mechanical properties had been included for transportation of neutron from the reactor core to the bioshield region.

Mathematical Model

MATLAB and MS-EXCELL has been used for calculation on decay chain and diffusion equation [2]. The core source term has been defined on watt fission spectrum, power density and cylindrical volumetric neutron source. Conversion of neutron flux to concentration of targeted radioactive nuclei with using decay equation for production correlated with time dependency [3].

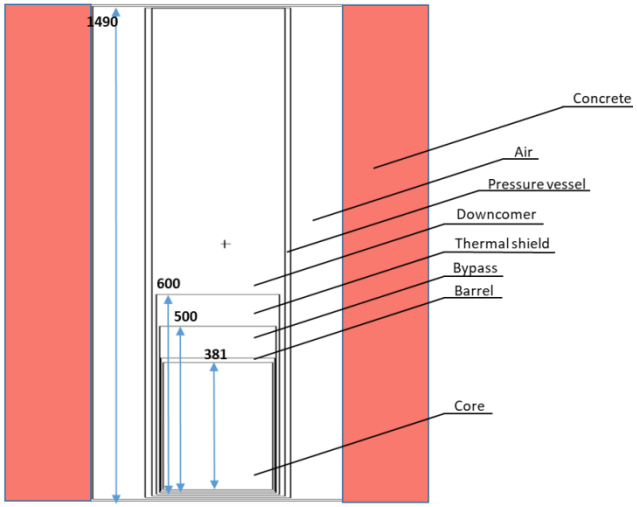

Fig. 1. Kori-unit 1 reactor vessel geometry [1] (cm)

RESULTS

The concentration of ^{60}Co, ^{152}Eu and ^{154}Eu had been analyzed based on neutron flux distribution result from MCNP6 modeling. Despite of their difference in concentration, similar exponential decreasing tendency has been achieved through result plotting due to square reduction of neutron flux along distance. For insuring the reliability of the modeling result, cross check with Trojan nuclear power plant (USA) has been initiated for their similarity on geometry, reactor type and EFPY (Effective Full Power Year) [3]. Impact ratio which described on TABLE I, that achieved by dividing each nuclei's concentration from entire concentration, showed ^{60}Co had each majority over 90% at whole region.

TABLE I. Kori-unit 1 major radioactive nuclides impact ratio

Distance	^{60}Co	Impact	^{152}Eu	Impact	^{154}Eu	Impact
cm	Bq/g	%	Bq/g	%	Bq/g	%
291.5	4.E+03	99.49	2.E+01	0.50	4.E-01	0.01
344.5	2.E+02	99.49	1.E+00	0.50	2.E-02	0.01
397.5	4.E-04	99.24	3.E-06	0.74	5.E-08	0.01
450.5	6.E-07	99.16	5.E-09	0.83	8.E-11	0.01
503.5	4.E-08	99.24	3.E-10	0.74	5.E-12	0.01

TABLE II. Trojan nuclear power plant bioshield radioactivity [3]

Distance	^{60}Co	^{152}Eu	^{154}Eu
cm	Bq/g	Bq/g	Bq/g
291.5	7.E+03	9.E+03	1.E+03
344.5	8.E+01	1.E+02	1.E+01
397.5	1.E+00	2.E+01	2.E+01
450.5	2.E-01	3.E-01	3.E-01
503.5	1.E-03	9.E-03	9.E-03

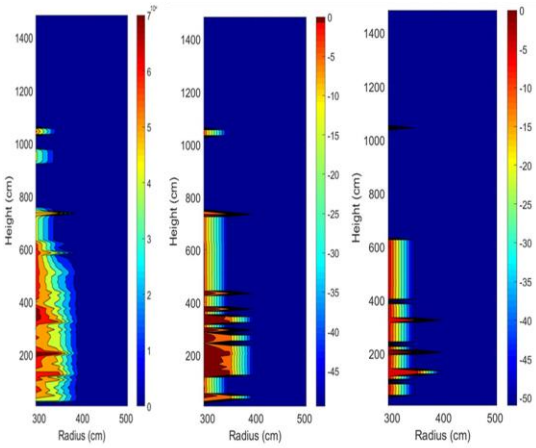

Fig. 2. Kori unit 1 bioshield radioactivity concentration ^{60}Co Bq/g (Left) ^{152}Eu Bq/g (Middle), ^{154}Eu Bq/g (Right)

From Fig. 2 to Fig. 5, described regional nuclides' concentration on Kori-unit 1 and Trojan. ^{60}Co (max:4.E+03 Bq/g min: 4.E-08 Bq/g) had its majority along, ^{152}Eu (max:2.E+01 Bq/g min: 3.E-10 Bq/g) and ^{154}Eu (max:4.E-01 Bq/g min: 5.E-12 Bq/g) were following with exponential decreasing tendency.

Comparing with TABLE II, difference of 17cm between Kori-unit 1 bioshield clearance radius which 397 cm Trojan, 380 cm was deducted. Concentration of ^{60}Co, ^{152}Eu, ^{154}Eu should be under 0.1 Bq/g for getting clearance from Republic of Korea Nuclear Safety and Security Commission, notice No.2014-003, Article 2, 2014.9.16.

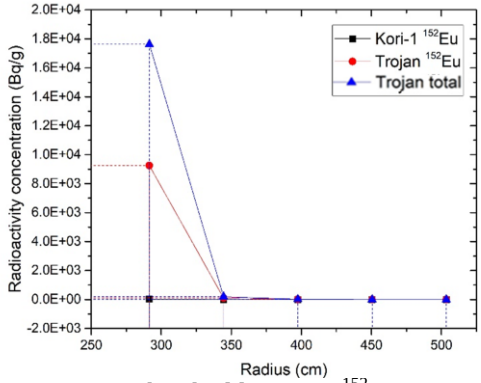

Fig. 3. Kori unit 1 bioshield average ^{152}Eu activity comparing with Trojan [3] nuclear power plant

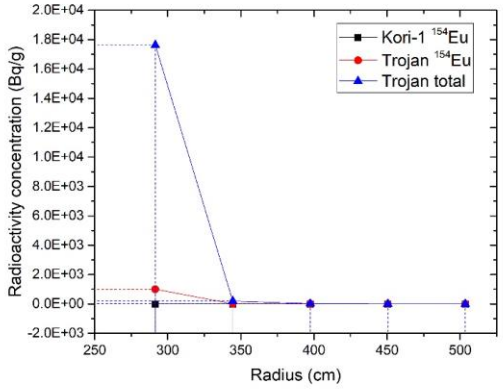

Fig. 4. Kori unit 1 bioshield average ^{152}Eu activity comparing with Trojan [3] nuclear power plant

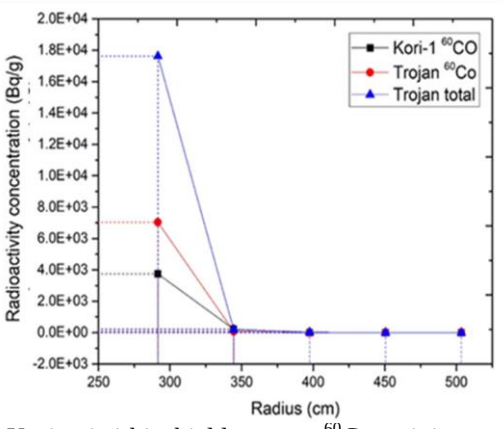

Fig. 5. Kori unit 1 bioshield average ^{60}Co activity comparing with Trojan [3] nuclear power plant

Further approach with larger number of radioactive nuclides could achieve more specific designation of clearance radius which enables solidified construction of waste management plan.

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