Effective Cross Section Estimation of ^{36}Cl and ^{41}Ca in Concrete of Kori Unit 1

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1. Introduction

The radionuclide inventory prediction of a nuclear power plant can help establish decommissioning plan by providing information of radiation environment. Accumulated radionuclide in reactors and related facilities after reactor shutdown can be divided into neutron activated materials and contaminated materials. Usually, the steps to calculate the radionuclide inventory are consist of two steps as follows: (1) calculating the neutron flux and (2) estimating induced radioactivity throughout the reactor. The neutron activated materials are generated in different amounts depending on the neutron flux and effective cross section.

In this study, we calculated the neutron flux and estimated the effective cross section of ^{36}Cl and ^{41}Ca in bio concrete of Kori Unit 1. These two radionuclides are important from the viewpoint of disposal because of its long half-life.

2. Methods and Results

2.1 Activation Products in Bio Concrete

Unlike metallic materials, which are specified in the technical standards of the American Society of Mechanical Engineers (ASME), concrete has no limit on the content of constituents. The composition of the bio concrete without impurity as shown in Table 1. [1] The type and content of impurities of concrete can be changed according to the factors such as manufacturing process and added aggregate. Therefore it is necessary to evaluate the amount of ^{36}Cl and ^{41}Ca produced depending on the impurities. The physicochemical characteristics of ^{36}Cl and ^{41}Ca are shown in Table 2.[2]

Table 1. Composition of the bio concrete without impurity

Element	Weight Fraction (%)
H	0.55
O	49.83
Si	31.57
Ca	8.26
Na	1.70
Mg	0.26
Al	4.55
S	0.13
K	1.91
Fe	1.23

Table 2. Physicochemical characteristics of ^{36}Cl and ^{41}Ca

Parent	^{35}Cl	^{40}Ca
Nuclear Reaction	n, γ	n, γ
Daughter Nuclide	^{36}Cl	^{41}Ca
Principal Emission	β-(β+, EC)	EC
Half-life(y)	301000	103000

2.2 Neutron Flux

To evaluate the effective cross section of ^{36}Cl and ^{41}Ca in bio concrete, it is necessary to calculate average neutron flux in each zone of reactor. In this research, we simplified the geometry of Kori Unit 1 as shown in Fig. 1 and consists of 8 zones as follows: (1) Baffle (2) Barrel (3) Bypass (4) Thermal Shield (5) Downcomer (6) RPV (7) Air (8) Bio Concrete. We calculated the averaged neutron flux in each zone using MCNPX code and the results are shown in Table 3.

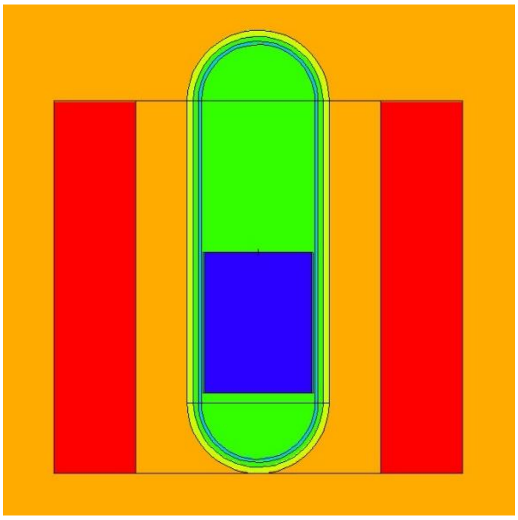

Fig. 1. Simplified geometry of Kori Unit 1.

Table 3. Neutron flux in each region of Kori Unit 1

	Zone	Neutron Flux(#/cm^2-s)
1	Baffle	7.79E+12
2	Barrel	4.41E+11
3	Bypass	2.79E+10
4	Thermal shield	3.59E+10
5	Downcomer	1.40E+10
6	RPV	6.73E+08
7	Air	2.75E+08
8	Bio concrete	1.39E+07

2.3 Effective Cross section in Bio Concrete

Using the calculated neutron flux, we estimated the effective cross section of ^{36}Cl and ^{41}Ca and the results are shown in Table 4.

Table 4. Effective Cross Section of ^{36}Cl and ^{41}Ca

Radionuclide	^{36}Cl	^{41}Ca
Reaction Rate	2.31E+08	2.24E+06
Effective Cross Section(barn)	1.794E+01	1.740E-01

3. Conclusion

In this research, we estimated the effective cross section of ^{36}Cl and ^{41}Ca using the averaged neutron flux in each region of Kori Unit 1. This results can be used the inventory of ^{36}Cl and ^{41}Ca using activation calculation code such as ORIGEN2.

REFERENCES

[1] International Atomic Energy Agency, "Radiological Characterization of Shut Down Nuclear Reactors for Decommissioning Purposes", Technical Reports Series No. 389 (1998).

[2] Gil Yong Cha, Soon Young Kim, Jae Min Lee and Yong Soo Kim, "The Effects of Impurity Composition and Concentration in Reactors Structure Material on Neutron Activation Inventory in Pressurized Water Reactor", Journal of Nuclear Fuel Cycle and Waste Technology, 14(2), 91-100 (2016).