Transactions of the Korean Nuclear Society Autumn Meeting
Busan, Korea, October 27-28, 2005

Analysis of Gamma Dose Rate Caused by Corrosion Products inside the Containment Building of Yonngwang Nuclear Power Plant Unit 3 During Shutdown Period

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1. Introduction

Occupational radiation exposure(ORE) of nuclear power plant(NPP) workers mainly occurs during the shutdown period. Major radioactive sources are the corrosion products released from the reactor coolant system(RCS). The corrosion products consist of circulating crud and deposited crud. Major radioactive corrosion products, ^{58}Co and ^{60}Co, are known to contribute approximately more than 70% of the total ORE.[1]

In this study, the corrosion products regarding cobalt were evaluated during the shutdown period, and gamma dose rates caused by them were calculated at the main working area inside the containment building of the Yonggwang NPP Unit 3.

2. Calculation of Gamma Source

Activities of corrosion products during the shutdown period were employed as the major gamma sources. They were calculated by using CRUDSIM, which is a computational code to predict the amount of the corrosion products and the radioactivity originated from the crud such as ^{58}Co and ^{60}Co in the primary coolant system.[2] It is known that CRUDSIM gives the activity of cobalt in the circulating crud inside the RCS and the deposited crud at the surfaces of steam generator(S/G) and reactor core, individually.

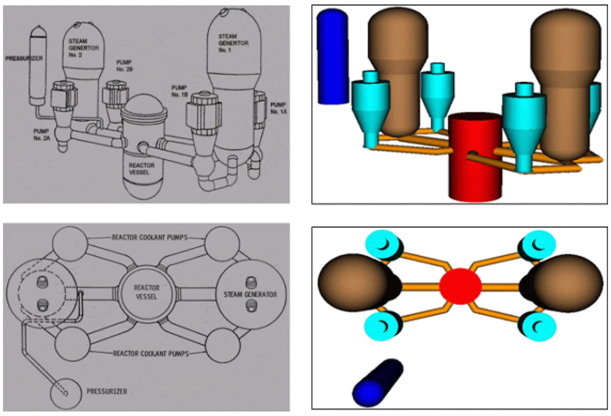
Activities of corrosion products depend on the several coolant conditions such as temperature, heat transfer, mass transfer, and material concentration. The coolant condition during the shutdown period is considered in the activity calculation. Table 1 shows the activity calculation results of the corrosion products by using CRUDSIM.

Table 1. Calculation Results of Activities of the Corrosion Products during the Shutdown Period by using CRUDSIM

	Co-58	Co-60
Reactor Core (μCi/cm^2)	6.58E-01	1.45E+00
S/G (μCi/cm^2)	1.94E+01	6.53E+00
Coolant (μCi/cm^3)	2.36E-04	1.84E-04

3. MCNP Modeling

Prior to the calculation of gamma dose rates, MCNP modeling was performed on the basis of the actual design for the containment building of Yonggwang NPP Unit 3. The structure inside the containment building is very large and complex. The principal interests of MCNP modeling are the structures affecting the radiation field distribution at the main working area. Therefore, major components such as reactor core, S/G, and reactor coolant pump(RCP) were modeled in this study. Their shape is identically modeled, and their material composition is homogenized on the basis of the actual design.[3,4] The shielding walls inside the containment building are mostly composed of concrete, and floor layers of them are located at the height levels of 100, 122, and 142 ft. Figure 1 shows the actual design and MCNP modeling Result of the major components.



A. Actual Design B. MCNP Modeling

Figure 1. Actual Design and MCNP Modeling Result of the Major Components

4. Analysis of Gamma Dose Rates

Activities of corrosion products calculated by using CRUDSIM were employed as gamma sources inside the containment building. It is assumed that the circulating crud exists inside the primary coolants passing through RCS, S/G, RCP and refueling pool. Deposited crud was employed only at the surfaces of reactor core and S/G. The ambient dose equivalent was calculated by using Mesh Tally option of MCNPX code.[5] The gamma dose rates were calculated by 1 meter interval at each height levels.[6] Figure 2 shows the MCNP modeling result and gamma dose rate distribution at 100 ft height level.

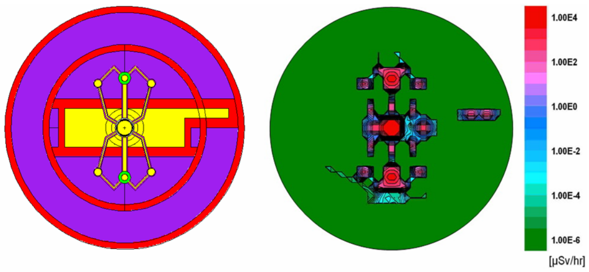
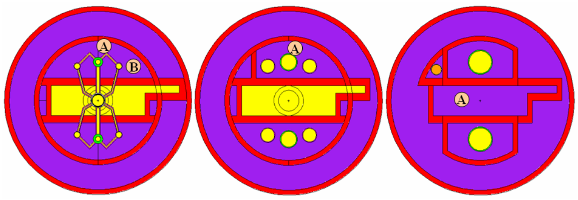


Figure 2. MCNP Modeling Result and Gamma Dose Rate Distribution at 100 ft Height Level

The gamma dose rates calculated by MCNP were analyzed at the main working area. Figure 3 shows the calculation points considered as main working area, and Table 2 presents the calculation results of gamma dose rates.



A. 100 ft B. 122 ft C. 142 ft

Figure 3. Calculation Points for Gamma Dose Rates

Table 2. Gamma Dose Rates at Main Working Area

Height	Point	By Circulating Crud (µSv/hr)	By Deposited Crud (µSv/hr)
100	A	243	586
	B	155	-
122	A	0.7	42.6
142	A	76.8	-

As the result of the calculation, total gamma dose rates at the A points around the S/G of 100 and 122 ft height levels are respectively 829 and 43.3 µSv/hr. Both the circulating crud and deposited crud were employed as gamma sources at those points. It is, from this study, found that gamma dose rates by deposited crud are higher than those by circulating crud.

On the other hand, only circulating crud was employed as gamma source at the B point of 100 ft height level and the A point of 142 ft height level.

Gamma dose rates at 100 ft height level are relatively higher than those at other points due to the activities of coolants inside the RCS. Statistical errors of gamma dose rates calculated by MCNPX were within 3% at all points.

5. Conclusions

In this study, analysis of gamma dose rates caused by corrosion products inside the containment building of Yonggwang NPP Unit 3 was performed by using CRUDSIM and MCNPX codes during the shutdown period. The results calculated by the computational codes can provide NPP worker with information on the dose rates at the regions such as S/G and reactor core considering both the circulating and deposited crud. If the calculation results are verified by the comparison with the measurements, it is possible to effectively expect the gamma dose rate inside the containment building using computational method. Hereafter, further study on the comparison between calculations and measurements should be conducted. In addition, study on the analysis of other radioactive species besides ^{58}Co and ^{60}Co and activities of deposited crud at other regions such as RCP and RCS is also necessary to effective evaluation of gamma source.

Acknowledgement

This work was supported by the SRC/ERC program (R11-2000-067-01001-0) and the long-term nuclear research and development program(M2050303003-05A0803-00310) of MOST/KOSEF.

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