Derivation of Preliminary Derived Concentration Guideline Level (DCGL) by Containment Building Reuse Scenario for Kori Unit 1 Using RESRAD-BUILD

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1. Introduction

In South Korea, the Kori Unit 1, the first South Korean commercial nuclear power plant, came into commercial operation in 1978 and continued to operate until 2007, when its operation was extended for 10 more years. Finally, it was shut down in June 2017 without the second extended operation.

This study provides a method of calculating a Kori Unit 1 preliminary site-specific DCGLs, by using RERAD-BUILD code, for radionuclides on the surface of buildings which will be expected to still stand after decommissioning. Additionally, this study provides a method for calculating the exposure dose to receptors such that it satisfied the site release criteria.

2. RESRAD-BUILD code description

The RESRAD-BUILD code is an exposure path analysis code for assessing the potential exposure dose of an individual or worker in a building contaminated with residual radioactive material. In the RESRAD-BUILD code, radioactive particulates in the air, aerosol indoor radon decay products, and tritium water vapor, including external exposure to penetration radiation, due to the air submersion of the radioactive material and radioactive particulates that have accumulated at the source, are considered. Additionally, consideration is given to the intake and ingestion pathways of materials emitted from the source and to materials that have accumulated on the building surface.

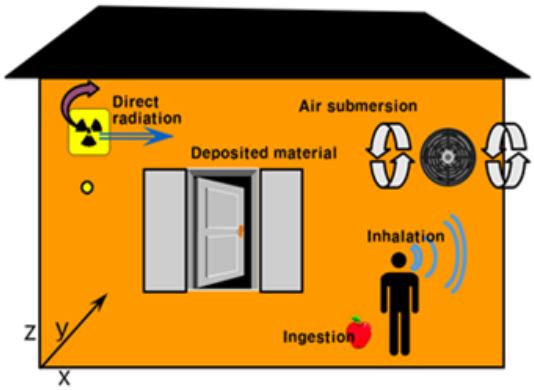

Fig. 1. Exposure pathway considered in RESRAD-BUILD [1].

3. Containment building worker scenario input values

For parameters related with the dose/risk, input values are set to the latest data in ICRP 60, the exposure duration was set to 179 days, and the indoor fraction was set to 0.351 [1, 2]. It is reported that the decommissioning process will begin in June 2022, and that the release of the site will begin in 2031 [3]. As a result, the worker dose evaluation time was set after 13 years (2030, when the decommissioning will be completed). The containment building was assumed to be consist of a single large room. The deposition velocity and resuspension rate were treated as probabilistic parameter. Tritium was set to zero for the deposition velocity.

For the Kori Unit 1 containment building, a cylindrical shape, height measured from the ground level to the containment building concrete height, and volume including the external reinforced concrete annulus, was taken into account. The calculated concrete volume inside the containment building was 62,287 m^3, based on a diameter of 35.48 m and a height of 63 m.

The floor and ceiling area was set to 988.18 m^2 for cylinder type. In the Kori Unit 1 containment building, the supply and exhaust fans were operated one by one and the building exchange rate was 0.68 h^{-1}, due to the flow rate per unit being 25,000 CFM. The area of the floor and ceiling was 988.18 m^2, and the length of one side was 31.44 m for rectangle type. To make the cross-sectional area of the containment building's cylindrical side equal to the width of the cuboid, the height of the cuboid was considered as 55.83 m.

By assuming that the concrete of the Kori Unit 1 containment building was a source, the worker was located 1 m from the wall of the building.

Under this scenario, the lead density was assumed as 11.36 g/cm^3 and the worker was assumed to wear a lead shielding suit (0.3 cm thickness). The direct ingestion rate was set to 0.052 for the volume source, 8.94×10^{-8} for the ceiling and floor in the area source, and 7.97×10^{-8} for the side.

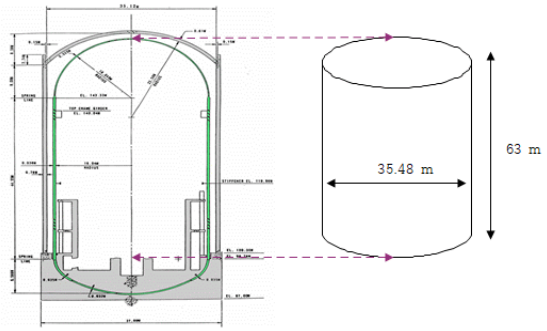

Fig. 2. Determination of building value for Kori Unit 1 Containment Building.

The radionuclides for calculating DCGL were selected from the radionuclides detected both at the Zion NPP and Rancho Seco NPP, which was selected as a reference NPP. Table 1 shows the radionuclides used in this study.

Table 1. Radionuclides detected in Rancho Seco and Zion NPP buildings [4, 5]

Radionuclide			
^{3}H	^{90}Sr	^{137}Cs	^{239}Pu
^{14}C	^{94}Nb	^{152}Eu	^{240}Pu
^{55}Fe	^{99}Tc	^{154}Eu	^{241}Pu
^{59}Ni	^{108m}Ag	^{155}Eu	^{241}Am
^{60}Co	^{125}Sb	^{237}Np	^{244}Cm
^{63}Ni	^{134}Cs	^{238}Pu	

4. DCGL calculation

In this scenario, DCGL was calculated using the volume source. The reinforced concrete density used in the containment building was calculated as 2.4 g/cm^3, and the source thickness was 15 cm. DCGL results are shown below.

Table 2. DCGL in Containment building worker scenario (dpm/100 cm^2)

Radion uclide	2030y 0.1 mSv/yr	Radion uclide	2030y 0.1 mSv/yr
^{3}H	1.70×10^{8}	^{137}Cs	2.18×10^{3}
^{14}C	8.13×10^{5}	^{152}Eu	1.49×10^{3}
^{55}Fe	7.84×10^{7}	^{154}Eu	1.87×10^{3}
^{59}Ni	8.06×10^{6}	^{155}Eu	6.77×10^{6}
^{60}Co	1.65×10^{3}	^{237}Np	3.67×10^{2}
^{63}Ni	3.22×10^{6}	^{238}Pu	5.79×10^{2}
^{90}Sr	1.45×10^{4}	^{239}Pu	4.70×10^{2}
^{94}Nb	5.55×10^{2}	^{240}Pu	4.73×10^{2}
^{99}Tc	1.16×10^{6}	^{241}Pu	1.80×10^{4}
^{108m}Ag	6.72×10^{2}	^{241}Am	4.67×10^{2}
^{125}Sb	7.27×10^{4}	^{244}Cm	1.35×10^{3}
^{134}Cs	4.62×10^{4}		

5. Conclusion

In this study, DCGL is derived through the probabilistic analysis of the RESRAD-BUILD code. Deterministic and probabilistic parameters that reflect the characteristics of Kori Unit 1 are applied then sensitivity analysis are performed for the containment building worker scenario. Through this process, we derived the Kori Unit 1 preliminary DCGL.

The location of the receptor was calculated at 1 m from the containment building wall and the Kori Unit 1 source area was 1.13 times larger than that of Rancho Seco. Also Site release criteria of South Korea is lower than Rancho Seco. According to different parameter values, the results dose obtained in the case of the Kori Unit 1 were more conservative. Applying more site-specific parameters of Kori Unit 1 will deduce more site-specific DCGL.

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