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A Review of Site-Specific Parameters in the Evaluation of Remaining Building Reuse from the NPPs Decommissioning

Hyung-Woo Seo [a*], Hye-Jin Jung[a], Chan-Gun Park[a], and Gang-Woo Ryu[a]
[a]*Korea Hydro & Nuclear Power (KHNP) Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, Republic of Korea*
[*]*Corresponding author: sehywo1727@khnp.co.kr*

1. Introduction

In order to exempt the site at the license termination stage in decommissioning the Nuclear Power Plant (NPP), we need to ensure that the Derived Concentration Guideline Level (DCGL) should be below the residual radioactivity concentration in accordance with site release criteria. In general, REDRAD computer code has been widely used to calculate DCGLs, and this family code may vary depending on the evaluation media, with RESRAD-Onsite for soil and RESRAD-Build code for buildings. One of the important parts to decide in using the code here is to reflect the site-specific data of each nuclear facilities. Representatively, we can refer to experience data such as License Termination Plan (LTP) of U.S. NPPs with prior decommissioning experiences. Therefore, this study aims to review the site-specific parameters of NPPs in deriving DCGLs of buildings that assumed to be remain after the license termination and analyze their effects.

2. Methods and Results

Among the input parameters of RESRAD-Build, it is necessary to identify what kinds of site-specific parameters are, and based on this, the effect is to be assessed. In this study, the Yankee Nuclear Power Station (YNPS) [1] and Rancho Seco (Rancho) [2] literature were reviewed to refer to the evaluation cases of buildings in overseas decommissioning NPPs.

2.1 Site-specific parameters used in overseas cases

There are a total of 50 input parameters handled by RESRAD-Build, which are classified into priorities 1 (High), 2 (medium), and 3 (low). Table 1 show the parameters divided according to the priority.

Table 1: RESRAD-Build input parameters [3]

Priority 1	
• Resuspension rate	• Source density
• Removable fraction	• Shielding density
Priority 2	
• Indoor fraction	• Time for source removal or source lifetime
• Deposition velocity	• Radionuclide concentration
• Room height	• Source thickness
• Room area	• Source erosion rate
• Air exchange rate for building and room	• Shielding thickness
• Receptor inhalation rate	• Wet + dry zone thickness
• Receptor indirect ingestion rate	• Volumetric water content
• Source length or area	• Water fraction available for evaporation
• Air release fraction	• Humidity
• Direct ingestion rate	• Source porosity
Priority 3	
• External dose conversion factor	• Source type
• Inhalation dose conversion factor	• Source room or primary room
• Ingestion dose conversion factor	• Source direction
• Air submersion dose conversion factor	• Source location
• Exposure duration	• Receptor location
• Number of evaluation times	• Number of regions in volume source
• Time	• Contaminated region - volume source
• Number of rooms	• Shielding material
• Net flow	• Dry zone thickness
• Outdoor inflow	• Radon release fraction
• Number of receptors	• Radon effective diffusion coefficient
• Receptor room	• Radon emanation coefficient
• Receptor time fraction	• Number of sources

Among these parameters, there are three parameters treated as site-specific in YNPS.

- Room Dimension (length, width, and height)
- Source Configuration (contaminated wall)
- Direct Ingestion Rate (1/hr)

YNPS set the room dimension based on the size of the building expected to remain on the site at the license termination stage. That is, for about 15 compartments, the dimension values (i.e., length, width, and height) were assumed by averaging the size of each compartment. As a result, the length and width of the room was set as 4.44 m and height of 3.51 m.

In the case of the source configuration, the contaminated part in the hexahedral shape was considered to be four walls and one floor, and in the case of ceiling, the contamination was insignificant or not contaminated due to renovation at the time of license termination.

Lastly, direct ingestion rate is described in RESRAD-Build as the direct ingestion rate from the source by any receptor in the compartment. YNPS set this value using the average ingestion rate of 1.1E-4 m^2/hr (this is representative for the average individual in an industrial setting). Therefore, the direct ingestion rate was calculated based on the total room surface area like the equation below.

Direct Ingestion Rate = Average Ingestion Rate / Source Area

2.2 The effect of the site-specific parameters

In order to execute the RESRAD-Build code, several factors must be defined: input parameters, application scenarios, and deterministic or probabilistic evaluation. Therefore, this study applied building occupancy scenario as an application scenario, used the results of the previous study for input parameters, and the evaluation method performed a probabilistic analysis of selecting sensitive parameters.

First, in this study, other conditions were set the same and the cases where 0.25 mSv/yr and 0.1 mSv/yr of site release criteria were applied and compared as shown in Fig. 1. Naturally, DCGLs are calculated by dividing the release criteria by the evaluated dose, so the higher the release criteria, the higher the DCGLs.

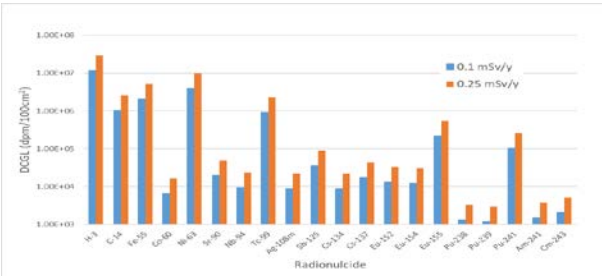

Fig. 1. DCGLs according to the site release criteria

Next, in terms of source configuration, the results of evaluating the five contaminated walls excluding the ceiling and the six areas including ceiling were compared. Graphically, it is shown in Fig. 2. The results of DCGLs from five sources for six sources were found to be different for each radionuclide, but to have the effect of a higher DCGLs of approximately 1.4 times. However, there was a bigger difference case for Pu-241. This is because the effect from ceiling on the inhalation and ingestion is relatively large, which is believed to require further detailed analysis in future studies.

Finally, the effect of the differences in building dimensions was analyzed. To do this, the cases of YNPS, Rancho, and Domestic cases were compared, and each room size was set differently. In case of YNPS, it was set to 4 m × 4 m × 3.51 m, Rancho was set to 11.7 m × 11.7 m × 3.89 m, and the last one was set to 22.7 m × 22.7 m ×13.3 m. The size of the room was set to be large in the order of YNPS, Rancho, and Domestic. As shown in Fig. 3, in the building occupancy scenario, it was confirmed that DCGLs were evaluated smaller as the room size increased.

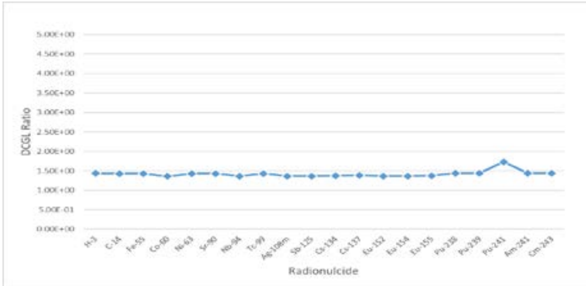

Fig. 2. DCGLs ratio of five sources to six sources

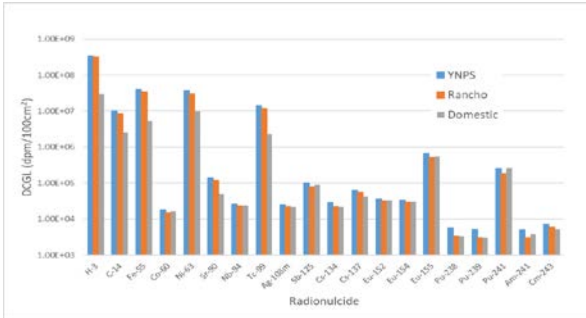

Fig. 3. DCGLs according to the room dimension

3. Conclusions

In this study, we evaluated the site-specific parameters by discriminating the values in three aspects. The first set the site release criteria at 0.1 mSv/yr and 0.25 mSv/yr, the second set the contaminated source are at 5 and 6 areas, and finally, the room dimensions were changed. In the first and second cases, the higher the release criteria, the smaller the source area, the higher the DCGLs were evaluated. In the case of room dimensions, it was confirmed that the dose was evaluated higher as the room size increased within the occupancy scenario, and the DCGLs were calculated to be smaller accordingly.

REFERENCES

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