

## Review on Comparison of Exposure Pathway in RESRAD and DandD Code

Won-Tak Lee<sup>a</sup>, Jae-Yong Lee<sup>a</sup>, Yong-Soo Kim<sup>a\*</sup>

<sup>a</sup>Department of Nuclear Engineering, Hanyang University,  
 222 Wangsimni-ro, Seongdong-gu, Seoul, 04763, Korea

\*Corresponding author: yongskim@hanyang.ac.kr

### 1. Introduction

Currently, 187 nuclear power plants are in permanent shutdown worldwide and 21 nuclear power plants have been decommissioned. In Korea, Wolsong Unit 1 is declared permanent shutdown in 2019 following Kori Unit 1, and a total of 2 nuclear power plants are in permanent shutdown. So, the number of nuclear power plants is expected to increase in the future in Korea.

The decommissioning of nuclear power plants is the most important step in the life cycle of nuclear power generation. After the successful decommissioning of nuclear power plants, the site will be released for "unlimited" or "limited" use. This step is essential to demonstrate whether the level of residual contamination meets the criteria for site release. Among various technologies to demonstrate the level of residual contamination, Derived Concentration Guideline Levels (DCGL) calculations and demonstration of regulatory compliance are mainly done using computer code.

In this study, the exposure pathways to residential scenario and building occupancy scenario, which are scenarios of RESRAD Codes and DandD Codes, were compared.

### 2. Comparison of Exposure Pathway in RESRAD code and DandD code

#### 2.1 RESRAD code and DandD code

In the United States, RESRAD Code and DandD Code are used mainly to demonstrate compliance with the criteria for site release when decommissioning of nuclear power plants.

RESRAD code is developed by ANL and designed to assess the potential radiation dose for individuals residing at sites with radioactively contaminated soil or residing in buildings containing residual radioactive materials.

RESRAD-ONSITE code and RESRAD-BUILD code were mainly used to evaluate the environmental impact of sites in nuclear power plant, decommissioned sites of nuclear power plant such as Rancho Seco and Connecticut Yankee in the United States for about 30 years.

Also, the DandD Code is a code developed by the Sandia National Laboratory under NRC in 1998 to provide a simple screening approach to demonstrate compliance with 10 CFR 20, Subpart E [1]. The two codes described above have been developed for similar

purposes and are sometimes used together through similar Scenario assumptions when calculating DCGLs for decommissioning of nuclear power plants.

However, the result of code differ due to the fact that the two codes consider similar exposure paths, but each codes consider different input parameters.

#### 2.2 Residential Scenario

Residential Scenario is a scenario in which a site is assumed to be released indefinitely after the decommissioning of nuclear power plant and used as a public or agricultural site. In this scenario, the exposure pathway considered is largely divided into external exposure, exposure of inhalation, and exposure of ingestion.

A schematic diagram of the exposure pathway considered in the Residential Scenario in decommissioning the plant is shown below.

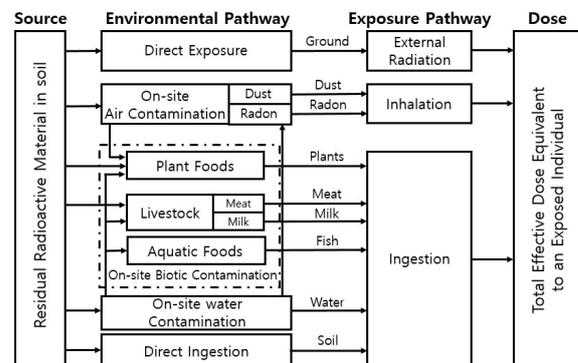


Fig. 2. Residential Scenario Pathways in RESRAD [2]

The DandD code and RESRAD-ONSITE code calculates residual radioactive concentrations through specific parameters to the decommissioning site for external exposure, exposure of inhalation, and exposure of ingestion from the environmental pathway upon application of Residential Scenario. However, the two codes differ to consider environmental pathways.

When comparing the environment paths of DandD code and RESRAD-ONSITE code, most of them consider similar pathway, but there are two differences. First, the DandD code considers the inhalation exposure by resuscitated surface sources of soil tracked indoor, but the RESRAD-ONSITE code does not distinguish between inhalation by indoors soil. On the other hand, the RESRAD-ONSITE code considers the inhalation exposure by radon progeny, but not this pathway in

DandD. Because the dose resulting from emanated radon is not a requirement of the final rule on radiological criteria for license termination [4].

In addition, for default parameters, the difference in the resulting values is shown because the DandD code uses a more conservative value than the RESRAD code. As shown in table, differences of pathway for two codes are shown when applying residential scenario.

Table I: Residential Farmar Scenario Pathways Considered by DandD and RESRAD [3]

Pathway	DandD	RES RAD
External Exposure		
Outdoors Soil	O	O
Indoors Soil	O	O
Inhalation Exposure		
Outdoors Soil	O	O
Indoors Soil	O	O
Indoors Surface Sources	O	X
Radon Progeny	X	O
Ingestion Exposure		
Soil-Direct	O	O
Indoors Soil	O	O
Drinking Water	O	O
Soil Plant Products	O	O
Aquatic Plant Products	O	O
Animal Products	O	O
Fish	O	O

### 2.3 Building Occupancy Scenario

Building occupancy scenario is a scenario that assumes the reuse of remaining buildings on the site after the decommissioning of nuclear power plants. As with residential scenario, exposure of external exposure, exposure of inhalation, exposure of ingestion is considered, but exposure of the soil is not taken into account because it is a scenario to calculate residual radioactive concentrations inside buildings.

A schematic diagram of the exposure path considered in Building Occupancy Scenario in decommissioning of nuclear power plant is shown below.

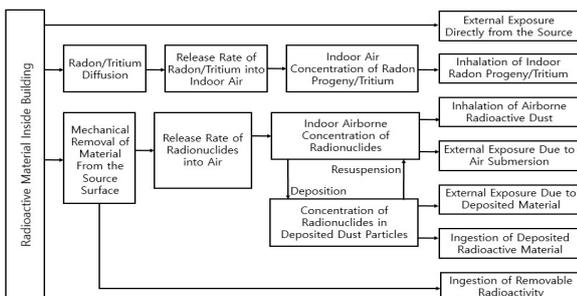


Fig. 3. Building Occupancy Scenario Pathways in RESRAD [4]

The table below summarizes parameters of the pathway applied in the DandD code and RESRAD code when applying Building Occupancy Scenario.

Table II: Building Occupancy Scenario Pathways Considered by DandD and RESRAD [5]

Pathway	DandD	RES RAD
External Exposure		
Source	O	O
Air Submersion	X	O
Material Deposited on Floor	X	O
Inhalation Exposure		
Airborne Radioactive material	O	O
Radon Progeny	X	O
Ingestion Exposure		
Radioactive Material	O	O

In the RESRAD Code, external exposure by air submersion, exposure by substances deposited on the floor, and exposure by radon are applied in addition to exposure by Radioactive Material. On the other hand, input parameters for the radioactive material are used for each exposure pathway in DandD code. This is because the RESRAD code contains a ventilation model, but the DandD code does not. In the case of Radon, it is not applied in DandD code for the same reasons as in residential scenario [4].

### 3. Conclusion

Verification of compliance with the site release criteria is made through calculation of DCGL using the DandD code and RESRAD code when decommissioning of nuclear power plants in U.S.. In this study, similarities and differences of input parameters of exposure pathway between in DandD code and RESRAD code are analyzed.

The site release must be completed in the event of the decommissioning of nuclear power plants. To this end, the two codes above should be used to demonstrate compliance with the release criteria using DCGL, as in the case of decommissioning of nuclear power plants in the U.S. There may be differences in the calculation values due to differences in the pathways to the parameters applied. Therefore, it is necessary to study sensitivity analysis and uncertainty analysis for each input parameter later in order to predict the exact value of DCGL that is changed due to site characteristic variables.

### Acknowledgment

This work was supported by the Human Resources Program in Energy Technology of the Korea Institute of Energy Technology Evaluation and Planning(KETEP) granted financial resource from the Ministry of Trade,

Industry & Energy (No. 20184030201970) and the National Research Foundation of Korea(NRF) grant funded by the Korean government(MSIP: Ministry of Science, ICT and Future Planning) (No. 2017M2B2B1072888)

#### **REFERENCES**

- [1] NRC, Residual Radioactive Contamination from Decommissioning, NUREG/CR-5512, Vol. 2, 2001.
- [2] ANL, User's Manual for RESRAD Version 6, ANL/EAD-4, 2001.
- [3] EPRI, Comparison of Decommissioning Dose Modeling Codes for Nuclear Power Plant Use RESRAD and DandD, TR-112874, 1999.
- [4] NRC, Comparison of the Models and Assumptions used in the DandD 1.0, RESRAD 5.61, and RESRAD-Build 1.50, NUREG/CR-5512, Vol.4, 1999.
- [5] ANL, User's Manual for RESRAD-BUILD Version 3, ANL/EAD/03-1, 2003.