An Analysis on Internal Exposure Evaluation Code for Radioactive Aerosols

Hakyun Lee, SunIl Kim, and Jongsoon Song*
Chosun University, 309 Pilmun-daero, Dong-gu, Gwangju, Korea
Leehakyun1@naver.com

1. Introduction

Radioactive aerosol generated in the course of decommissioning of nuclear power plants is the main factor of internal exposure to radiation of the workers. Radioactive aerosol is mainly generated during cutting of concrete, cutting of metal and melting of metal. The level of risk to the decommissioning workers is determined by the nuclide contained in the aerosol. There have been studies on the exposure to radiation caused by radioactive aerosol generated due to critical accidents. This study comparatively analyzes the internal radiation exposure evaluation codes with the size distribution of aerosol as a factor in order to evaluate the risk of radioactive aerosol to the workers during decommissioning of nuclear power plants.

2. Main title

2.1 Aerosol-based internal exposure scenario

Internal exposure means exposure of tissues or organs of a human to the radionuclide infiltrated into human body by way of inhalation, intake or dermal penetration, and adsorbed and disintegrated in various tissues and organs according to physiological flow. When evaluating the internal exposure dose, it is very important to understand the behavior of radionuclide within a body. To evaluate the internal exposure dose, it is required to understand the type of radionuclide element taken, and distribution of the radionuclide elements in a human body according to physical and chemical state.

The amount of aerosol adsorbed in respiratory organs of a worker varies considerably depending on the size of particles. In general, particles of with the diameter of 10um or larger tend to depose in nasal mucosa. The particles between 2.5 um and 10 um move to the upper tissues of the respiratory organs, affecting the exposure dose and risk depending on type and concentration of radionuclide. Those of 2.5 um or smaller can infiltrate into the blood vessel via alveoli and lung sac, causing exposure of entire body. Fig. 1 and Table 1 show the deposition rate and deposition fraction by particle sizes suggested by ICRP. ET1 is the front of nasal cavity. ET2 is the rear of nasal cavity, pharynx and larynx. BB is windpipe, main bronchus and bronchial tubes. bb is bronchiole and terminal bronchiole. AI is respiratory bronchiole, alveoli and lung sac.

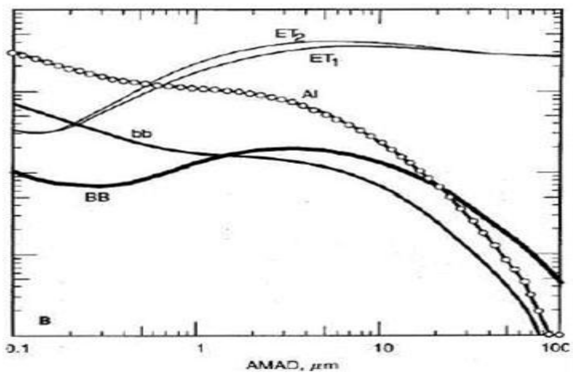

Fig. 1. Particle deposition rate by respiratory area according to AMAD.

Table 1. HRTM deposition fraction (AMAD=5μm)

Area	Deposition fraction (%)
ET_1	33.85
ET_2	39.91
BB	1.78
bb	1.10
AI	5.32
Total	81.96

2.2 Internal exposure evaluation code

2.2.1 BiDAS (Bioassay Data Analysis Software). This code uses ICRP-66 respiratory organ model, ICRP-30 digestive organ model, and ICRP-30/56/67/69/71 biomechanics model. The code for inhalation and ingestion is subdivided into 0.01 um, 0.03 um, 0.1 um, 0.3 um, 1 um, 3 um, 5 um and 10 um, and depending on the type of absorption of chemical (Type F,M,S).

2.2.2 KIDAC (KHNP's Internal Dosimetry Assessment Code). KIDAC is the code developed by KHNP for evaluation of internal exposure dosage. The code uses ICRP-66 respiratory organ model, ICRP-30 digestive organ model, and ICRP-56/67/69 metabolism model. The code evaluates CED based on the amount of intake and by using the dosage conversion factor. The code can calculate the radionuclide of 1um, 3um, 5um and 10um.

2.2.3 IMBA (Integrated Modules for Bioassay Analysis). This code uses ICRP-66/30 gastrointestinal tract model, NCRP wound model and ICRP-78 biometrics model. For respiratory model, digestive organ model and metabolism model, the code evaluates the exposure dose with ICRP-68 standard worker as the recommended model. The size of the radionuclide supported for calculation is 5um as recommended by ICRP. The user can change the factors.

2.2.4 MONDAL (Monitoring to Dose Calculation). The code uses ICRP-66 respiratory organ model, ICRP-30/56/67/69 metabolism model and ICRP-30 digestive organ model. The sizes of the radionuclide supported for calculation are 0.1 um, 0.3 um, 1 um, 3 um, 5 um and10 um.

2.3 Estimation of size distribution of particles for decommissioning of nuclear power plant

Typical processes conducted during decommissioning of a nuclear power plant are cutting, milling and grinding. In order to estimate the size distribution of aerosol generated during decommissioning work, the change of size of aerosol generated during milling of Fe alloy has been analyzed. The test shows that longer the milling work, the average particle size gets smaller. The particle size varies widely from 0.09 um to 40 um. In general particles of 10 um or larger are filtered by mask.

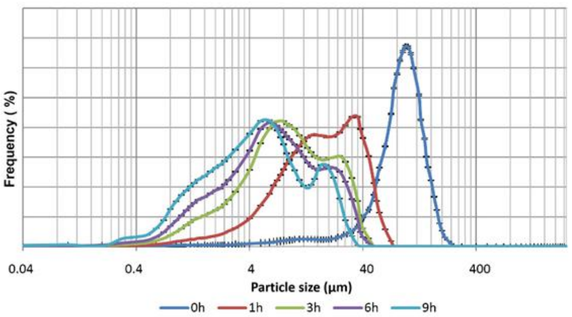

Fig. 2. Size distribution of aerosols generated by Milling.

3. Conclusion

Aerosol generated during decommissioning of a nuclear power plant can be in the form of submicron particle. The submicron aerosol particles deposit in lung sac, causing exposure of the entire body through blood, and hence, more critical than aerosol of larger particle. Therefore, BiDAS is the most appropriate code for evaluation of internal exposure of decommissioning workers as it calculates small aerosol particle of 0.03 um. The code is also proven for its reliability through IMIE. Therefore, it can be used as an important index for evaluation of internal exposure dose of the workers in future decommissioning of nuclear power plants.

REFERENCES

[1] Werner Hofmann, "Modelling inhaled particle deposition in the human lung", 2011.

[2] KAERI, "Technology Development for Evaluation of Operational Quantities in Radiation Protection", Final Research Report, 2003.

[3] Tea-Yong Lee, Jong-Kyung Kim and Jong-Il Lee and Si-Young Chang, "Bioassay Data Analysis Software for Evaluating a Radionuclide Intake and Dose", Journal of the Korean Radioacitve Waste Society, 2(2), 113-124 (2004).

[4] KOARA, "Development of Internal Exposure Dose Assessment Techniques for Domestic Workers Using Radiation and Radioisotope", Final Research Report, 2014.

[5] Eun-Ju Kim, Hee-Geun Kim, Gak-Hyun Ha and Hyung-Suk Lee, "Comparison of Internal Dose Assessment due to Intake of I-131", Proceeding of the Korean Radioactive Waste Society, 1(2), November (2003).