Dose Assessment Considering Worker's Internal Exposure Factors Affecting Contaminated Metallic Waste Recycling

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1. Introduction

As Korea's first commercial NPP (Nuclear Power Plant), Kori-1, will be decommissioned, proper disposal of radioactive waste will become a major issue. In particular, when recycling metallic waste at the clearance level the exposure assessment of workers and the general public should be evaluated in advance. The RESRAD-RECYCLE computer code was developed by Argonne National Laboratory (ANL) Environmental Assessment Division (EDA) under the support of the U.S. Department of Energy (DOE) for the purpose of assessing the radiological consequences. [1] The justification for the evaluation results will largely depend on the choice of site-appropriate parameters. Some parameters that affect internal exposure such as an ingestion rate and a respiratory protection factor can be adjusted. In this study, we observe the effects on the dose results when the ingestion rate is modified at maximum and when the respiratory mask used in the general industry is applied.

2. Methods and Results

2.1 Key Radionuclides

Three representative radionuclides (Co-60, Cs-137, and Sr-90) are chosen because they are considered to be the major source of radiation dose in metallic wastes from NPP. The allowable concentration limits by regulation are shown in Table I. [2]

Table I: Allowable Concentration by Radionuclide for Clearance

Radionuclide	Concentration (Bq/g)
Co-60	0.1
Cs-137	0.1
Sr-90	1

2.2 Selection of Scenarios

There are 41 scenarios for dose assessment purpose in RESRAD-RECYCLE. Exposure scenarios that cause internal exposure of the worker are considered for comparison of dose results. A total of 13 worker scenarios are selected: (1) scrap cutter, (2) scrap loader, (3) scrap processor, (4) scrap yard worker, (5) smelter loader, (6) furnace operator, (7) baghouse processor, (8) refinery worker, (9) ingot caster, (10) small object caster, (11) slag worker, (12) sheet maker, and (13) coil maker.

2.3 Key Parameters

The adjustable parameters for the radiation exposure from internal are an airborne-dust-loading factor, a respiratory protection factor and an ingestion rate. The RESRAD-RECYCLE adopts a value of 1.0 x 10^{-3} g/m^3 as an upper-bound of dust loading factor, a fraction of upper-bound value and a value of 1 as a respiratory protection factor. To eliminate ambiguity of the distinction of dust loading for scenarios, we used upper bound value of 1.0 x 10^{-3} g/m^3 conservatively for all worker scenarios. For workers, the respiratory protection factor can be highly dependent on the efficiency of the respiratory mask. It ranges from 0 to 1 (no mask). According to U.S. OSHA (Occupational Safety and Health Administration) [3], a value of 0.2 as the respiratory protection factor is applicable to quarter masks. RESRAD-RECYCLE adopts conservatively 1 as the default. However, if the proper management for respiratory protection is possible at the site, 0.2 can be applied. An ingestion rate value of 0.00625 g/h is provided by default in RESRAD-RECYCLE and a uniform distribution of 0 - 0.02 g/h is assigned in NUREG-1640. [4] Therefore, this study uses a conservative value of 0.02 g/h and compared it with the default value.

2.3 Dose Results with Default Parameters

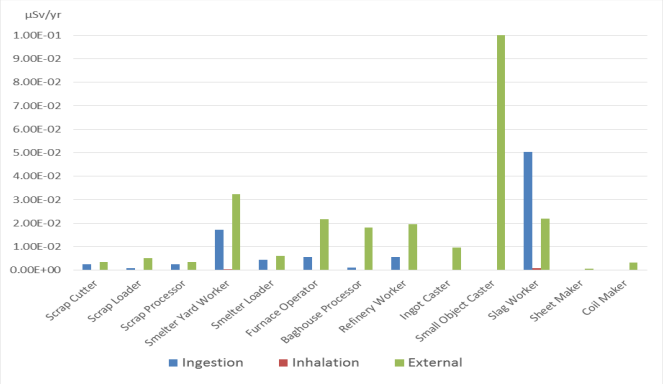

Fig. 1. Dose results for workers by pathways

For our analysis, dose results are calculated by using the RESRAD default value. As can be seen Fig. 1, the two major pathways (external and ingestion) are significant for the worker, and ingestion is the main

cause of exposure to the internal pathway. The dose of small object caster and slag worker is the highest, and the internal exposure by ingestion also have a great influence on the slag worker.

2.4 Dose Results with Modified Parameters

In order to compare the dose results according to the change of key parameters of internal exposure, a set of parameter group was organized as shown in Table II. Dose results were divided into ingestion and inhalation, and the effects of dose on workers were observed.

Table II. Parameter groups

Group	Ingestion Rate (g/h)	Respiratory Protection Factor
ID-RD[a]	0.00625	1
IM-RD[b]	0.02	1
IM-RM[c]	0.02	0.2
ID-RM[d]	0.00625	0.2

[a] ID - RD: Ingestion default-Respiratory default
[b] IM - RD: Ingestion modified-Respiratory default
[c] IM - RM: Ingestion modified-Respiratory modified
[d] ID - RM: Ingestion default-Respiratory modified

In case of ingestion (Fig. 2), the dose is increased by more than 100% when the conservative maximum value of ingestion rate is applied. Compared to the case where the operator did not were the protective mask or not, the result of wearing the mask showed a little less dose. The most affected scenarios are the slag worker and the smelter yard worker, which suggests that the worker in these two scenarios during actual work has a high exposure ingestion.

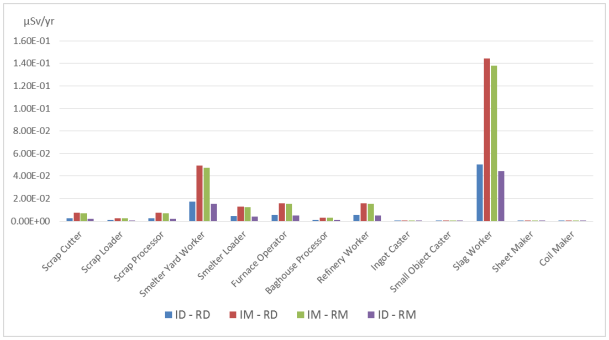

Fig. 2. Comparison of Ingestion Dose by Parameter Group

In case of inhalation (Fig. 3), it can be seen that the dose is not affected by an increase in the ingestion rate. The inhalation dose is reduced to about 5 times by adjusting respiratory protection factor to 0.2, which represents the wearing of the protective mask in work places. Although the graph shows that the inhalation dose is not lager than that of ingestion, it can also be seen that the inhalation dose can be reduced by wearing a protective mask.

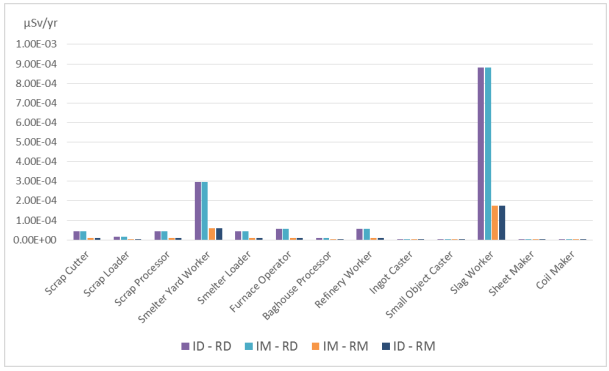

Fig. 3. Comparison of Inhalation Dose by Parameter Group

3. Conclusions

RESRAD-RECYCLE, a dose assessment for radioactive contaminated materials, was useful in identifying the results from changes in parameters affecting internal exposures. The ingestion rate and the respiratory protection factor were found to be influential factors on ingestion dose, and the change of ingestion rate had a great effect. In the case of inhalation dose, there was no causal relationship with the ingestion rate, and dose was significantly reduced by applying respiratory protection factor. However, it was also seen that the inhalation dose is not large compared to the ingestion. The results of this study can be used as useful data for the workers' radiation protection measures in recycling of the radioactive contaminated metallic waste.

4. Acknowledgements

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