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# Inhalation Dose Assessment of Workers in Welding Electrode Manufacturing Industry

Seong Yeon Lee[1], Byung Min Lee[1], Jong Hyeok Park[1], Kwang Pyo Kim[1]*
[1]*Kyung Hee University, 1732 Deokyoungdaero, Giheung-gu, Yongin Gyeonggi-do, Korea, 17104*
[*]*Corresponding author: kpkim@khu.ac.kr*

## 1. Introduction

According to the International Atomic Energy Agency (IAEA) Safety Report 49, Zircon is naturally occurring radioactive material (NORM) containing 2 - 4 Bq/g for U-238 [1]. International Commission on Radiological Protection (ICRP) stated Zircon handling industry as one among 12 industrial activities that cause NORM exposure [2].

In Korea, there are a number of industries handling Zircon, one of which is the welding electrode manufacturing industry. Welding electrodes are materials used for electric welding and are widely used in basic industrial fields such as construction and machinery. Some domestic welding electrode manufacturing industries are producing welding electrodes using mineral materials such as Zircon and bauxite as raw materials.

The domestic welding electrode manufacturing industry selected in this study handles a powder-type Zircon mixture. Workers handling raw materials in a number of processes in the industry are likely to inhale airborne particulates containing NORM, which can cause internal exposure. Therefore, inhalation dose assessment should be performed for the safety management of workers in the welding electrode manufacturing industry.

The objective of this study is to evaluate the inhalation doses of workers in the welding electrode manufacturing industry. ICRP recommended that site-specific information on airborne particulate properties should be measured and then used for inhalation dose assessment [3]. Thus, in this study, particulate properties of industrial sites were analyzed and inhalation dose assessment was performed.

## 2. Material and Methods

In this study, two domestic welding electrode manufacturing industries were selected. Particulate properties analysis and inhalation dose assessment were performed by the industry.

Particulate properties were analyzed for airborne particulate concentration, radioactivity concentration, shape, mass density. The airborne concentration was analyzed by collecting particulates from the site using Cascade impactor. Radioactivity concentration was analyzed using HPGe for samples collected from the site. The mass density of particulates was analyzed using a Pycnometer after collecting materials handled in the field as samples. Shape of particulates was analyzed using Scanning Electron Microscope (SEM) for some of airborne particulates collected with Cascade impactor.

The inhalation dose assessment was performed through the worker's breathing rate, annual working time, and effective dose coefficient for inhaled particulates. The worker's breathing rate was selected 1.2 $m^3$/h, the default value suggested by the ICRP. Annual working time was derived by conducting interviews at each industry. The effective dose coefficient for inhaled particulates was derived based on the Human Respiratory Tract Model (HRTM) presented in the ICRP publication 66 using the IMBA code.

## 3. Results and Discussion

### *3.1 Particulate Property*

Fig.1 shows the airborne particulate concentrations of two welding electrode manufacturing industries. The airborne particulate concentrations of industry A and B ranged 0.137 - 0.359 μg/L and 0.130 - 4.981 μg/L, respectively. The process area showing the highest airborne particulate concentration in industry A and B was the manual mixing room. In the manual mixing room, a lot of airborne particulates were generated compared to other process areas due to a large amount of raw material in powder form was inserted.

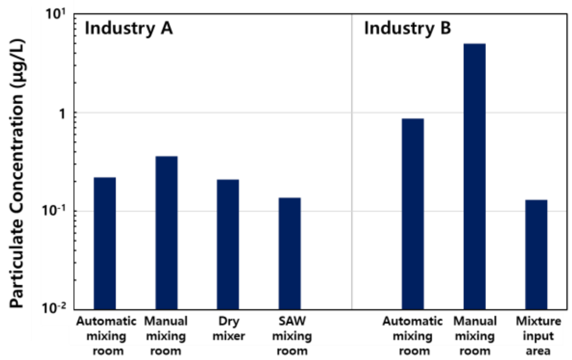


Fig.1. Airborne particulates concentration in welding electrode manufacturing industry

Fig.2 shows the radioactivity concentration of the sample collected from two industries. Radioactivity concentrations in industry A ranged 0.051 - 3.542 Bq/g for uranium series and 0.020 - 0.526 Bq/g for thorium series. Radioactivity concentrations in industry B ranged 0.092 - 2.719 Bq/g for uranium series and 0.047 - 0.408 Bq/g for thorium series. The samples showing the highest radioactivity concentration for the uranium series and thorium series in industry A were zircon sand. In the case of industry B, the samples showing the highest radioactivity concentration for uranium series and thorium series are Zircon sand and Calcined rutile sand, respectively.

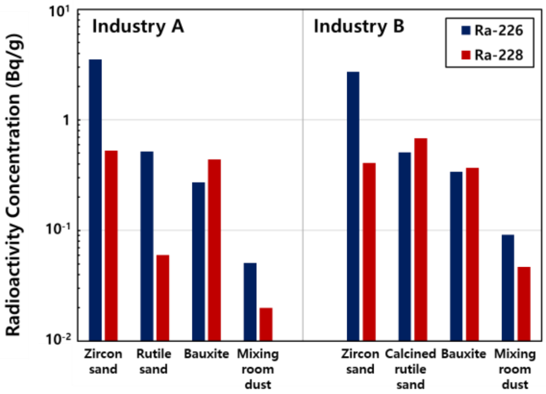


Fig.2. Radioactivity concentration of handled material in welding electrode manufacturing industry

The shape of particulates appeared to be spherical in most process areas in both industries, and few cylindrical particulates existed. Therefore, the shape factor was set to 1 for airborne particulates existing in both industries.

Table I shows the mass density of the sample collected from two industries. The mass density in industry A and B ranged 3.4 - 5.8 g/cm$^3$, 3.5 - 5.8 g/cm$^3$, respectively. In both industries, the process area showing the highest mass density is raw material warehouse.

Table I: Mass density of particulates in welding electrode manufacturing industry

| Process area | | Sample | Density (g/cm$^3$) |
|---|---|---|---|
| A | Warehouse | Zircon oxide | 5.8 |
| | Manual mixing room | Dust | 3.6 |
| | Automatic mixing room | Zircon sand | 4.6 |
| | | Rutile sand | 4.2 |
| | SAW mixing room | Bauxite | 3.4 |
| B | Warehouse | Zircon sand | 5.8 |
| | Automatic mixing room | Calcined rutile sand | 4.2 |
| | | Bauxite | 3.5 |
| | Mixing room | Dust | 3.6 |

### *3.2 Inhalation dose*

Fig. 3 shows inhalation doses for workers in two domestic welding electrode manufacturing industries. The inhalation doses of workers working in industries A and B ranged from 1.00×10$^{-4}$ - 1.60×10$^{-3}$ mSv/y, 1.00×10$^{-4}$ - 6.00×10$^{-3}$ mSv/y, respectively. Industry A and B presented the highest inhalation dose in the automatic mixing room. The inhalation doses of workers in each process were different depending on the particulate property and work type of handling material. Although the automatic mixing room does not generate a lot of dusts compared to other processes, the highest dose was derived due to longer working time and the raw materials with relatively high radioactivity concentration were handled.

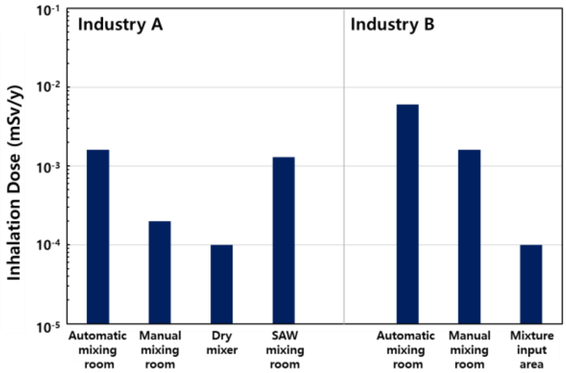


Fig.3. Inhalation doses in welding electrode manufacturing industry

## 4. Conclusions

In this study, the inhalation doses of workers in domestic welding electrode manufacturing industries were evaluated. The inhalation dose in the welding electrode manufacturing industry was greatly affected by particulate properties such as airborne particulates concentration and radioactivity concentration and work type. In addition, the inhalation dose of industries A and B does not exceed 1 mSv/y, the annual dose limit for the public. The results of this study will be used as database for analyzing the current status of radiation exposure of domestic welding electrode manufacturing industries.

## ACKNOWLEDGMENTS

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## REFERENCES

[1] IAEA, Assessing the Need for Radiation Protection Measures in Work Involving Minerals and Raw Materials, SRS 49, 2006.
[2] ICRP, Radiological Protection from Naturally Occurring Radioactive Material (NORM) in Industrial Process, ICRP 142, 2020.
[3] ICRP, Human Respiratory Tract Model for Radiological Protection, ICRP 66, 1994.