Negative Impact on Radiation Safety of Workers in D&D by Nano-Scale Aerosols from Metal Cutting Process

Sungyeol Choi*, Min-Ho Lee, Wonseok Yang, and Nakkue Chae
Korea Advanced Institute of Science and Technology, 291, Daehak-ro, Yuseong-gu, Daejeon, Republic of Korea
*sungyeolchoi@kaist.ac.kr

1. Introduction

As the lifetime expiration of nuclear power plants (NPPs) constructed at the 1970s approaches, the technology of NPP decommissioning and decontamination (D&D) activities become more important. During the D&D process, the primary step is a massive amount of radioactive material such as steel containment, pipe, and concrete should be cut into small pieces. Making things work, we could use various cutting technics. However, the cutting process can cause undesirable results in generating radioactive aerosols [1].

The inhalation of a radioactive aerosol is deeply concerned about of internal exposure of workers at the D&D facility. The characteristics of aerosol such as density, shape, and aerodynamic diameter are strongly dependent on risk assessment of worker`s internal dose. Especially, activity median aerodynamic diameter (AMAD) is a critical factor for accurate internal exposure assessment [2].

Therefore, in this study, we designed the aerosol measurement system at a metal cutting condition. The experimental data of aerosol distribution could be helpful for the risk assessment of internal dose.

2. Methods and Experimental setup

2.1. Automatic metal cutting system

In laboratory experiments, Plasma cutter (Powermax 125, Hypertherm) was used to cut stainless steel plate. The plasma cutter was fixed in the center of the chamber ceiling. The plasma cutting device operated at 75A current with supplying compressed air. The movable table controlled by sub-motor system helped to control the metal cutting speed automatically (Fig.1).

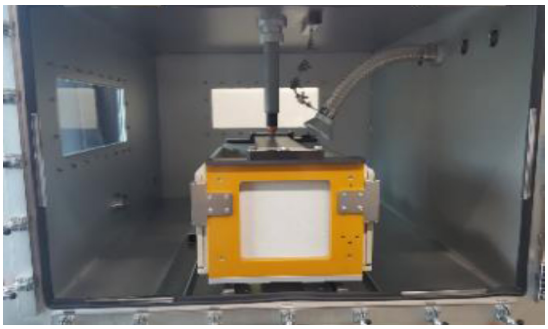

Fig. 1. Plasma cutting device (Powermax 125, Hypertherm) and movable table controlled by sub-motor system.

2.2. Aerosol distribution measurement

We designed the isolated aerosol chamber for collecting generated aerosol particles without leakage outside (Fig. 2). The measurement of the aerosol is performed using the electrical low-pressure impactor (ELPI®+, DEKATI). All aerosol particles which have the size from 6 nm up to 10 μm collected at each 14 different size stages.

Fig. 2. The system for aerosol measurement from metal cutting in KAIST Nuclear Fuel Cycle Lab.

3. Results and Discussion

3.1 Internal dose depending on aerodynamic diameter

The activity median aerodynamic diameter (AMAD) which is the half of the radioactivity in the cumulative size distribution. In general, as decreasing aerodynamic diameter, committed effective doses for aerosol inhalation became increasing more [3]. In the

previous study for measurements of aerosol at nuclear workplaces, recommended AMAD is in the region of 5 μm However, it is the better assessment to use real experimental data [4].

3.2 Number and mass aerodynamic diameter distribution

Fig. 3 shows the number and mass aerodynamic diameter distribution when stainless steel samples were cut using the plasma arc. The peak value in number distribution was observed near 100 nm. On the other hand, the mass of aerosol tended to increase with increasing AMAD.

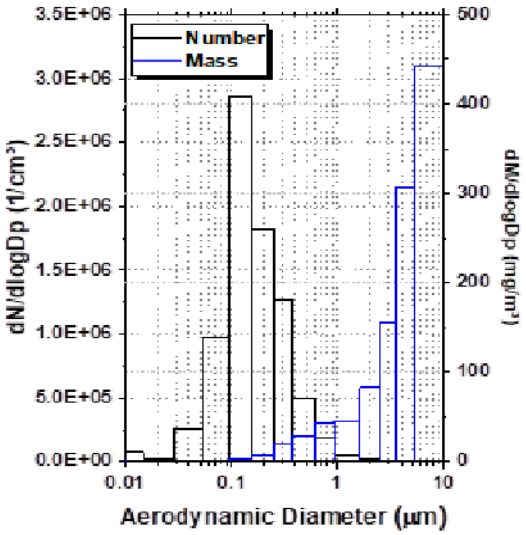

Fig. 3. Counted number and mass aerodynamic diameter distribution of stainless steel cut with plasma cutter.

3.3 Radioactive aerosol captured at the HEPA filter depending on particle size.

The nuclear facilities including the D&D workplace usually used HEPA filters to prevent radioactive aerosol leakage and to keep workers safe. Most of the aerosols do not pass through the filter. However, the aerosol particles around 100 nm in size cannot be completely removed by a filter because of HEPA filters have the lowest filtration efficiency in a 100 nm size region [5].

Therefore, the radiation risks of public and environment are not under consideration when HEPA filter works well for this expectation. However, it is still a risk for the internal exposure of the worker [6].

4. Conclusion

It is significant to fully understand the distribution of radioactive aerosols during the D&D process. The experimental data of aerosol distribution could be helpful for the risk assessment of internal dose. Although the protection system managed the internal dose admirably, dispersion behavior and generation of very small aerosol under 0.1 μm should be considered from a worker`s safety standpoint. To put it in a nutshell, nano-scale aerosols from the metal cutting process could have a negative impact on the worker in D&D.

ACKNOWLEDGMENT

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