Radioactive Aerosol Size Distribution Measured in Nuclear Workplaces

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Introduction

Inhalation is the main route for internal exposure of workers to radioactive aerosols in the nuclear industry. Aerosol's size distribution and in particular its activity median aerodynamic diameter (AMAD) is important for determining the fractional deposition of inhaled particles in the respiratory tract and the resulting doses.

Respiratory tract models have been published by the International Commission on radiological Protection (ICRP). The former model has recommended a default AMAD of 1 micron for the calculation of dose coefficients for workers in the nuclear industry [1]. The recent model recommends a 5 microns default diameter for occupational exposure which is considered to be more representative of workplace aerosols [2]. Several researches on radioactive aerosol's size distribution in nuclear workplaces has supported this recommendation [3,4]. This paper presents the results of radioactive aerosols size distribution measurements taken at several workplaces of the uranium production process.

Measurements

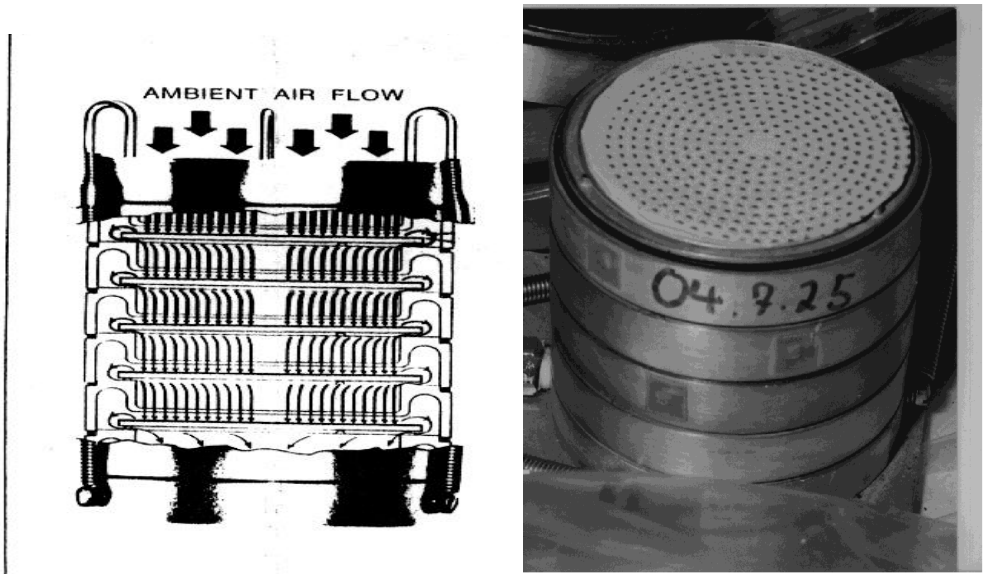
Aerosol's diameter size distribution was measured using a cascade impactor, as recommended in the literature [5]. The cascade impactor, shown on Figure 1, separates particulate aerosols according to their inertial tracks into several different size fractions based on their aerodynamic diameter. The appropriate size fractions for a 28.3 L/min flow capacity are presented in Table 1. Measurements were taken at several workplaces at which the following processes were conducted: conversion process of UO_3 into UF_4 fine powder and UF_4 conversion into metal uranium process. Each site was sampled at least twice for 2-10 days each sample. The appropriate sampling locations were selected according to the following criteria:

One. The sampling locations had to cover areas of potential workers' occupancy and consequently internal exposure to the radioactive aerosols.

Two. The conditions at and around the sampling locations during sampling had to be representative of the normal working conditions.

Three. Sampling locations had to meet the requirement of accessibility for the measurement equipment, on one hand, and the avoidance of normal work disruption, on the other hand.

In practice, since some of the above criteria had a potentially conflicting nature, the final choice of sampling locations was, in some cases, a compromise between desirability and practicality.



(a) (b)

Fig. 1. (a) Schematic description and (b) a picture of the cascade impactor.

Table 1. Cascade impactor particles' size separation for a 28.3 L/min flow capacity.

Stage	Size range (microns)
1	<0.4 (*)
2	0.4-0.7
3	0.7-1.1
4	1.1-2.1
5	2.1-3.3
6	3.3-4.7
7	4.7-5.8
8	5.8-9.0
9	>9.0

(*) external backup filter.

Results and Discussion

Figure 2 presents the distribution of radioactive aerosol's aerodynamic diameter as measured in one of the sampling periods near the conversion process of UO_3 into UF_4 powder. The distribution had an AMAD of 4.9 microns and a geometric standard deviation of 2.5 microns. Values of the radioactive aerosol's AMADs measured at other workplaces are presented in Table 2. The measured AMADs ranged from 2.1 to 11.0 microns with a median of 4.7 μm. The geometric standard deviations in these measurements ranged between 2.0 to 3.0 microns.

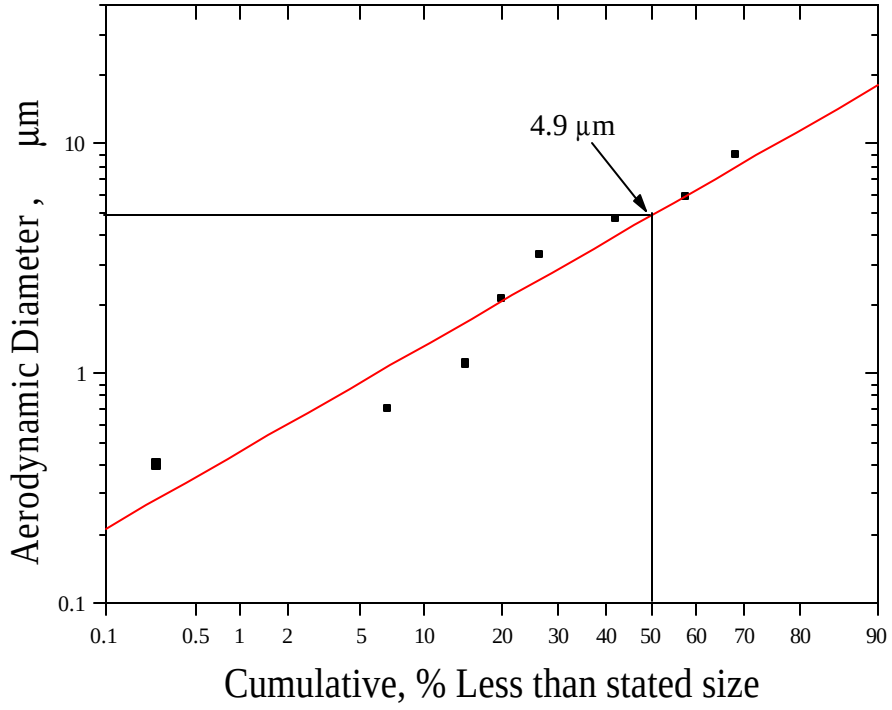


Fig. 2. The distribution of radioactive aerosol's aerodynamic diameter as measured near the conversion process of UO_3 into UF_4 powder.

Table 2 . Measured AMADs of workplace radioactive aerosols.

Workplace	Number of measurements	AMAD (microns)	
		Range of values	median
UO_3 conversion into UF_4 powder	8	2.1-8.2	4.62
UF_4 conversion into metal uranium	10	2.2-11.0	4.75
All workplaces	18	2.1-11.0	4.7

According to our results, the AMAD value of 5 microns recommended in ICRP Publication 68 [2] is a realistic value for radioactive workplace aerosols. The geometric standard deviation approximation of 2.5 microns is also a reasonable value for these aerosols.

References

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