PROPERTIES OF AEROSOL FLOATING IN THE AIR IN A NUCLEAR POWER PLANT WORKPLACE ENVIRONMENT

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ABSTRACT

An investigation was carried out on properties of radioactive aerosol floating in the air at several workplaces in a nuclear power plant.
The principal results are as follows:

(1) The aerosol particle size distributions consisted of two particle groups, whose aerodynamic diameters ranged from 4 to 7 microns and from 0.4 to 0.6 microns.
(2) The radioactive aerosol particle size distribution were unimodal. The mean activity median aerodynamic diameter (AMAD) was 6 microns, with geometric standard deviation 1.9 microns.
(3) The average density of the aerosol was about 2.2g/cm^3.

INTRODUCTION

Knowledge of the particle size distribution of radioactive aerosol floating in the environmental air at workplaces in a facilitiy handling radioactive materials is essential for estimating the internal radiation exposure dose of workers, caused by respiration and for monitoring the concentration of radioactive aerosol.

Task Group on Lung Dynamics of the ICRP has proposed a lung model for estimating the dose, following inhalation of radioactive aerosol.[1][2] This model takes particle size into account and also defines three classes of rètention, which, in part, reflect the chemical form of the aerosol. This model shows that the pattern of deposition can be related to the activity median aerodynamic diameter (AMAD) of the aerosol, for a log-normal distribution of diameters, which seems typical distribution of aerosol. Therefore the particle size distributions of radioactive aerosol are important and have been studied in detail in the present work.

Aerosol particles floating in the air at several workplaces were sampled during the maintenance period of a nuclear power plant. Analysis were carried out for the samples and particle size distributions of total aerosol and radioactive aerosol were determined.

MEASUREMENTS AND DATA ANALYSIS

Samples of aerosol floating in the environmental air at several workplaces in a nuclear power plant were collected with a cascade impactor (Andersen sampler model AN200). The Andersen sampler consists of 8 stages and a backup filter, and flow rate was regulated at 28.3 l/min. The height of sampling position was about 1.2 meter above the working floor, corresponding to the worker's respiratory zone. The sampling time was 60 to 90 hours at a workplace. After sampling, the weight of the aerosol particles taken at each sampler plate (stage) were measured with a micro balance (minimum detectable weight is 0.01mg) and gamma radioactivity of the each plate (stage)were measured with a Ge-detector and a multichannel pulse height analyser.

Data analysis for particle size distribution of aerosol were made with the method proposed by Fujimura and Hashimoto(3). In this method, at first, a cumulative distribution curve F(D) for aerosol particle diameter D is drawn by plotting the percentages of cumulative weight (or radioactivity) on a semi-logarithmic graphpaper. Then, the F(D)curve is differentiated to obtain a frequency distribution curve f(D),by plotting the gradient dF(D)/d(logD) It is suitable to obtain an intuitive image of the size distribution for aerosol particles.

The "Floating Method" was used to determine particle density. In this method, aerosol accumulations were soaked into a liquid and the liquid density was changed by mixing two other liquids whose densities were different from each other. If the aerosol density was equal to the liquid density, the aerosol particles float in the liquid. So, by measuring the liquid density, the aerosol density can be obtained.

RESULTS

The aerosol size distribution (mass frequency distribution) was found to be bimodal, as shown in Fig.1, consisted of two particle size groups, whose aerodynamic diameters were 4 to 7 microns and 0.4 to 0.6 microns. The particle size distribution for each aerosol group closely resembled to logarithmic normal distribution. Their average mass median aerodynamic diameter was 6 microns and 0.5 microns, with geometric standard deviations of 1.9 and 2.1 microns, respectively.

On the other hand, the particle size distribution for radioactive aerosol were found to be unimodal, as shown in Fig.2. The mean activity median aerodynamic diameter (AMAD) was 6 microns with geometric standard deviation of 1.9 microns. As shown in Fig.3, the concentration of radioactive aerosol particles in the air strongly depended on the concentration of larger particle group, whose aerodynamic diameters were 4 to 7 microns.

The radioactive nuclides, included in the aerosol, were Cr-51, Mn-54, Fe-59, Co-58, Co-60, Zn-65 and Ag-110m. These radioactive nuclides were activation products of structural materials by neutrons. The main radioactive nuclides were Mn-54 and Co-60 .

The densities of aerosol, measured by the "Floating Method", is shown in Table 1. Measured densities for aerosol were ranged from 1.8 to 2.6 g/cm^3 in place by place, and average aerosol density was about 2.2 g/cm^3.

Other observed properties of the aerosol were chemical elements. The main chemical element included in the aerosol was iron.

CONCLUSION

An investigation was carried out on properties of radioactive aerosol floating in the environmental air at workplaces of a nuclear power plant.

The results are as follows:

(1) The aerosol particle size distributions consisted of two particle groups, whose aerodynamic diameters ranged from 4 to 7 microns and from 0.4 to 0.6 microns.

(2) The particle size distributions for each aerosol group closely resembled to logarithmic normal distribution. Their mean mass median aerodynamic diameter (MMAD) was 6.0 and 0.5 microns with geometric standard deviations of 1.9 and 2.1 microns, respectively.

(3) The particle size distribution of radioactive aerosol were unimodal. The mean activity median aerodynamic diameter (AMAD) was 6 microns, with geometric standard deviation of 1.9 microns. The radioactive aerosol concentration in the air strongly depended on the concentration of the larger particle group, whose aerodynamic diameters ranged from 4 to 7 microns.

(4) Other observed properties were:

(a) The average density of the aerosol was about 2.2 g/cm^3.

(b) The main radioactive nuclides, included in the aerosol were Mn-54 and Co-60.

(c) The main chemical element, included in the aerosol was iron.

REFERENCES

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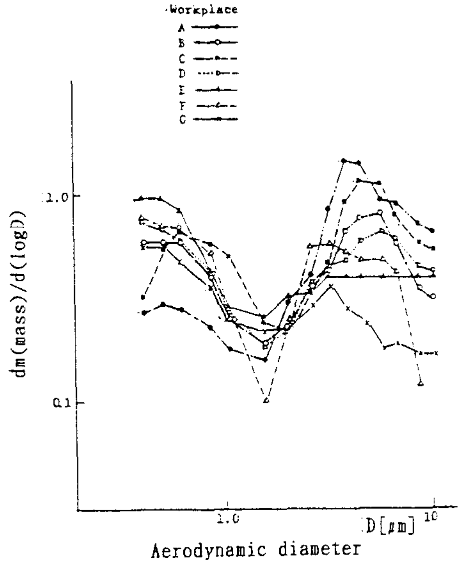

Fig. 1 Particle size distribution of aerosol in workplace [Mass]

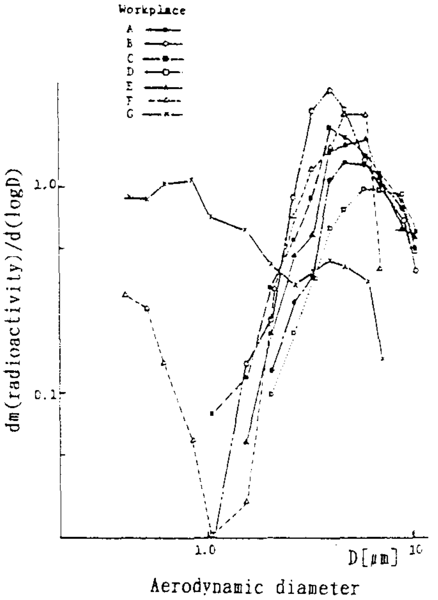

Fig. 2 Particle size distribution of aerosol in workplace [radioactivity]

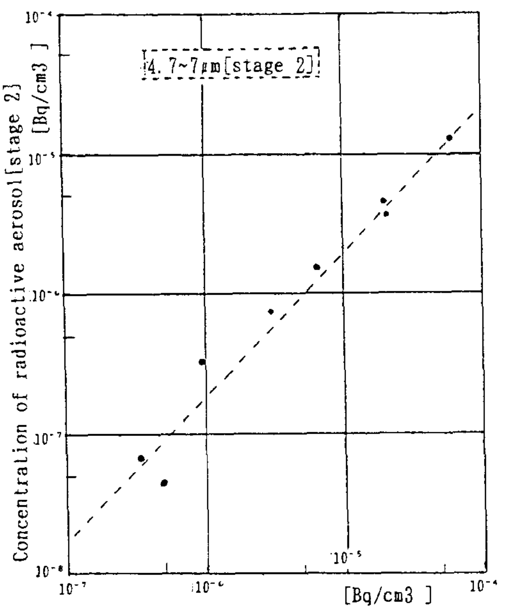

Fig. 3 Relationship between concentration of total radioactive aerosol and concentration of radioactive aerosol at [stage2]

Table 1 Particle density of aerosol

Workplace	Particle Density [g/cm^3]
A	2.6
B	1.8
C	2.0
D	2.0
E	2.1
F	2.5
G	2.6
Average of Particle Density	2.2