EXPERIENCES IN MONITORING AIRBORNE RADIOACTIVE CONTAMINATION IN JAERI

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In Japan Atomic Energy Research Institute(JAERI) there are many facilities and laboratories where the protection from airborne radioactive materials is more important than that from external radiation. In them air monitoring is indispensable to confirm the kinds and amounts of airborne radionuclides and estimate the personnel exposure dose due to these atmospheric contaminants.

This report describes some problems which have been experienced in air monitoring for hot cells for handling highly radioactive materials, glove boxes for handling plutonium and a cell for producing ^{99}Mo.

DISPERSION FACTOR

When irradiated uranium metal fuel was cut in a hot cell, the ratio of activity of airborne dust to that of the whole dust was determined for representative nuclide (1). The dispersion factor $\varepsilon(k)$ for nuclide k was defined as

$$\varepsilon(k) = D(k)/ M(k)$$

D(k) is the activity of nuclide k dispersed in the air in a hot cell when the fuel was cut; it was evaluated from the concentration of airborne nuclide k activity, the volume of the hot cell($144m^3$) and the ventilation rate of the cell(10 volumes/h). M(k) is the total activity of nuclide k contained in the cut dust; it was calculated from the irradiation history of the fuel. Airborne radioactive dust in the hot cell was collected on a cellulose-asbestos filter paper(Toyo HE-40) and a charcoal- loaded filter paper(Toyo CP-20). The activities of the dust were determined using a gamma-spectrum analyzer with a 5"x4"NaI(Tl) scintillation detector.

The results showed that the dispersion factors were the order of 10^{-2} for semi-volatile form of ^{125}Sb and $10^{-3} \sim 10^{-4}$ for particulate forms of ^{137}Cs and ^{144}Ce-^{144}Pr.

SIZE DISTRIBUTION OF RADIOACTIVE AEROSOL

For radioactive aerosols produced during works (mainly decontamination in the hot cells), the size distributions were investigated with a 4-stage cascade centripeter developed by U.K.A.E.A..

Radioactive aerosols were collected by the centripeter operated at flow rate 20 l/min for the work duration(10 min ∿ 2 h). The representative size(expressed as aerodynamic diameter) for each stage of the instrument at flow

Table 1 Size distributions of radioactive aerosols produced during various works at the hot laboratory

Group	Radiation work	Height of sampling point (m)	Size distribution AMAD (μm)	Size distribution σ_g
A	Decontamination of the hot cells	0.7-1.1	2.5-11 (6.0-6.4)*	1.7-3.2 (1.6-1.9)*
	Exchange of the exhaust filters	0.3 1.1	7.0 10	1.7 2.6
	Overhauling in the hot cells(1)	1.1	6.5 8.0	1.8 2.0
	Handling of the contaminated container	0.3 0.7	8.5 12	1.8 2.8
	Handling of irradiated graphite	0.6	15	2.8
	Dismantling of the hot drain pipe	1.1	9.0	1.7
B	Overhauling in the hot cells (include welding) (2)	0.3	0.41 1.2	7.1 12.5

* Size results of aerosol with alpha activity.

rate 20 l/min was calculated from the data(the effective cut-off sizes for the four stages at flow rate 30 l/min) given by Hounam,R.F. and Sherwood,R.J.(2) and O'Connor,D.T.(3), using the reiationship that the aerodynamic diameter of aerosol is inversely proportional to the square root of the flow rate on the basis of impaction theory. Activity median aerodynamic diameter(AMAD) and geometric standard deviation(σ_g) of the size distribution were estimated graphically on a log-normal probability paper, assuming a linear relationship between cumulative percentage of the activity on each stage and the representative size.

In Table 1 are shown aerosol size results for 24 aerosol samples with beta activity and for 3 samples with alpha activity. AS seen in Table 1, the AMAD and σ_g of the size distributions in usual radiation works(group A) are in the range of 2.5 ∿ 15μm and 1.6 ∿ 3.2, respectively. The most remarkable in the present investigation was group B having AMAD less than 1μm with σ_g of larger than 7. Such fine, respirable aerosols could be produced by high temperature burning in the air of radioactive contaminants within the cell due to arc welding.

RESUSPENSION FACTOR

In a plutonium handling laboratory, surface materials of the floor and equipments were contaminated extensively by particulate plutonium oxide(PuO_2) due to break of the negative pressure in a glove box. Therefore, the suspension factor(the ratio of the concentration of airborne contamination to the level of surface contamination) had to be evaluated to determine the procedure of decontamination and the type of respiratory equipment. Two workers who wore Harwell self-contained air-ventilated blouses, moved around in a PVC sheeting tent to fix the contaminant and seal up the leakage positions on the glove box. Volume and area of the contaminated floor inside the tent were about 6 m^3 and 2 m^2, respectively, and its ventilation rate was 10 volumes/h. Floor surface was almost uniformly contaminated at 4.5 x 10^{-2} $\mu Ci/cm^2$. The contamination was measured with a ZnS scintillation survey meter. Airborne contaminant was sampled with a personal air sampler, and its particle sizes were evaluated by autoradiographic technique. The particle size distribution was in the range of mass median diameter(MMD) 6.4 to 26μm, and σg was from 2.3 to 2.7.

The resuspension factor was found to be 4 x 10^{-8} ∿ 2 x $10^{-7} cm^{-1}$ for plutonium oxide particles deposited on the floor surface. The values agreed well with those obtained by Jones,I.S. and Pond,S.F.(4).

COLLECTION EFFICIENCY OF CHARCOAL-LOADED FILTER PAPER FOR AIRBORNE RADIOIODINE

A new charcoal-loaded filter paper(Toyo CP-20T) was made in order to improve collection efficiency of CP-20 filter papers and decrease its air resistance. Specifications of CP-20 and CP-20T filter papers are shown in Table 2. The radioiodine generated in ^{99}Mo production process was used for test, and consisted of 60 % inorganic and 40 % organic iodide. The chemical forms were determined with a sampler modified Maypack(5). The test conditions of air flow through filter papers were relative humidity 40 ∿ 80 %, face velocity 50 cm/sec and flow time of iodine 4 ∿ 18h.

Table 2 Comparison of specifications of charcoal-loaded filter paper

Specification	Charcoal-loaded filter paper	
	CP-20	CP-20T
Weight (g/m^2)	700	650 ∿ 700
Thickness (mm)	2.0	2.2
Base material	Cellulose-asbestos fiber	Glass fiber
Activated charcoal	Tsurumi coal HC	Tsurumi coal HC
Size of charcoal granule(mesh)	60 ∿ 200	60 ∿ 200
Charcoal content(wt %)	45	75

Following are the results:

(1) Collection efficiencies with and without the triethylenediamine(TEDA)-impregnated charcoal were found to be greater than 95 % and about 80 %, respectively.

(2) Air resistance across the new filter paper decreased to less than 1/2(0.8mmHg rise/cm face velocity) compared with CP-2o.

(3) Iodine retention efficiency of CP-20T during 24h following start of air flow was greater than 95 %, thereafter, there was found no more desorption of iodine.

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