APPLICATION OF ION-EXCHANGE MEMBRANE SOURCE TO PREPARATION OF CALIBRATION SOURCE SIMULATING FILTER PAPER FOR DUST MONITORS

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ABSTRACT

Ion-exchange membrane sources were applied to preparation of beta-ray calibration sources simulating filter paper for dust monitors. Concerning the influence of backscattering on counting efficiencies of detectors, the similarity between the filter paper and the prepared sources is discussed. The sources were proved to be more suitable for the realistic calibration of dust monitors.

INTRODUCTION

A calibration source for dust monitors consists of an active layer and a backing material(for example, aluminum or stainless-steel). Usually, the backing is thick enough to prevent the penetration of beta-rays backscattered by structural materials behind the filter paper. The sources can be standardized in surface emission rate[1)] but not in radioactivity. However, the actual filter is relatively thin and penetrable for the beta-rays. When the radioactive aerosols collected on the filter are measured, the backscattering radiation influences the counting efficiency of detectors. Taking account of the backscattering effect, the calibration source requires (a)the similarity in material to the filter paper and (b)the standardization in radioactivity. Taking these matters into consideration, the filter-simulated sources with ion-exchange membrane(hereafter, FSS) were prepared. This paper presents the preparation method of the calibration sources, and the discussions on such characteristics of the sources as self-absorption, release of radioactivity and the effect of backscattering.

EXPERIMENTS

The ion-exchange membrane sources were prepared by soaking ion-exchange membranes into the solution in which radionuclides and their carriers were mixed, washing and drying them.[2)] Three types of membrane sources(about 0.7, 3 and 6 mg/cm^2 in the thickness) were prepared for each radionuclide of ^{60}Co, ^{137}Cs and ^{90}Sr+^{90}Y. The activities of ^{60}Co and ^{137}Cs membrane sources were determined by the manner of relative measurement using a well-type HPGe detector. For the ^{90}Sr+^{90}Y membrane source, its activity was determined with ^{85}Sr as a tracer. The sources consist of protective film(polyester), the ion-exchange membrane source(polyethylene), adhesive(acrylic family) and backing material(polyester). The total thickness of FSS was approximated to that of filter paper (12.7 mg/cm^2). Experiments were made without the protective film and with two types of detectors, a plastic scintillation detector and a GM tube. The counting loss of beta-rays by the protective film(0.28 mg/cm^2) was about 2 % for ^{60}Co and less than 1 % for ^{137}Cs and ^{90}Sr+^{90}Y.

Since the active layer of FSS is about 0.7 to 6 mg/cm^2 thick, beta-rays are self-absorbed in the active layer. For evaluation of the self-absorption, an experiment was made. A thin ion-exchange membrane source(about 0.7 mg/cm^2) and several polyester membranes were layered. The total thickness of the layer was approximated to 12.7 mg/cm^2. The membrane source was inserted into any position of the polyester layer, the total thickness being kept constant. The beta-rays were measured for each position of the membrane source. Then, an absorption curve for each radionuclide was obtained as a function of source position. The correction factor of self-absorption was estimated by integrating the absorption curve in respect of the source position.

The radioactive aerosols are assumed to be collected on the surface of actual filter paper. In order to compare the FSS with the actual filter paper, the calibration sources of which radioactivity was adhered on the surface of filter paper(hereafter, RAS) were prepared.

RESULTS AND DISCUSSION

Table 1 gives the counting efficiencies of plastic scintillation detector and GM tube measured with the RAS and the FSS. As seen in Table 1, the detectors can be calibrated with the FSS as well as the RAS. However, as for $^{90}Sr+^{90}Y$, the counting efficiencies for the FSS are systematically somewhat smaller than those for the RAS. The correction factors of self-absorption for each radionuclide with the plastic scintillation detector are shown in Fig. 1. The correction of $^{90}Sr+^{90}Y$ FSS is 2 % at most(in the case that the active layer is about 6 mg/cm^2 thick). Hence, the reason for the smaller efficiency is considered to be possible overestimation of the activities of $^{90}Sr+^{90}Y$ FSS.

Measurements with a dust monitor include the backscattered beta-rays by structural materials behind the filter paper. By using the FSS, the influence of backscattering was evaluated for three types of filter paper support. One of them is a stainless-steel mesh plate usually attached to the dust monitors. The others are stainless-steel and aluminum plates of 2 mm in thickness. The counting efficiencies were measured with these different supports and without supports. Although there are some structural materials behind the supports, the influence of backscattering is considered to be small because of sufficient distance between the support and the material. For $^{90}Sr+^{90}Y$, the efficiencies increase to 20 % or more using the stainless-steel plate, and to about 8 % using the typical mesh plate, in comparison to the efficiencies without supports. These results indicate that the influence of backscattering behind the filter paper is not negligible for more realistic calibration of dust monitors.

The counting efficiencies of plastic scintillation detector for the sources with a thick backing are shown in Fig. 2. The thick backing can prevent the penetration of beta-rays backscattered behind itself. The activities of the sources are assumed to be twice the surface emission rate measured by a windowless 2π-proportional counter. In the figure, the efficiencies for the FSS are also shown. The mean beta-ray energies of ^{60}Co and ^{137}Cs referred to the NCRP Report[3], and that of $^{90}Sr+^{90}Y$ was derived from the spectrum by a plastic scintillation spectrometer. The FSS makes the backscattered beta-rays penetrate through itself, and is standardized in radioactivity. The counting efficiency for the FSS includes the influence of backscattering, and the efficiency for actual filter paper as well. The differences in thickness and reference quantity of calibration sources reflect on the calibration of dust monitors.

When an unsealed source is handled in routine calibration works, the release of radioactivity from the source may lead to accidental contamination. Therefore, the RAS is not suitable to the routine calibration works. The ion-exchange membrane source is free from the contamination because the release of radioactivity is extremely small. With the protective film, the FSS becomes much safer against the contamination.

CONCLUSION

The FSS can be used for the calibration of dust monitor in consideration of the influence of backscattering. Although the active layer of FSS is several mg/cm^2 thick, its self-absorption can be easily estimated due to its simple structure. Especially, this source is more suitable for the realistic calibration if the main radionuclides are fixed in nuclear facilities. Moreover, the FSS can be safely handled in the routine calibration because of negligible release of radioactivity. This study confirmed that this type of source was useful for the calibration of dust monitors.

REFERENCES

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3. National Council on Radiation Protection and Measurements, NCRP Report No.58 (1985)

Table 1 Counting efficiency of detectors for several sources.

Detector	Radio-nuclide	RAS*1	FSS*2		
			0.7 mg/cm²	3 mg/cm²	6 mg/cm²
Plastic scintillation detector	^{60}Co	0.128±0.001	0.128±0.001	0.125±0.001	0.125±0.001
	^{137}Cs	0.217±0.001	0.213±0.002	0.218±0.003	0.212±0.002
	^{90}Sr+^{90}Y	0.272±0.002	0.252±0.005	0.261±0.005	0.265±0.004
GM tube	^{60}Co	0.159±0.001	0.157±0.002	0.154±0.001	0.155±0.001
	^{137}Cs	0.257±0.001	0.249±0.003	0.248±0.003	0.252±0.002
	^{90}Sr+^{90}Y	0.308±0.002	0.284±0.006	0.289±0.005	0.293±0.004

*1 Source of which radioactivity is adhered on filter paper.
*2 Filter simulated source with ion-exchange membrane.

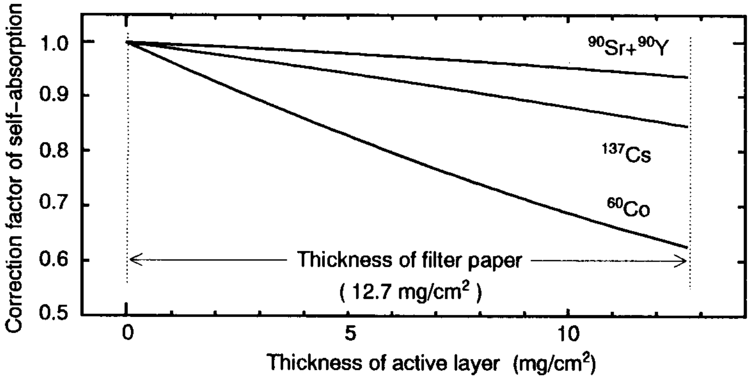

Fig. 1 Correction factor of self-absorption for each radionuclide with plastic scintillation detector.

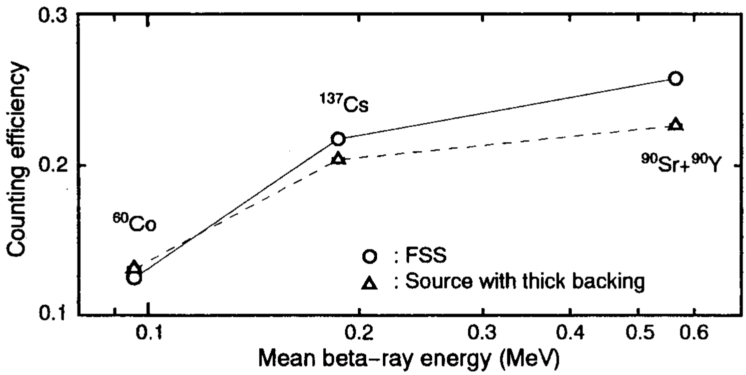

Fig. 2 Counting efficiency of plastic scintillation detector for two types of source.