^{226}Ra 密封小線源の漏洩・汚染検査について (西奥・鳥住(和)・根来・大西・鳥住(久))

ノート

^{226}Ra 密封小線源の漏洩・汚染検査について

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THE CHECKOUT METHOD FOR LEAKAGE AND CONTAMINATION OF ^{226}Ra IN A SEALED SMALL VESSEL

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Summary

In order to check for leakage and contamination of ^{226}Ra sealed in a small vessel, the characteristics of the smear method, direct immersed method and indirect sealed method were investigated. The direct immersed method employing toluene was better for sensitively detecting radioactivity and reproducibility, when compared with the smear method and sealed indirect method. However a problem exists with this method regarding

radioactivity in case ^{226}Ra is sealed in a small vessel since radioactivity is irregularly leaked from it.

1. Introduction

In the event that the powder formed ^{226}Ra is packed onto a platinum plate (0.5mm to 1.0mm in thickness) in sealed small vessel of ^{226}Ra , it can be modified into cell-tube or spindle-type forms. The half-life span of ^{226}Ra is as long as 1622 years and ^{226}Ra decays to ^{222}Rn in gas to have a half-life span of 3.8 days and finally becomes stable ^{206}Pb , mediated via process of radioactive nuclide materials after disintegration. Thus, needless to say, if the sealed small vessel is destroyed or damaged in any way, the radioactive material will leak and disperse in the atmosphere. The examination of contamination and leakage of radioactive material must be prevented, under the laws prohibiting the leakage and contamination of radioactive material. Therefore, we are urging the establishment of a sensible and dependable method for the safe and easy containment of this type of substance.

2. Methods

We are investigating to find a method which is simple to carry out and one that will not affect routine work. The method we have devised is described in the following.

2.1 Smear method

The filter paper used in this experiment was obtained from Toyo Doshi, Co., LTD. The paper is No. 2 type with a diameter of 1.3cm. This filter paper was immersed into a solution of toluene. The surface of the sealed small vessel of ^{226}Ra was wiped clear with filter paper immersed in toluene. This paper was put in the bottom of a 15ml scintillation vial (INSTA-GEL) and the influence of the counting rate with geometrical efficiency was taken in to consideration for this substance determined to be radioactive.

2.2 Direct immersed method

The sealed small vessel was directly immersed in about 5ml of toluene for 24 hrs and parts of this solution (3ml) was transferred to the liquid scintillation vial and 15ml of INSTA-GEL was added to those part determined to be radioactive.

2.3 Indirect sealed method

According to the method applied to the difference of the coefficient distribution of $^{222}\text{Rn}^{1)}$ as described by Matsuoka et al.²⁾, a 10ml of toluene and the sealed small vessel were put together for 24 hrs in a desicator, then 3ml of the toluene was mixed with 15ml of INSTA-GEL in a liquid scintillation counter and was determined to be radioactive.

The indirect sealed method is shown in **Fig. 1**. We applied our index value, calculating from following formula (the radioactivity of the sample / the radioactivity of the background) to mark the grade of contamination and leakage of radioactivity in each sample. More than 2.0 of the index value was defined to have leakage of

Fig. 1 Indirect immersed method.

radioactive material from the samples, compared with those of background. The radioactivity was measured in the window range from 0 to 2,000KeV, using a TRI-CARB scintillation counter (Parkard Co., LTD.).

3. Results and Discussion

3.1 Smear method

Ten samples consisting of three samples of the 2mCi cell and one sample of the 3 mCi cell presumably without any damage to any of the cells and six samples of the 3mCi cell with presumable damage of each cell, each sample containing ^{226}Ra , were used for the smear method. As shown in **Table 1**, one sample, using a methyl alcohol solution, was positive having an index value of 2.7. These results indicated that, in the case of big damage and leakage from sealed small vessel of ^{226}Ra , ^{226}Ra of powder from and ^{222}Rn in gas stuck to the surface of sealed small vessel of ^{226}Ra was able to detect its radioactivity. This method was thought to be unfit as a method for examining the leakage of a sealed small vessel counting ^{226}Ra .

Table 1 The measurement of radioactivities examined leakage and contamination using the smear method.

		Toluene		Methyl alcohol		Ethyl alcohol	
		Counting rate (cpm)	Index value	Counting rate (cpm)	Index value	Counting rate (cpm)	Index value
Background (B.G.)		52.8	—	46.9	—	40.8	—
^{226}Ra (2 mCi)	Ⓐ	44.1	0.8	60.7	1.3	40.6	1.0
	Ⓑ	55.9	1.1	48.7	1.0	41.0	1.0
	Ⓒ	55.2	1.0	47.3	1.0	41.9	1.0
^{226}Ra (3 mCi)	①	68.5	1.3	47.8	1.0	54.3	1.3
	2	53.3	1.2	64.4	1.4	50.1	1.2
	3	57.3	1.1	51.0	1.1	41.9	1.0
	4	58.8	1.3	47.3	1.0	43.8	1.1
	5	64.6	1.2	126.4	2.7	52.2	1.0
	6	53.5	1.0	49.7	1.1	55.7	1.4
	7	78.2	1.5	64.2	1.4	54.5	1.3

3.2 Direct immersed method

With various solutions such as toluene, methyl alcohol, ethyl alcohol and water, the effects of each solution on immersed and sticky action of radioactivity materials were investigated with the direct immersed method. As demonstrated in **Table 2**, toluene had a better sticking, and immersing effect for ^{222}Rn than methyl alcohol, ethyl alcohol and water. Toluene was suitable as a solution for carrying out this method and had no quenching effect and was contained in a liquid scintillation solution. In **Table 3**, the reproducibility of the measurement using the direct immersed method was conducted, using a toluene solution which was suitable for the direct immersed method. The coefficient variation of the measurement ranged from 9.0% to 90.3%, indicating that it

Table 2 The measurement of radioactivities examined leakage and contamination using the direct immersed method.

		Toluene		Methyl alcohol		Ethyl alcohol		Water	
		Counting rate(cpm)	Index value	Counting rate(cpm)	Index value	Counting rate(cpm)	Index value	Counting rate(cpm)	Index value
Background(B.G.)		41.3	—	50.8	—	56.4	—	54.8	—
^{226}Ra (2 mCi)	Ⓐ	43.8	1.1	57.1	1.1	59.3	1.1	60.8	1.1
	Ⓑ	49.9	1.2	63.5	1.3	60.8	1.1	63.4	1.2
	Ⓒ	73.2	1.8	52.4	1.0	66.6	1.2	55.3	1.0
^{226}Ra (3 mCi)	①	69.7	1.7	52.9	1.0	64.0	1.1	57.9	1.1
	2	2474.6	59.9	114.6	2.3	184.1	3.3	230.8	4.2
	3	1848.5	44.8	200.1	3.9	99.7	1.8	181.1	3.3
	4	3412.1	82.6	198.3	3.9	236.4	4.2	406.8	7.4
	5	1099.8	26.6	316.5	6.2	119.8	2.1	599.9	10.9
	6	495.4	12.0	196.4	3.9	130.4	2.3	122.7	2.2
	7	803.6	19.5	94.9	1.9	100.9	1.8	159.1	2.9

Table 3 The reproducibility of measurement of radioactivity, using the direct immersed method.

		I	II	III	Mean	S.D.	C.V.(%)
^{226}Ra (2 mCi)	Ⓐ	1.1	1.2	1.0	1.1	0.1	9.0
	Ⓑ	1.2	1.1	1.5	1.3	0.2	15.4
	Ⓒ	1.6	1.0	1.1	1.2	0.3	25.0
^{226}Ra (3 mCi)	①	1.7	1.4	1.2	1.4	0.3	21.4
	2	59.9	17.9	50.4	42.7	22.0	51.5
	3	44.8	20.3	14.6	26.6	16.0	60.2
	4	82.6	41.9	43.7	56.1	23.0	40.9
	5	26.6	24.8	20.0	23.8	3.4	14.3
	6	12.0	2.3	16.6	10.3	7.3	70.9
	7	19.5	62.7	10.7	30.9	27.9	90.3

[Index value]

Table 4 The comparison of the direct immersed method and indirect immersed method.

	Direct immersed method	Indirect immersed method
Counting rate (cpm)	1297.7	136.8
Background (B.G.)	45.0	45.0
Index value	28.8	3.0

was variable and was necessary to confirm whether the contamination and leakage of radioactivity should be checked again, if a index value of around 2.0 was obtained by the calculation.

3.3 Indirect immersed method

Table 4 shows the comparison of the direct immersed method with this method. The indirect immersed method had a radioactive sensitivity which was 9 times lower, compared with that of the direct immersed method. Therefore, it seemed to be unable to detect the least radioactivity, in the case of only slight damage and leakage from sealed small ^{226}Ra vessel.

4. Conclusion

The direct immersed method by employing a toluene solution was able to handle in the same easy way as the smear method and indirect immersed method. The direct immersed method was thought to provide the easy way to handle and sensitive method to detect radioactivity, compared to the other methods described. If radioactivity in a sample detect two times higher radioactivity than one of the background count, it is necessary to be checked the radioactivity again for possible irregular leakage of ^{226}Ra sealed in small vessel.

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