The Calculation of Self-Disposal Date by Analyzing the Radioactive Contamination of Air Filters Disused in Radioisotope Production Facility

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1. Introduction

Radioisotope, produced by 30, 50 MeV cyclotron and carried from other institutions, is used to treat patients, diagnose diseases, and research technology in Korea Institute of Radiological and Medical Sciences (KIRAMS). With unsealed sources generate radioactive contamination in air, it is important to use fume hood or hot cell. These protect human from radioactive contamination and send to air filter. When radioactive wastes are expelled, activity of radioactive wastes compares to standard activity whether it is below limit value or not [1].

To self-dispose used air filters, we use Gamma spectroscopy to analyze a nuclide and to measure radioactive contaminations for the air filters used in radioisotope facility at KIRAMS. With their measurement, self-disposal date is calculated and it defines disposal method.

2. Materials and Methods

2.1 Air filter

Air filters are used three types. Charcoal filter removes harmful gas and bad smell. HEPA filter (High Efficiency Particulate air-filter) is used to eliminate fine particle. Pre filter is used to remove thick particle physically. With regulation, charcoal filter, HEPA filter, pre filter is each changed once in two years, every half year, quarterly. If activity of used air filter is higher than recommended activity, Air filter can change early. On the other hand, It is possible to use until next replacement time if activity of air filter is lower than recommended activity.

In this study, the activity of air filters was lower than recommended activity. Air filters were changed within 2 years. There are several radioisotope facilities in KIRAMS, we changed air filters of 30 MeV cyclotron accelerator room, 30 MeV iodine product room, 30 MeV radioisotope (RI) product room, 50 MeV iodine product room, iodine-131 therapy ward. After air filters were changed, the used air filters were placed on swipe tissue. Charcoal filters were disassembled by using driver. Using a scoop, their powders were collected in 90 ml plastic containers for sampling. HEPA and pre filters were resolved by using nipper or scissors. A piece of filters was collected in 90 ml plastic containers. For a precise measurement, it was conducted to collect 5 samples in a same air filter. Air filters were replaced for the 9 rooms of radioactive product. An electric scale (AJH-2200 ED, Vibra Shinko Denshi, Japan) is used to measure weight of samples in regular patterns. Fig. 1 shows respective samples of air filters.

Fig. 1. The photograph of charcoal filter (left), HEPA filter (middle) and pre filter (right) collected in 90 ml plastic containers for sampling.

2.2 The analysis of radionuclide and contamination of air filter sample

We used gamma spectroscopy for measurements of nuclide and radioactive contamination followed the operating procedure of Genie-2000 (Canberra, USA). Certified Reference Materials (CRM), have the same size and shape of 90 ml plastic container used for sampling, were produced by Korea Research Institute of Standards and Science (KRISS). We used the maximum value of radioactive contamination to calculate self-disposal date from measured nuclide and radioactive contamination. Generated radioactive wastes from air filters were analyzed for each radioisotope work place. There is an appearance of Gamma Spectroscopy used for detecting the samples, as shown in the Fig. 3.

2.3 The calculation of self-disposal date

The International Atomic Energy Agency (IAEA) suggested annual dose limit of individual and group in 1992 for self-disposal standard of radioactive, it was

Fig. 2. The photograph of CRMs for measurement efficiency of Gamma Spectroscopy.

Fig. 3. The photograph of Gamma Spectroscopy to analyze nuclide and radioactive contamination of the used air filters samples.

changed to radioactive concentration by nuclide in 2004. The calculation of self-disposal date follows Nuclear Safety Act article No.107 [3] and storage date is calculated permissible concentration by radionuclide under Nuclear Safety and Security Commission (NSSC) notification No. 2014-003. [4]. Storage date was calculated by the recommended value of maximum contamination which was detected to compute date eligible for self-disposal of radioisotope facilities in KIRAMS [5]. Permissive concentration was applied with that I-123: 100 Bq/g, I-124: 0.1 Bq/g, I-131: 10 Bq/g, Te-123m: 1 Bq/g, Te-121: 0.1 Bq/g, Na-22: 0.1 Bq/g, Tl-202: 10 Bq/g, Co-57: 1 Bq/g under Nuclear Safety and Security Commission (NSSC) notification. Total result value has an uncertainty within 5%. We use equation for calculation of self-disposal date.

$$\text{Self-disposal date} = -1.443 \times \ln\left[\frac{permissive\ activity\ \left(\frac{Bq}{g}\right)}{maximum\ activity\ \left(\frac{Bq}{g}\right)}\right] * half\ life(d) \quad (1)$$

3. Results

Table 1 shows radioactive contamination and self-disposal dates for charcoal filters. There were four nuclides which were I-123, I-131, Te-121, and Te-123m in 30 MeV iodine product room and two nuclides which were I-124, and I-131 in 50 MeV iodine product room. To dispose of the air filters, it is important to make the longest self-disposal dates on the preferential basis. To decrease the maximum activity to permissive activity, used air filters of 30 MeV iodine product room should be stored until 4 days by activity of Te-121 which has half-life of 16.8 days and permissive activity of 0.1 Bq/g. And the used air filters of 50 MeV iodine product room should be stored until 28 days by activity of I-124 which has half-life of 4.17 days and permissive activity of 0.1 Bq/g.

Table 1: The calculation of self-disposal dates for charcoal filters.

Sampling Position	Nuclide	Activity (Bq/g)		Date of self-disposal (day)
		Avg.	Max.	
30 MeV Iodine	I-123	1269	1823	2
	I-131	1.13	1.48	Direct (0)
	Te-121	0.12	0.12	2
	Te-123m	0.5	0.71	Direct (0)
50 MeV Iodine	I-124	9	10.6	28
	I-131	0.21	0.21	Direct (0)

Table 2: The calculation of self-disposal dates for HEPA filters.

Sampling Position	Nuclide	Activity (Bq/g)		Date of self-disposal (day)
		Avg.	Max.	
50 MeV Iodine	I-124	30.8	40.5	36

Table 2 represented that, I-124 for HEPA filters was detected in 50 MeV iodine product room. HEPA filters should be stored until 36 days for self-disposal.

Table 3: The calculation of self-disposal dates for pre filters.

Sampling Position	Nuclide	Activity (Bq/g)		Date of self-disposal (day)
		Avg.	Max.	
50 MeV Iodine	I-124	30.8	40.5	36
30 MeV Iodine	I-123	1236	1526	2
	Te-123m	2.01	2.52	160
	Tl-202	130	205	53
30 MeV RI	Na-22	0.18	0.18	827
	Tl-202	167	339	62
30 MeV accelerator	Co-57	0.35	0.61	Direct (0)
	Tl-202	0.75	0.75	Direct (0)
50 MeV Iodine	I-124	48	62.6	39
I-131 Ther. ward	I-131	9.52	13.9	4

Table 3 shows self-disposal dates and radioactive contaminations for used pre filters. In 30 MeV iodine product room, storage period is decided to be 160 days by Te-123m which has a half-life of 120 days and permissive contamination of 1 Bq/g. In 30 MeV radioisotope product room, self-disposal is to be done after storage period of 827 days by Na-22 which has a half-life of 952 days and permissive contamination of 0.1 Bq/g. In the case of storage period is up to 1000 days, it is not necessary to be self-disposal but disposal of external institution. Co-57 which has a half-life of 272 days and permissive contamination of 1 Bq/g and

Tl-202 which has a half-life of 12.2 days and permissive contamination of 10 Bq/g were detected in the radioisotope facility of 30 MeV cyclotron accelerator, respective contamination is below permissive contamination, it is allowable to disposable without storage. I-124 is allowable to be disposed 39 days later in 50 MeV iodine product room. Self-disposal was decided to be implemented 4 days after by I-131 which has a half-life of 8 days and permissive contamination of 10 Bq/g in the iodine-131 therapy ward.

4. Conclusions

The aim of the study is to decrease the diffusion of air contamination which occurred in radiation work places handle radioisotope under the permissible level. Accordingly, we replaced used air filter with a new one at the appropriate time, and computed disposal dates for disposing used air filters by calculate radioactive contamination. Air filter contaminated by radioactivity is possible to be self-disposed on condition that all detected nuclides is below permissible level according to Nuclear Safety and Security Commission (NSSC) notification No. 2014-003. The accurate date needs to be calculated by the equation for calculation of self-disposal date. If disposal date is in 1000 days, disposal for external institution is required.

With increasing the number of medical institute which was related to use the radioisotopes, the importance of radioactive safety management was increased. As disposing radioactive waste, in particular, is the procedure of inspecting for releasing radioactive waste to outside, appropriate action and continuous research are required at a radioactive safety management.

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