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Sampling of RI Wastes for evaluation of radionuclide inventories

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1. Introduction

In Korea, Radioisotope (RI) utilizing institute, such as educational, research and hospital institutes etc., increase at a ratio of 10 % every year, which had reached to about 3,500 institutes as of December, 2007. The RI waste drums generated from these institutes are stored more than 10,000 drums on the basis of 100 Liter at the Nuclear Engineering & Technology Institute (NETEC) interim storage facility. In the near future, all of the RI waste drums will be shipped to the permanent disposal facility, which is currently under construction. However, most radioactivities in the RI waste drums could be estimated to environmental level, because most radionuclides are low level beta emitters with short half-lives, such as I-125, I-131, Tc-99m and etc. and their acceptance date are mostly before 2000 year. So, these waste drums are expected to be applicable to the clearance according to Notice No. 2008-64 of MEST (Ministry of Education, Science and Technology). The Notice allows RI waste drum below 100 Bq/g of total radioactivity to be repurposed as an industrial waste. For the evaluation of total radioactivity for RI waste drums, the chemical analysis was carried out by destructive method through representative sampling from RI waste drums.

Thus, in this study, the RI waste drums were classified by the various conditions of the half-life, surface dose, acceptance date, waste form, generator, etc. About 30 % drums in the classified RI waste drums were opened. A sample for radiochemical assay was obtained through mixing samples of each drum. The representative sampling was proven by using statistical methods

2. Methods and Results

2.1 Statistical Methods for Sampling

The existing approaches to a representative sampling include a judgmental, simple random, stratified random, systematic grid, systematic random, composite, and adaptive sampling. The fundamental representative sampling methods can be described as follows [1,2,3].

- Simple random sampling: Each sample is selected with the same probability. Large error occurs if a population is heterogeneous.
- Stratified random sampling: Heterogeneous population is divided into several homogeneous subgroups by using the existing known information. Random sampling is performed for each subgroup. The existing known information is a prerequisite.
- Systematic sampling: Sampling is performed along with uniform intervals.
- Judgmental sampling: Sampling is made depending on an experts' experience and opinions. The disadvantage is that we cannot quantify the degree of a representative sample and accuracy.
- Other samplings such as a composite sampling, adaptive sampling, etc.

2.2 Status of RI waste drums

RI waste drums have collected from RI utilizing instate and stored in the interim storage facility of NETEC. As of December 2005, the amount of RI waste drums was 10,470 drums.

Table 1. Status of RI waste drum in the interim storage facility

	No. of generator	No. of drum
Combustible	215	8,636
Incombustible	68	981
Non-compressible	139	683
Filter	22	170
Total	241	10,470

2.3 Selection and Classification of RI Waste Drums

Two sampling methods of a judgmental sampling and a stratified random sampling are incorporated and applied in this study. First, a judgmental sampling which reflects an expert's experience ad opinions is used to classify the RI wastes according to the type of nuclide (pure β emitting nuclides and β-γ emitting nuclides), surface dose rate of a drum (based on 0.06 mR/h), half-life of a nuclide (based on 100 days), acceptance date of a drum (based on the calendar year of 2,000), source of the RI waste (hospitals, educational and research institutes, industries, military), and the type of the waste form (combustible, in-combustible, non-compressible, and spent filter). Secondly, a stratified random sampling is used to determine whether additional drums should be opened or not in order to meet a specified level of reliability. The waste drums are considered to have the same waste group, only if the acceptance date and the source of the waste are the same. If the number of drums is less than three within the same waste group, only one drum is required. If the number of drums is more than four within the same waste group, two drums are randomly selected and additional drums are determined based on the analysis results. Through the above methods, a total of 2,594 drums (chosen rate 26%) among 10,130 drums are selected at the first screening stage. In the case of the drums containing the pure β nuclides, the drums are selected at a ratio of 28% from among the 2,594 drums, and in the case of the drums containing the β emitting nuclides, the drums are selected at a ratio of 24% from among the 2,594 drums.

Figure 4 shows the sample groups classified by an expert's judgment. In Figure 4, Group 1 is suspected to be hot drums containing nuclides with a higher concentration than the other groups so all the drums of group 1 are opened. Also Group 4 has a relatively low priority when compared with the other groups due to their low dose rate, short half-life, and long storage period. Their concentration is believed to be close to the clearance level of the regulatory limit. In these cases, the number of samples can be reduced more as a result of grouping drums based on their undertaking date and drum surface dose rate. Accordingly, the total number of analysis samples is determined to be a ratio of 10% from the total number of drums.

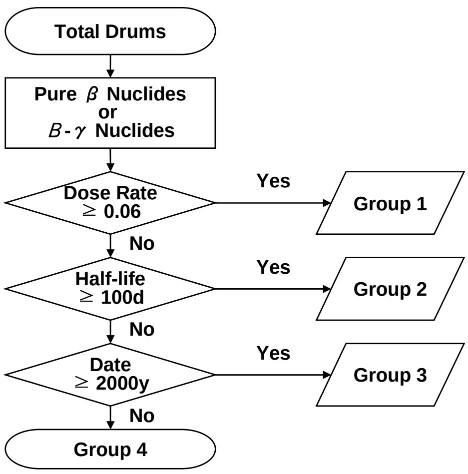

Figure 1. Flow diagram of classification of the drums containing the pure β and β -γ nuclides

2.4 Verification of representative sampling

Adequacy and propriety of the chosen drums and their number can be evaluated by using the total quantity of the open drums. Also, the nuclides for an examination are selected as β emitting nuclides (^{3}H, ^{35}S) and γ emitting nuclides (^{60}Co, ^{137}Cs).

The developed sampling protocol includes estimating the number of drums within a waste stream, estimating the number of samples, and a confirmation of the required number of samples. The statistical process control for a quality assurance plan includes control charts and an upper control limit (UCL) of 95% to determine whether a clearance level is met or not.

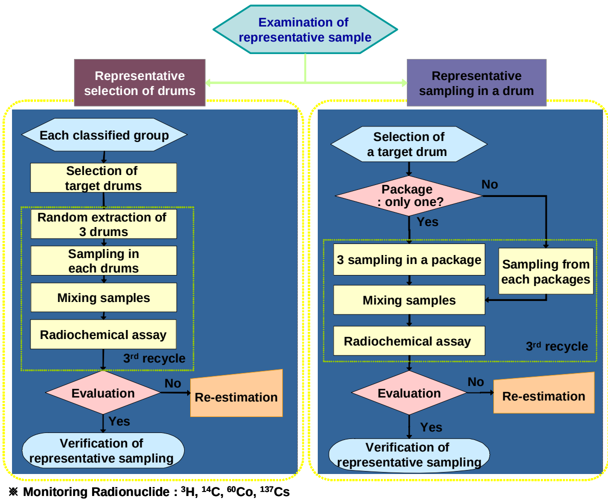

Figure 2. Flow diagram of classification of the drums containing the pure β and β -γ nuclides

3. Conclusions

Simulation techniques using TRIM, MATLAB, and PSpice can be useful tools for designing detector channels. Thus far TRIM, MATLAB and PSpice have been used to calculate the detector current output pulse for SiC semiconductor detectors and to model the pulses that propagate through potential detector channels. This model is useful for optimizing the detector and the resolution for application to neutron monitoring in the Generation IV power reactors.

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