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Performance Test of the Modified Radioactive Waste Assay System

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1. Introduction

To dispose of radioactive waste drum according to the regulation about radioactive waste acceptance criteria, it is essential to not only detect more than 95 % of total nuclei incorporated in the drum but also analyze the concentration for 13 nuclei and gross alpha. And also, in the case of concentration analysis of nuclide by means of the radiation detection method, the regulation requires the analysis skill to successfully evaluate of 1 % level of concentration limitation for disposal.

It is very difficult to measure the concentration of nuclide with accuracy form the waste drum and the analysis results have a large error. Therefore, to improve the accuracy of analysis, we modified the existing waste assay system such as an easy control of the distance between detector and drum that is possible to change the number of segments of drum.

Two drums having a different density were used to analyze the nuclide concentration inside the drum in this study. After carrying out the system calibration, we measured the gamma rays emitted from the standard source inside the model drum with changing the distance between the drum and the detector. The measured values were corrected with the three kinds of gamma attenuation correction method[1,2], as a result, the error was less than 10 % in the low density drum and less than 25 % in the high density drum. The measured activity in the short distance was more accruable than in the long distance. The transmission correction for the mass attenuation showed good results compared to the mean density and the differential peak correction method.

2. Methods and Results

The cork and sand drum that have a different density each other are used to have a performance test. The standard mixed source (^{60}Co, ^{137}Cs, ^{133}Ba) is located at the center of these drums.

2.1 Modification of the waste assay system

We added the detector moving unit to have a proper measuring time and to maintain the lower dead time for the application to the high or low activity drum and to the various drum size (100 ~ 350 L). And also, we modified the collimator to change the solid angle of an aperture as shown in Fig. 1. Therefore, it is possible to freely select the number of segments of drum in any geometry.

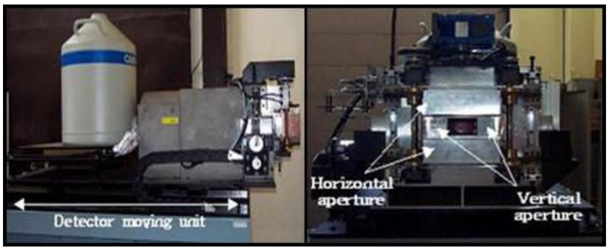

Figure 1. The detector moving unit and the modified aperture.

2.2 Measuring time

When the radioactive waste assay system applies to real waste drum, it is important to select the proper measuring time that means the ability of drum treatment in the waste assay system. Therefore, to find out the most efficient and proper measuring time, we investigated the distribution of the measured values according to the change of measuring time as shown in Fig. 2.

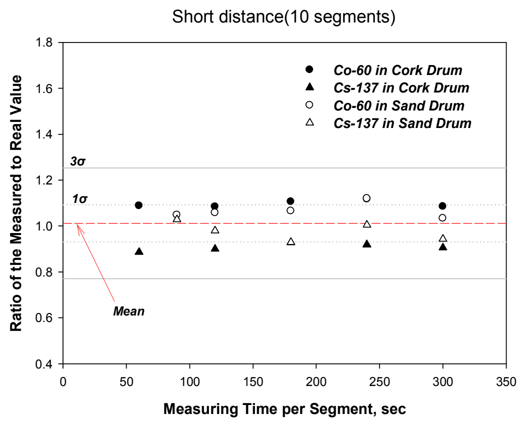

Figure 2. The distribution of the measured values according to the measuring time.

2.3 Correction method of gamma-ray attenuation

In the measurement of gamma rays emitted from the nuclide inside the radioactive waste drum, to analyze the nuclide concentration accurately, it is necessary to use the proper calibration standards and to apply correction for the attenuation of gamma rays.

In general, there are three kinds of the correction methods for gamma ray attenuation which are usually used in radioactive waste assay system. The three methods of correction are average density correction, differential peak correction, and transmission source correction.

In each of these methods, an attenuation correction factor is calculated for each peak found in the sample, then the individual peak efficiencies are scaled by this amount.

$$\varepsilon_C = CF_i \times \varepsilon_i$$

where,

CF_i is the correction factor at energy E_i,

ε_i is the uncorrected efficiency at energy E_i,

ε_C is the corrected efficiency at energy E_i.

After measured gamma ray emitted form the standard source inside the model drum, these measured values were corrected by three kinds of correction methods each other. The results were compared with the measured value from the empty drum that means non-attenuated value as shown in Fig. 3, 4.

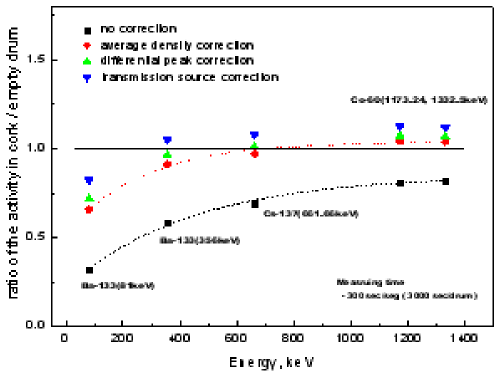

Figure 3. The ratio of the activity in cork drum to empty drum at short distance.

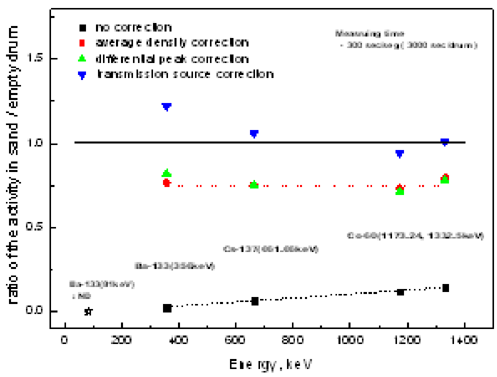

Figure 4. The ration of the activity in sand drum to empty drum at the short distance.

2.4 The mass attenuation coefficient

It is essential to know the accurate information about the composition of the drum for the precise analysis of nuclide concentration. The mass attenuation coefficients are properly selected according to the composition of the drum. However, it is difficult to know the accurate composition of the drum. To resolve this problem, the compositions of the waste drums generated in the NPP are classified into several representative materials[3] as shown in table 1.

Table 1. The composition of the waste drum generated in NPP and its representative material.

Drum Type	Main Components	Representative Material
miscellaneous	vinyl sheets, protection cloth paper, wood	polyethylene
shielded	glass, metal, sand	SiO_2
spent resins	cement, water, wet resins	cement (63 %), water (30 %), resins (7 %)
spent filter	filters shielded by cement	cement
concentrate	paraffin, boric waste	paraffin (25 %), borate (75 %)

So the cork drum and the sand drum belong to the miscellaneous and the shield drum respectively. To evaluate of the influence of the change in mass attenuation coefficient on the analyzed value, the similar mass attenuation coefficients each other (cork : wood and polyethylene, sand : SiO_2 and cement)[4] were used to analyze the nuclide concentration inside the drum.

In the high density drum, it was hardly influenced by the change in mass attenuation coefficient. However, in the low density drum, there was 5 % difference by the change in coefficient in case of the average density and differential peak correction method.

3. Conclusion

To analyze the nuclide concentration accurately, we added the detector moving unit and modified the collimator. An optimum operating conditions of the modified radioactive waste assay system was induced by evaluating several factors.

As a result, the measurement error was less than 10 % in the low density drum and less than 25 % in the high density drum. The transmission correction for the mass attenuation showed good results compared to the mean density and the differential peak correction method.

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