Evaluation of the dose to curie conversion factor of the high compressed dry active waste drum by using the MCNP code

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1. Introduction

Estimation of radioactivity of nuclides in the drums is necessary to dispose radioactive waste in perpetuity. However if it is hard to measure radioactivity directly by using gamma emitting nuclide assaying device as very high level activity or the large amount of total waste drums, the activity of gamma decaying nuclides can be measured by using the drum surface dose rate and dose to curie conversion factor.

Repacked dry active waste drums consist of two compressed general which account for 50 percent of all dry active waste drums. According to conservative estimates, so far, the lower conversion factor of the two subordinated drums is simply selected as the conversion factor of repacked drum. As a result, radioactivity of repacked drum has been overestimated. Therefore improvement of the efficiency of disposal space resources by estimated reasonable conversion factor (CF) is required.

This study proposes reasonable conversion factor of repacked 200L dry waste drum by using the MCNP code.

2. Methods

2.1 DTC method

The radioactivity of nuclides is estimated by DTC method that dividing measured the drum surface dose rate by the CF. Therefore estimation of the average drum surface dose rate according to segments is needed. Supposing nuclides are distributed uniformly, the surface dose rate changes linearly according to quantity of the nuclides. So the radioactivity in the drum can be expressed as follows: [1]

$$A_t = \frac{D}{\sum_{i=1}^{n} d_i f_i} \qquad (1)$$

,where A_t : the total radioactivity(mCi), D : the measured dose rate on the surface(mR/hr), f_i : the ratio of radionuclide i to total gamma emitting radionuclide, d_i :the CF of each gamma radionuclide (mR/hr/mCi).

2.2 Assumptions for MCNP modeling

MCNP is radiation transport analysis code which utilizes Monte Carlo method minutely. It is widely use to simulate motion of particles with high detailed geometry such as design and dosimetry of reactor, accelerator, radiotherapy. [2]

Based on the detection probability of particles which were transported from the source, the MCNP code calculated the dose rate (mR/hr) from radio source activity (mCi) as follows: [3]

$$X = \int_E R_X(E)\varphi(E)dE = \text{exposure(dose) rate}, \qquad (2)$$

Where R_X = response function, φ = photon flux.

As above, modeling of 3-dimension, source geometry and material in drum are needed to estimate the whole drum CF. This study supposes the drum has column geometry and uniformly distributed materials in the drum.

Also dry waste drums are classified by density difference. This study limited the case of drum density to five cases in which one's density is 0.2, 0.7, 1.2, 1.7, and 2.2 g/cm^3 respectively.

General Drum	Compressed Drum
0.2	0.43
0.7	1.51
1.2	2.59
1.7	3.67
2.2	4.88

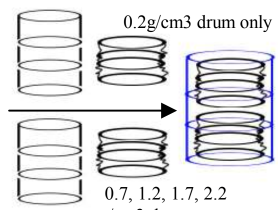

Fig.1. Repacking process and comparison density of dry active waste in the general and high compressed drums (g/cm^3)

In the case of compressing the contained drum to half, the density of the contained waste materials dose not increase twice precisely as there is little change in the drum material itself. Fig.1 shows the density of inner waste which is calculated with a stricter supposition about the compression. The compressing experiment with the model drum was performed to estimate the geometry of the compressed drum. The result showed that there were no variations on the upper and lower sides. However there was uniform zigzagged bending on the sides regardless of the segments. Therefore we regarded the increasing rate of side thickness the same as the drum compressing rate.

3. Evaluation procedure

The repacking process of two 200L dry waste drums which have different density is shown in Fig.1. In the repacked drum, high density drum occupies the low part, lower density one occupies the upper part. Dry waste drums were classified into five types according to density difference. In those types, combustible dry waste drum ($0.2\ g/cm^3$) was fixed as higher part drum in the repack drum. The others were set as lower part drums variably. So those can be compounded totally four combinations of repacked drum. Point gamma ray sources were supposed to place at the center of each subordinated drums emitting 1mCi (unit activity). We evaluated CF of the above four combinations in conditions of being exposed to eight major gamma emitting nuclides (^{134}Cs, ^{58}Co, ^{125}Sb, ^{144}Ce, ^{110}Ag, ^{54}Mn, ^{137}Cs, ^{60}Co) as follows.

1) Before the drum was compressed, CF of the two subordinated 200L drum which composed the repacked drum is calculated by using the MCNP code for each segment in the upper, middle, and lower detecting parts. Among the two CF, the lower one is taken as the established CF according to the conservative supposition.

2) CF of the repacked drum is calculated by using the MCNP code for each segment in the upper, middle, and lower detecting parts. It is newly proposed CF.

3) The mean value of established CF and newly proposed CF above are set as final CF over the each situation. More reasonable CF can be obtained by compare the difference between each value for density and kinds of nuclide.

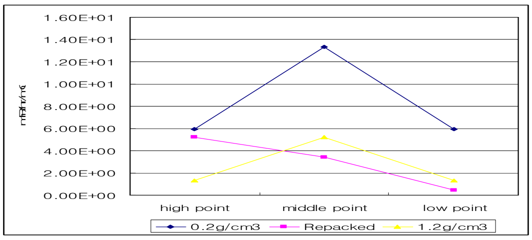

Fig.2. The CF of drums for density 0.2, 1.2, and repacked under ^{60}Co nuclides according to the detecting points

4. Results and Discussion

Fig.3 and Fig.4 show the CF of established and newly proposed for four combinations in condition of being exposed to eight gamma emitting nuclides respectively.

The more the density difference between subordinated drums increases, the more the CF decreases. Because shielding effect became larger as increasing density of the lower drum. When the established CF is compared with the newly proposed factor, a section of density difference within $0.8\ g/cm^3$ indicates that the established factor is higher than the other. However sections of density difference more than that indicates newly proposed factor is higher than the established one under the case of identical nuclide. Although the density difference between the two subordinated drums increases linearly, the decreasing aspects of CF according to the density difference are nonlinear. On the other hand, even in the case of different nuclide, changing aspects of CF according to density change are so similar.

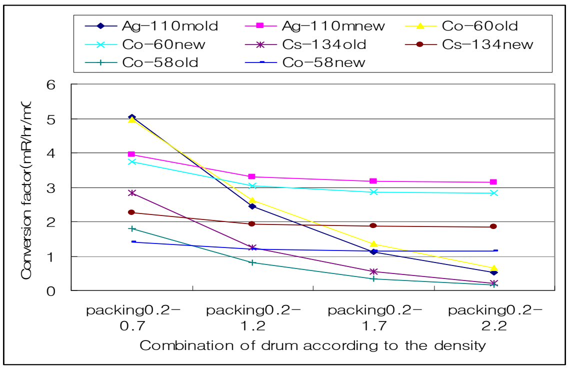

Fig.3. Comparison of the dose to curie CF of dry waste drum exposed to 1mCi of high-dose nuclide (old: the established factor, new: the proposed factor)

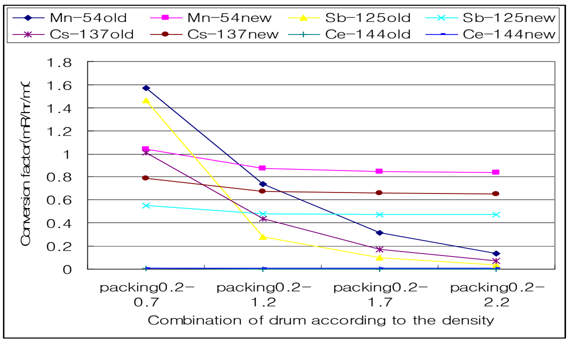

Fig.4. Comparison of the dose to curie CF of dry waste drum exposed to 1mCi of low-dose nuclide (old: the established factor, new: the proposed factor)

5. Conclusions

The higher the conversion factor (CF) is, the more effective the waste disposal space resources could be, since a lower radio activity for the same surface dose rate is estimated. As above, the newly proposed CF is more reasonable than the established factor as taking a higher value except for the section of density difference within $0.8\ g/cm^3$. Also the CF of the repacked drums is more affected by attenuation with density increasing rather than by geometry or kinds of sources.

REFERENCES

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