

Comparison of leaching Behavior of ^{137}Cs and ^{60}Co in the Simulated Paraffin Waste Form

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1. Introduction

The evaluation on the leachability of waste form incorporated various radionuclides, plays an important role in the development of solidification matrix, safety analysis for the choice of the suitable waste management system, and quality assurance of the waste treatment process (installations). Various foreign countries have been developed and standardized the leaching test method compatible to their social circumstances because the results of leaching test are very important in quality control of waste forms and in the comparison of results obtained from many laboratories. The leaching test methods can be classified according to the purpose for use, the interval period of renewal of leachant, and the mixing existence of leachant. In this study, the leaching test were performed for the paraffin waste forms incorporated ^{60}Co and ^{137}Cs by using HEPSE method, ANS 16.1 which are popular in IAEA, USA. Those 2 tests are different in the exposing area to the leachant, the number of renewal of leachant, the total leaching time, the presentation (or calculation) of the leaching results, and type of leachant. And we evaluated the leaching test results with the semi-infinite diffusion model.

2. Methods and Results

2.1 Manufactured of specimen

The mixing weight ratio of waste form between boric acid and paraffin was 3.3/1. Using specimens with the same diameters and heights(50/50, mm). The mixing temperatures was given that the range from 70 °C to 100 °C. Paraffin / boric acid / nuclide of ^{60}Co and ^{137}Cs mixtures. The mixture shall be placed in the PVC mold so that it is properly filled. The gap shall be filled with rubber bond which is waterproof. The curing period given a week at air.

2.2 Leaching test

The leaching test shall be performed at a temperature of 25 °C ± 5 °C. Using four specimens with the same diameters, heights and two leachant, leaching rates of ^{60}Co and ^{137}Cs were measured in accordance with IAEA standard leach test procedure for 246days and ANSI 16.1 test procedure for 90days. The leachant shall be demineralized water and sea-water. The amount of leachant added shall be accurately measured and shall be such that value of the ratio volume of leaching Solution/exposed area of sample does not exceed 10 cm.

IAEA sampling frequency was daily during the first week, once per week for the following eight weeks, once per month during the following six months and ANSI 16.1 Sampling frequency was 2, 5, 17, 24, 24, 24, 336, 672, 1032 hours.

- The results shall be expressed by a plot of the cumulative fraction of radioactivity leached from the specimen as a function of the total time of leaching thus

$$\frac{\sum a_n}{A_0} / \frac{F}{V} \text{ versus } \sum t_n \text{ or } \frac{\sum a_n}{A_0} \text{ versus } \sum t_n$$

where a_n = radioactivity leached during the leachant renewal period, n

A_0 = radioactivity initially present in specimen

F = exposed surface area of specimen (cm^2)

V = volume of specimen (cm^3)

t_n = duration (days) of leachant renewal period

- The results may also be expressed by a plot of the incremental leaching rate, R_n ,

as a function of the time, t (days) of leaching, where

$$R_n = \frac{\sum a_n}{A_0} / \frac{F}{V} t_n$$

and the other terms are as defined above.

Values for R_n , calculated as above, shall be plotted against $t_n - (t_n - t_{n-1})/2$

2.3 leaching behavior of ^{60}Co and ^{137}Cs from the Paraffin Waste Form by IAEA test method.

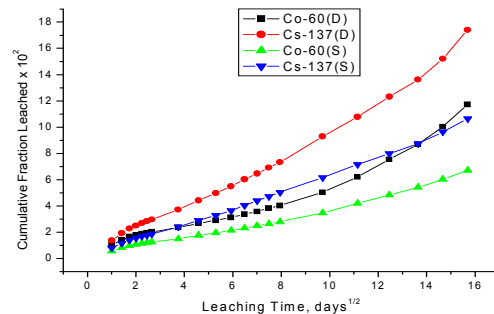


Fig. 1. CFLs of ^{137}Cs and ^{60}Co in paraffin waste form (D: demineralized water, S: simulated sea-water)

Fig 1. shows that the CFLs in demineralized water are increased more than the artificial seawater. initially, Small CFLs during the 63 days. CFLs were increased since 94days. It is seems that the boric acid was dissolution. and that,

the boric acid is attached ^{60}Co and ^{137}Cs . And the cumulative fraction leached of ^{137}Cs are increased more than ^{60}Co .

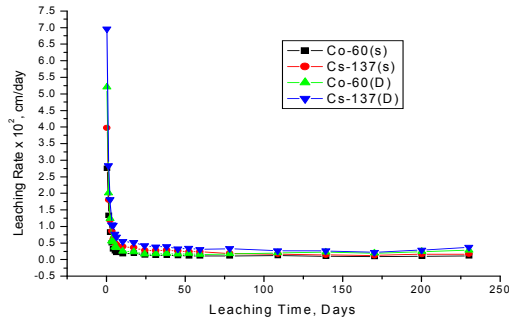


Fig. 2. Leaching rates of ^{137}Cs and ^{60}Co in paraffin waste form (D: demineralized water, S: simulated sea-water)

Fig. 2 shows that the leaching rate of ^{137}Cs are increased more than ^{60}Co . ^{60}Co is 0.0028 and ^{137}Cs is 0.0036/cm/day.

2.4 leaching behavior of ^{60}Co and ^{137}Cs from the Paraffin Waste Form by ANSI 16.1 test method.

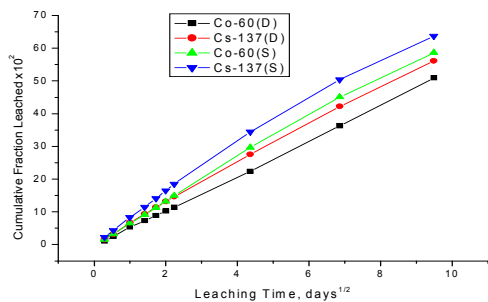


Fig. 3. CFLs of ^{137}Cs and ^{60}Co in paraffin waste form. (D: demineralized water, S: simulated sea-water)

The cumulative fraction leached of demi-water Leachant were ^{60}Co is 0.5090 and ^{137}Cs is 0.5613. The cumulative fraction leached of sea-water leachant were ^{60}Co is 0.5861 and ^{137}Cs is 0.6366. As test result, The cumulative fraction leached of sea-water are increased more than demi-water.

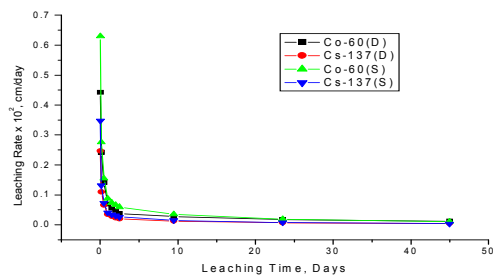


Fig. 4. Leaching rates of ^{137}Cs and ^{60}Co in paraffin waste form. (D: demineralized water, S: simulated sea-water)

Fig. 4 shows that the leaching rate of sea-water is Increased more than demi-water.

2.5 leaching behavior of ^{60}Co and ^{137}Cs by IAEA / ANSI 16.1 test method

Table 1-1. Leaching Behavior of ^{60}Co and ^{137}Cs .

		Cumulative Fraction Leached		Leaching Rate(cm/day)	
		Co-60	Cs-137	Co-60	Cs-137
IAEA	Demi-water	0.1172	0.1739	0.0028	0.0036
	Sea-water	0.0671	0.1063	0.0011	0.0016
ANSI 16.1	Demi-water	0.5090	0.5613	0.00012	0.00004
	Sea-water	0.5861	0.6366	0.00011	0.00004

Table 1-1. shows that the CFLs in ANSI 16.1 test Method are increased more than IAEA procedure.

3. Conclusion

1. The cumulative fraction leached of ^{137}Cs are large more than ^{60}Co .

2. The cumulative fraction leached of demi-water were ^{60}Co is 0.1171 and ^{137}Cs is 0.1739. The cumulative fraction leached of sea-water were ^{60}Co is 0.0671 and ^{137}Cs is 0.1063. As IAEA test result, the cumulative fraction leached of demi-water are increased more than sea-water.

3. The cumulative fraction leached of ANSI 16.1 were ^{60}Co is 0.5090 and ^{137}Cs is 0.5613 in demi-water. The cumulative fraction leached of sea-water were ^{60}Co is 0.5861 and ^{137}Cs is 0.6366. As test result, the Cumulative fraction leached of sea-water are increased more than demi-water.

4. Short time test method prefer ANSI 16.1 test methods to IAEA test method.

Reference

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3. U.S. Nuclear Regulatory Commission, "Low-Level Waste Licensing Branch Technical Position on Waste Form" Rev. 0. May 1983.