Leaching Test of Lime Precipitate Radioactive Waste Containing Uranium

Changhwan Cho[a*], Sungjong Kim[a], Seunghoon Han[b], Youngjong Ju[b], Jungwoo Lee[b], and Jeongmyeong Kim[b]
[a]MIRAEEN Co. Ltd., 72, Techno Jungang-ro, Yuseong-gu, Daejeon, Republic of Korea
[b]KEPCO NF, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon, Republic of Korea
[*]changhwan.cho@mirae-en.co.kr

1. Introduction

Homogenous radioactive wastes (condensate waste, spent resin, sludge) should be solidified for delivery through acceptance by KORAD (Korea Radioactive Waste Disposal), which encompasses the acceptance tests such as compressive strength, leaching test, immersion test, thermal cycling, irradiation test, and free standing water test to meet the acceptance criteria of solidified radioactive wastes.

In this paper, it provides the leaching characteristics of sludge type of radioactive waste according to the ANSI/ANS 16.1[1] that contains uranium. This test should show the leachability index of solidified radioactive waste in the face of water like rain or ground water.

2. Leaching Test Methods and Results

This section provides the test methodology and results that is performed based on the ANSI/ANS 16.1[1]

2.1 Test Methods

2.1.1 Test Equipment. For leachability test, demineralized waster of leachant with electrical conductivity of less than 5[μmho/cm] at 25 ℃ is used, and leach test vessel and its specimen holder is a material of high density polyethylene that does not cause chemical reaction.

2.1.2 Specimen Preparation. The specimen of sludge type of lime precipitate is solidified using Calcium Aluminate Cement (CAC) agent is prepared in the shape of cylinder as indicated in Table 1.

Table 1. Dimension of specimen

Specimen No.	Diameter [mm]	Height [mm]	Surface Area [cm^2]	Height-to-Diameter Ratio
LS-2017042912-LC	49.950	97.995	192.968	1.962
LS-2017042934-LC	49.820	98.195	192.677	1.971

2.1.3 Activity measure of specimen. To conduct the leaching test, initial activity (A_o) of U-235 of the specimen is measured using the HPGe (High-Purity Germanium) detectors as in Table 2.

Table 2. A_o measurement

Specimen No.	Activity of U-235 [Bq]
LS-2017042912-LC	1.3407E+4
LS-2017042934-LC	1.3323E+4

2.1.4 Leaching test. The Fig. 1 shows a leaching test cut. The specimen is fixed with holder in leach test vessel containing leachant for leaching test.

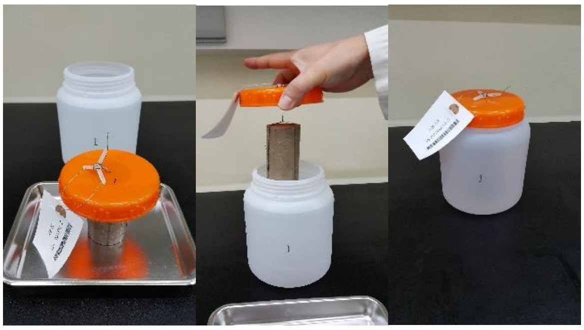

Fig. 1. Process of leaching test.

When replacing leachant, the demineralized water to collect the U-235 by rinsing the surface of the specimen and leach test vessel is mixed with leachate together and measure total weight of rinsing water and leachate.

Some of these is put in marinelli beaker and measure weight of leachate in it. Also activity concentration of U-235 of leachate in marinelli beaker is measured using the HPGe (High-Purity Germanium) detectors in each leach interval.

2.2 Test Results

2.2.1 Leachate's activity of U-235 in each leach interval. Leachate's activity of U-235(a_n, where leach interval n = 1, 2,...,10) in each leach interval is calculated based on the leachate's activity concentration of U-235 and the its weight.

The test results of each specimen are described in Table 3.

Table 3. Leachate's activity in each leach interval.

Leach Interval (n)	LS-2017042912-LC Activity Concentrations of U-235 [Bq/g]	LS-2017042912-LC Activity of U-235 [Bq]	LS-2017042932-LC Activity Concentrations of U-235 [Bq/g]	LS-2017042932-LC Activity of U-235 [Bq]
1	9.22E-04	2.43964	4.1825E-4*	1.04923
2	5.46E-04	1.36655	6.02E-04	1.53783

3	2.8258E-4*	0.72304	6.21E-04	1.63465
4	3.2075E-4*	0.83354	5.14E-04	1.39682
5	5.50E-04	1.4506	5.59E-04	1.52514
6	6.45E-04	1.64331	5.07E-04	1.36975
7	4.57E-04	1.18797	3.1250E-4*	0.82854
8	1.08E-03	2.67381	7.6720E-4*	2.0453
9	7.5370E-4*	1.89801	7.6571E-4*	2.00519
10	7.16E-04	1.93304	5.58E-04	1.44714

* Activity concentration of U-235 is measure to 0 (zero), therefore the activity concentration of U-235 is determined MDA (Minimum Detectable Activity) value.

2.2.2 Analysis of leaching test result. This test is conducted through standard and extended leach interval to acquire the effective diffusivity (D) and leachability index (L), and test result of each leach interval is summarized in Table 4 and 5.

Table 4. Analysis result of LS-2017042912-LC

Leach Interval	Leaching Time [S]		Incremental Fraction Leached	Incremental Leaching Rate [fraction/s]	Effective Diffusivity (D_n) [cm^2/s]	Leach-ability Index (L_n)
	Incremental $(\Delta t)_n$	Cumulative $t = \sum(\Delta t)_n$	a_n/A_o	$(a_n/A_o)/(\Delta t)_n$		
1	7,210	7,210	1.81967E-4	2.52382E-8	3.6082E-10	9.4
2	18,000	25,210	1.01928E-4	5.66267E-9	1.5116E-10	9.8
3	61,200	86,410	5.39303E-5	8.81214E-10	1.2635E-11	10.9
4	86,400	172,810	6.21722E-5	7.19586E-10	2.0701E-11	10.7
5	86,400	259,210	1.08197E-4	1.25228E-9	1.0648E-10	10.0
6	86,395	345,605	1.22571E-4	1.41873E-9	1.9228E-10	9.7
7	86,400	432,005	8.86082E-5	1.02556E-9	1.2945E-10	9.9
Results of Standard Test Leachability Index(L) : 10.1 Confidence Range : 8.9 to 11.3 Correlation Coefficient : -0.09						
8	1,209,600	1,641,605	1.99434E-4	1.64876E-10	8.1092E-12	11.1
9	2,419,200	4,060,805	1.41569E-4	5.85188E-11	2.9539E-12	11.5
10	3,715,200	7,776,005	1.44181E-4	3.88084E-11	2.7305E-12	11.6
Results of Extended Test Leachability Index(L) : 10.5 Confidence Range : 8.3 to 12.6 Correlation Coefficient : 0.74						

Table 5. Analysis result of LS-2017042932-LC

Leach Interval	Leaching Time [S]		Incremental Fraction Leached	Incremental Leaching Rate [fraction/s]	Effective Diffusivity (D_n) [cm^2/s]	Leach-ability Index (L_n)
	Incremental $(\Delta t)_n$	Cumulative $t = \sum(\Delta t)_n$	a_n/A_o	$(a_n/A_o)/(\Delta t)_n$		
1	7,205	7,205	7.87536E-5	1.09304E-8	6.7835E-11	10.2
2	18,067	25,272	1.15427E-4	6.38882E-9	1.9326E-10	9.7
3	61,267	86,539	1.22694E-4	2.00261E-9	6.5570E-11	10.2
4	86,400	172,939	1.04843E-4	1.21346E-9	5.9108E-11	10.2
5	86,400	259,339	1.14474E-4	1.32493E-9	1.1962E-10	9.9
6	86,395	345,734	1.02811E-4	1.19001E-9	1.3575E-10	9.9
7	86,405	432,139	6.21890E-5	7.19738E-10	6.3970E-11	10.2
Results of Standard Test Leachability Index(L) : 10.0 Confidence Range : 9.6 to 10.5 Correlation Coefficient : 0.07						
8	1,209,600	1,641,739	1.53517E-4	1.26915E-10	4.8203E-12	11.3
9	2,419,200	4,060,939	1.50506E-4	6.22130E-11	3.3489E-12	11.5
10	3,715,200	7,776,139	1.08620E-4	2.92366E-11	1.5544E-12	11.8
Results of Extended Test Leachability Index(L) : 10.5 Confidence Range : 8.4 to 12.6 Correlation Coefficient : 0.88						

The following Fig. 2 indicates the trend of cumulative fraction leached in each leach interval, showing that the leachability in the beginning increase constantly, then stabilized after leach interval 7.

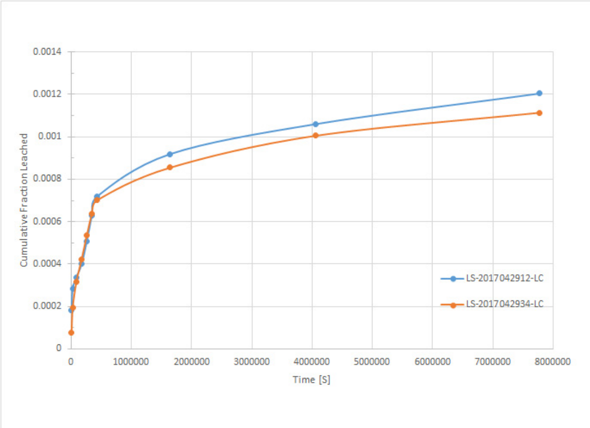

Fig. 2. Trend of cumulative fraction leached.

3. Conclusions

After the leaching test, it is identified that the leachability index of solidified radioactive waste containing uranium is more than 6 that is acceptable for waste disposal.

Also it is found that the leachability after leach interval 7 is abruptly decreased and stabilized, which means that standard interval for leaching test is enough to get the reliable leachability index without performing extended interval.

REFERENCES

[1] ANSI/ANS 16.1-2003, 'Measurement of the Leachability of Solidified Low-level Radioactive Wastes by a Short-term Test Procedure', 2003.

[2] ASTM C1308-08, 'Standard Test Method for Accelerated Leach Test for Diffusive Releases from Solidified Waste and a Computer Program to Model Diffusive, Fractional Leaching from Cylindrical Waste Forms', 2008.

[3] K.h Kim, 'Evaluation of Standard Leaching Tests in Cemented Waste Forms Incorporated Borate Waste', Transactions of the KNS Spring Meeting, 2004.