The Validation of Radiochemical Analysis Results for NPP Dismantling Radwastes

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1. Introduction

The amount of the NPP Dismantling Radwastes is about 14,500 drums, which are mainly contaminated concretes and Metals. The concretes are discharged through decontamination of various structures. The metals are collected from contaminated facilities. It is expected that it will be difficult to distinguish between deregulated waste and regulated waste unless it is systematically managed through radiochemical analysis because the radioactive waste from nuclear power plant dismantling has a complex medium and a large range of radioactive intensity. After confirming and verifying the validity of the radioactivity analysis method for radioactive waste, the analysis institution must have a procedure for monitoring the validity of the results. In this study, a reference material was developed to ensure the validity of the radionuclide analysis results using SUS 304 for radioactive metal waste generated in large quantities during nuclear power plant dismantling, and was used for comparative testing between radiochemical analysis institutions.

2. Methods and Results

The chemical analysis procedure for radionuclides contained in radioactive waste from nuclear power plant dismantling is based on the results of a previous study on the separation and recovery of radionuclides contained in operating waste from nuclear power plants developed by the Korea Atomic Energy Research Institute [1-4]. Based on this technology, the reliability of the nuclear power plant dismantling radioactive waste analysis results should be increased. To this end, this study selected the type of the evaluation sample and radionuclide for the comparative test between the test institutions and evaluated the results of the comparative test between the three analysis institutions.

2.1 Selection of evaluation sample type

It is known that about 89,000 drums of dismantling waste from Kori Unit 1 and the total amount of waste to be disposed of through reasonable self-disposal and volume reduction technology is expected to be 14,500 drums. As for the type and the amount of waste generated from unit 1 of the light-water reactor predicted by the IAEA (Table 1) and the type of waste according to the dismantling stage and period, radioactive and contaminated metals are most frequently generated, and followed by concrete.

Therefore, metal, especially SUS 304, which is most commonly used in the nuclear industry, was selected as the type of sample for the comparative test between the test institutions.

Table 1. The amount of Radwaste from PWR dismantling.

Radioactive Waste Forms	Amount (Drum)	Proportion (%)
Metal Waste	650	10.5
Concrete Waste	300	4.8
Contaminated Metal	3,500	56.5
Contaminated Concrete	600	9.7
Contaminated Metal Piece	150	2.4
Contaminated Solid Piece	1,000	16.1
Total	6,200	100

2.2 Preparation of the metal radwaste reference material

The simulated SUS 304 solution are prepared for metal radwaste reference material. It is a dilute nitric acid solution composed of Fe, Ni, Cr, and Mn. It is added the radioisotopes of Sr-90, Cs-137, Co-60, and Cs-134. It was designed in our group and then manufactured by the Korea Research Institute of Standards and Science (KRISS). Table 2 is shown the radiochemical characteristics of the metal radwaste reference material. The simulated SUS 304 solution for metal radwaste reference material is shown in Fig 1.

Table 2. Characteristics of a comparative testing sample

Species	Concentration (g/kg)	Radioactivity (Bq/kg)
Fe	13.72	-
Ni	1.86	-
Cr	3.8	-
Mn	0.4	-
^{60}Co	-	267
^{134}Cs	-	206
^{137}Cs	-	255
^{90}Sr	-	248

Fig. 1. A SUS 304 Reference Material containing Sr-90, Cs-134, Cs-137 and Co-60

2.3 Statistical technique for interlaboratory comparison of analytical results

$$(E_n)_i = \frac{x_i - x_{pt}}{\sqrt{U^2(x_i) + u^2(x_{pt})}}$$

In the equation [5],

- x_i: *Reported value of A, B and C test institutes*
- x_{pt}: *Assigned value determined by reference laboratory*
- $U(x_i)$: *Expanded uncertainty of A, B and C institute*
- $U(x_{pt})$: *Expanded uncertainty of certified value*
- *Satisfactory range is -1.0 < En < 1.0*

2.4 Evaluation of analytical results

To ensure the validity of the radionuclide analysis results, a SUS 304-nitric acid reference standard solution simulating the acid-dissolution solution of radioactive metal waste generated during nuclear power plant dismantling was prepared. A, B and C test institutes participated in the comparative test between analysis institutions and the results are shown in Table 3.

Table 3. Analytical results of reference materials

Analysis Institute	Radio-nuclide	Assigned value		Reported value		En-score	Result
		Radioactivity (Bq/kg)	Uncertainty (k=2)	Radioactivity (Bq/kg)	Uncertainty (k=2)		
A	^{134}Cs	206	8	179	3	-3.1	US
	^{137}Cs	255	13	254	6	-0.1	S
	^{60}Co	267	10	259	6	-0.7	S
	^{90}Sr	248	12	245	8	-0.2	S
B	^{134}Cs	206	8	182	11	-1.8	US
	^{137}Cs	255	13	245	14	-0.5	S
	^{60}Co	267	10	265	15	-0.1	S
	^{90}Sr	248	12	335	15	4.5	US
C	^{134}Cs	206	8	185	12	-1.5	US
	^{137}Cs	255	13	246	22	-0.4	S
	^{60}Co	267	10	265	24	-0.1	S
	^{90}Sr	248	12	347	21	4.1	US

* US: Unsatisfactory, S: Satisfactory

3. Conclusions

All analysis institutes showed dissatisfaction with the measurement results of Cs-134. These were evaluated that the ratio of the reported value to the set value is 80 to 90%, which was due to the simultaneous synthesis effect of Cs-134 [6], and correction for this was necessary. In addition, B and C test institutes, excluding A were dissatisfied with the results of Sr-90. The reason was judged to be that Cs-134 and Cs-137, a gamma-ray emitting beta nuclide, were not be completely separated or removed, the recovery rate of Sr-90 was more than 100%.

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