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Radiological Irradiation Performance for Inspection of Integrity of Solidified Radioactive Waste

Jae-Ho Kim*, Ho-Je Kwon , Min Ho Joe, Yunjong Lee

Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute, 29, Geumgu-gil, Jeoneup, 56212, Republic of Korea

**Corresponding author :y jlee@kaeri.re.kr*

Introduction

Radioactive wastes are stored in a solidified form to store radioactive waste stably for a long period of time. However, when solidified wastes are irradiated, they are affected by various factors such as swelling, gas or acid production, volatilization of volatile substances and deterioration of materials, which can lead to instability in disposal sites as well as structural stability [1].

NRC/BTP in the United States assumes that solidified wastes are exposed to approximately 10^8rads of exposure from internal nuclides during the 300 years of disposal and management when they contain Cs-137 or Sr-90 in solidified wastes and their radioactivity concentrations are 111.1 Ci/m (10 Ci/ft) [2].

The regulation states that the characteristics of cement solidified waste need to be verified when it contains ion exchange resins or other organic materials, or when the expected cumulative exposure is 10^9 rads or higher. At this time, the gamma dose must be 10^9 rads or more and is required to be performed with at least three specimens[3].

The influence on the G value (sample size, irradiation temperature, gamma irradiation dose rate, etc.) should be determined in order to know the amount of gas generated by the influence of radiation, but this was not specified.

Unlike the United States, FT-05- 030 in France assumes that the solidified waste is exposed to about 10^7 rads from internal nuclides during 300 years of management. France describes the irradiation test in FT-05-030 more specifically than in the United States, and the main point is that solidified waste with a contact dose of 50 rad/h or less should be irradiated up to 10^7 rads at an irradiation rate of 2×10^4 rad/h. [4][5]

In addition, the G value of the generated gas is also calculated by analyzing the radiated decomposition gas generated by radiation irradiation. The FT-05-030 test method in France sets the irradiation dose rate in the Gy/h range. During Irradiation, the temperature change of each container shall be recorded continuously, and this temperature shall not exceed 80°C.

Pressure changes should also be recorded within each container, either continuously or regularly measured. After the test is completed, prepare a table of the weight, size, etc. before and after the sample irradiation to prepare the generated gas generation amount, dose rate, total absorbed dose, temperature and pressure changes according to the irradiation time. From these, the values of Q and G are also obtained. Here, G for gas is defined as the number of moles of generated gas for an absorption dose of 100 eV. Long-term irradiation of solidified waste was performed twice in 21 years at a radiation irradiation facility operated by Advanced Radiation Research Institute. The purpose of this was to analyze the physicochemical characteristics of waste by irradiation in order to confirm the soundness of radioactive waste when disposing of radioactive waste generated at nuclear power plants.

Materials and methods

2.1 Irradiation Facilities

The Advanced Radiation Laboratory of the Korea Atomic Energy Research Institute has devices that Irradiator by embedding gamma (Co^{60}) sources. This facility imported the IR221 model sold by MDS Nordion in Canada and was installed and operated in January 2006. The maximum capacity of this facility was 100,000 Ci based on Co^{60} sources, but the permission of the Nuclear Safety Act was 400,000 Ci. There are 93, Co^{60} sources built in, and their total radioactivity is 193,611 Ci. The target material to be irradiated is placed on a table installed therein as shown in Figure 1. The range of irradiation doses is designed to emit radiation of up to 10^4 Gy per hour.

Fig.1 High-level Gamma-ray irradiation facilities operated by the Advanced Radiation Research Institute of the Korea Atomic Energy Research Institute – 93 sources of cobalt 60 are loaded, with a total radiation dose of 193,611Ci.

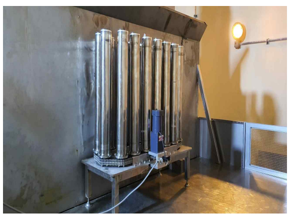

Fig. 2 To evenly irradiate the solidified waste with radiation, a separate rotating device was manufactured and worked.

2.2 Solidified Wastes

A total of 117 solidified radioactive wastes were to be tested by irradiation. The size of the shelf in the radiation irradiation room was limited, and the quantity was divided into two and irradiated. The first irradiation was performed at 64 and the second number was 53. The solidified waste was well sealed in a separate container made of stainless steel in a cylindrical shape of 8 cm in diameter and 15 cm in height to prevent leakage of radioactive materials. These wastes were transported in a dedicated carrier as shown in Figure 3. The required dose condition is 10^7 Gy and irradiation is performed under a condition in which the dose rate is 4,200Gy/h.

2.3 Dosimetry

The high-level dose was measured using an equipment called e-SCAN manufactured by applying the electron spin resistance principle from Bruker, Germany in Fig. 2. The equipment can measure doses of 80 kGy at a minimum of 5Gy. Since there was no equipment capable of measuring 10^7Gy, an alanine dosimeter was attached back and forth to the surface of solidified waste to measure dose, and the absorbed dose of solidified waste was determined using the average value.

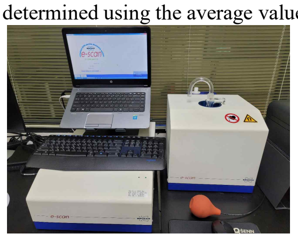

Fig. 3 e-SCAN radiation dose measuring instrument . – An instrument for measuring radiation dose using an alanine dosimeter.

Fig. 4 Packages for transportation to transport solidified waste - unloading radioactive waste.

Results

The first commissioned solidified waste was subjected to irradiation for 2,327 hours over 104 days from April 20 to August 2, 2021. The second round of solidified waste was carried out over 2,100 hours for 90 days from September 3 to December 2, 2021. Due to the structure of the source, there was a dose deviation in the upper and lower levels, and irradiation proceeded while changing the position to correct it. After radiation irradiation, there was no change in the physical shape of the solidified waste. A leakage test of radioactive materials was performed using the Smear method, but there was no leakage of radioactive materials. The radioactivity of the loaded radiation source at the high-level radiation irradiation facility decreased significantly after the loading, resulting in a prolonged overall schedule.

Conclusion

The delay time was longer as the intensity of the source attenuated than the expected irradiation time. There was no change in the physical shape of solidified waste before and after irradiation. Radiation irradiation was safely terminated without leakage of radioactive substances that had been feared.

References

[1] Efficiency of Sulfoaluminate Cement for Solidification of Simulated Radioactive Borate Liquid Waste, Q. Sun, J. Wang, 2010, in : Proc. 18th Int. Conf. Nucl. Eng., Xi'an, China,: pp. 1–6. 10.1115/ICONE18-30154. Google Scholar.

[2] Concentration Averaging and Encapsulation Branch Technical Position, 2015 , Revision 1, Volume 2, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards.

[3] J. Zhou, G. Ye, K. Van Breugel, Cement hydration and microstructure in concrete repairs with cementitious repair materials Constr. Build. Mater., 112 (2016), pp. 765-772,

[4] Characterization of Low and Medium Active Wastes, Aresene Saas, CEA. France.

[5] 중저준위 방사성폐기물의 특성 평가를 위한 표준 시험법 비교평가, 한국원자력연구원, 2008, KAERI/TR-3695/2008/

[6] Comparison of various Standard Test Methods for Characterization of Radioactive Waste Forms