Estimation of the Amount and Reduction Rate of Contaminated Asbestos Waste in Decommissioning NPP

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1. Introduction

The generation of asbestos waste generally occurs at the demolition site of a building. In particular, according to the Occupational Safety Health Act and the Building Act, building materials containing 1% or more asbestos must be classified and dismantled prior to the demolition of the structure. [1] Moreover, if the asbestos is contaminated with radionuclides, the risk will increase further along with the harmfulness of the existing asbestos itself. Therefore, when decommissioning a nuclear power plant, it is very important to accurately identify the amount of contaminated asbestos waste (CAW) among construction materials, as well as evaluate the treatment method and reduction rate for disposal. Therefore, this paper aims to evaluate the amount of CAW generated during decommissioning of Kori Unit 1 using actual asbestos construction material data (as of February 2022) from the Asbestos Management Comprehensive Information Network, and to evaluate the reduction rate through a high temperature melting process.

2. The calculation of the amount of CAW

The construction of Kori No. 1 nuclear power plant began in 1971 with technical support from Westinghouse. At that time, there were no restrictions or prohibitions on the use of asbestos. Therefore, large amounts of asbestos are used in construction materials (insulation, fireproofing, ceiling and floor tiles), friction products (brake and transmission parts), gaskets, fireproof curtains and asbestos gloves.[2] Based on this fact, it is reported that the amount of CAW generated during decommissioning at Kori Unit 1 and nuclear reactor type similar to Kori Unit 1 among decommissioned nuclear power plants in the United States are 65 drums (200 l/drum) of very low-level waste and 712 drums (200 l/drum) of low-level waste.[3]

The actual data is collected from the Asbestos Management Comprehensive Information Network based on the asbestos building materials in the containment building, which has the greatest effect of radiation contamination among the Kori Unit 1 buildings. As a result, except for asbestos removed or replaced through maintenance and maintenance work, [4] as shown in Figure 1, it is confirmed that 282.45 ㎡ of contaminated asbestos construction materials(insulation), which remain in the containment building.[5]

The thickness of insulation required to calculate the amount of generation in liters is investigated based on the nuclear power plant built by Westinghouse in the 1970s. Insulation (insulation) used in piping is generally at least 2 feet long and 3 to 4 inches thick, and has been identified as being divided into two parts so that each section covers half of the pipe.[6] If the thickness of the insulation material is taken as the average value (3.5 inch) and calculated, the amount of generation is about 125.5 drums (200 l/drum) as shown in Table 1.

Table 1. The amount of very low/low level asbestos waste generated in containment building

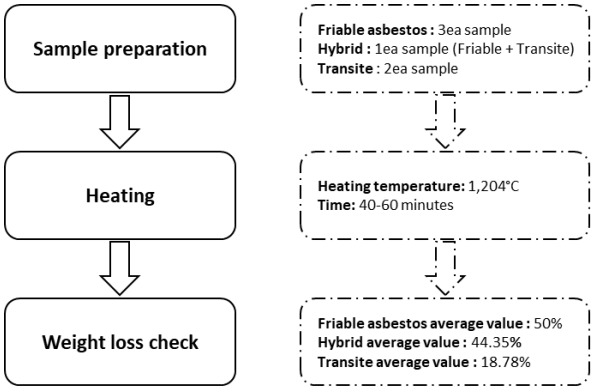
Location	Asbestos construction material	The total area of asbestos construction material(㎡)	Thickness of Insulation (m)	Total CAW calculation (Drum)
Pipe (CS-TE-126)	Insulation	282.45 [25.11 ㎡]	0.0889 [3.5 Inch]	about 125.5 (200 l/drum)
Pipe (CS-VCS-8419)	Insulation			
Pipe (Connecting pipe.1)	Insulation			
Pipe (CS-TE-122)	Insulation			
Pipe (XHX-28)	Insulation			
Pipe (Connecting pipe.2)	Insulation			
Pipe (Connecting pipe.3)	Insulation			
Pipe (RHR'B')	Insulation			
Pipe (XTK-3A)	Insulation			
Pipe (VSI-8817)	Insulation			
Pipe (VCS-8142)	Insulation			
Pipe (XTK-3B)	Insulation			
Pipe (VSI-8816)	Insulation			
Pipe (VSI-8800B)	Insulation			
Pipe (Connecting pipe.1)	Insulation			
Pipe (Connecting pipe.2)	Insulation			
Pipe (VSI-8905)	Insulation			
Pipe (RHR'A')	Insulation			
Pipe (Connecting pipe.1)	Insulation			
Pipe (Connecting pipe.2)	Insulation			

3. Loss on Ignition (LOI) of asbestos waste

Asbestos is a non-combustible material, and the detoxification method is generally to denature asbestos to lose its fiber structure, and high-temperature melting is currently used as a treatment method for this. In this process, harmful substances of asbestos change safe substances, become harmless. The volatile substances are released, and the mass decreases. Through this, the mass reduction rate of the material is calculated as a percentage, and the value is LOI.

According to the ARI Technologies, .Inc test report, there are two types of asbestos containing materials based on their internal chemical composition: friable asbestos and transite (cementitious asbestos). The main difference between the two materials depends on the SiO_2, CaO and MgO content.[7] Transit had relatively high SiO_2 and CaO content, whereas friable asbestos had relatively high MgO content. Figure 1 below shows the

experimental flow and loss ignition according to two different asbestos materials.



$$\text{Loss on Ignition}(\%) = \frac{(W_2 - W_3)}{(W_2 - W_1)} \times 100$$

W1 = weight of crucible or plate
W2 = weight of crucible or plate and sample (before Heating)
W3 = weight of crucible or plate and sample (after Heating)

Figure 1. Loss on ignition formula and experiment.[7]

In order to evaluate the reduction rate of asbestos waste, the experimental result in Figure 1, average LOI value of friable asbestos (50%), is applied, because in general, the insulation belongs to the friable asbestos category. In addition, the density of the insulation used in the 1970s is applied, the density (dry) of the insulation is 13-14 lb/ft³.[6] Accordingly, the average value (13.5 lb/ft³) is applied for the density before melting, and the value (2.5 g/cm³) from the test report in Figure 1 is applied for the density after melting. The total amount of CAW is shown in Table 2, and the value is about 5.5 drums (200 l/drum).

Table 2. Total asbestos waste after mass change

	Total volume of CAW (㎥)	CAW density (g/cm³)	Total weight of CAW (g)	Loss on Ignition (%)	Total CAW after mass change (Drum)
Friable asbestos	25.11	0.216 [6] (13.5 lb/ft³) [before melting] 2.5 [7] [after melting]	5,423,178.96	50	about 5.5

4. Conclusion

The amount of CAW generated in the containment building of Kori Unit 1 and the reduction rate are investigated. As a result, it is confirmed that the reduction of 95.6 % from 125.5 drums to 5.5 drums. If it is possible to obtain data on the chemical composition of the insulation inside the containment building of Kori Unit 1 in the future, a more accurate calculation of the value can be expected through comparison with the experimental data. In addition, it will be helpful to establish in detail the disposal cost according to the calculation and reduction of the amount of CAW called mixed waste containing both of hazardous material and radioactive material.

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