Waste Management of Dismantling North Korean Nuclear Facilities: Investigation of Facilities Subject to Vitrification for Decommissioning Waste

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1. Introduction

For the settlement of peace on the Korean peninsula, the complete dismantlement of all North Korean nuclear facilities should be prioritized. However, for the complete denuclearization of North Korea, managing dismantled waste is more important than dismantling North Korean nuclear facilities. In this study, the status of dismantling waste of North Korean nuclear facilities and the treatment method according to waste type are reviewed. On the other hand, investigation for the overseas cases of radioactive waste disposal by vitrification is performed, and the facilities applicable to vitrification for management of waste generated by dismantling North Korean nuclear facilities are investigated. In addition, the necessity of preliminary research is suggested so that the technology of vitrification facilities at Uljin Power Station can be utilized in the dismantlement of reprocessing facilities in North Korea.

2. Status of waste generation and classification of waste in the dismantling of North Korean nuclear facilities

2.1 Status of waste generation by the dismantlement of North Korean nuclear facilities.

In this study, the major facilities directly related to nuclear weapon development among the nuclear facilities concentrated in the Yongbyon area are investigated. Among them, the IRT-2000 research reactor, 5MWe graphite moderated reactor, ELWR and reprocessing facility are limitedly considered. Figure 1 shows a view of North Korea's nuclear facilities in Yongbyon.

Table 1 summarizes the types and quantities of waste generated when these facilities are dismantled, based on previous research [1].

Fig. 1. A view of Nuclear Facilities in Yongbyon (source: http//blog.naver.com/vkfks0732).

Table 1. Decommissioning Wastes of North Korea's Nuclear Facilities[1]

Facilities	Type of Waste	Quantity
IRT-2000	Activated Concrete	18 m^3
	Metal Waste	23.8 m^3
	Spent Fuel	10-12 bundles/year
5MWe Graphite Moderated Reactor	Graphite	600 ton
	Concrete(Including Shielding Concrete)	6744(144) ton
	Metal(Including Pressure vessel)	491(164) ton
	Spent Fuel	3850 bundles
ELWR (Experimental LWR)	Concrete	86 ton
	Metal Waste	77 ton
Radiochemistry Laboratory (Reprocessing Facility)	Concrete	36,994 ton
	Metal Waste	2,252 ton
	HLW(Liquid)	562,000 ~ 1,498,000 m^3
	ILW(Liquid)	472 m^3

2.2 Classification and disposal method of wastes

As shown in Table 1, the dismantled wastes of North Korea's nuclear facilities can be classified into four types, such as spent nuclear fuel, concrete waste, metal waste, and special waste including liquid waste and graphite. In the end various types of dismantled wastes must eventually be converted into a manageable form that is suitable for movement, storage and final disposal. The choice of treatment measures for the management is dependent on the level of activity and the type of waste. Table 2 shows types of waste and brief treatment processes and measures.

Table 2. Treatment Measures of Types of Waste

Type of Waste		Treatment Measures
Spent Fuel		The spent fuel is stored in a sealed canister after a sufficient cooling period.
Concrete		The contaminated part is stored after decontaminated by grinding , and most of the waste is treated as industrial waste
Metal Waste		Contaminated metal waste is recycled after decontamination using melting and decontamination techniques such as ultrasonic, chemical and blasting.
Special Waste	Graphite	Separate classification and management required. Current treatment plan is under study
	ILW/HLW (Liquid Waste)	Solidification is necessary and vitrification is the most stable method.

3. Investigation of North Korea's nuclear facilities applicable to vitrification

3.1 Vitrification condition and process

The key to dismantling waste management is how to manage high-level waste. In fact, most HLW, other than spent fuel itself, arises in a liquid form from the reprocessing of spent fuel, shown in Table 1. The immobilization of HLW requires the formation of an insoluble, solid waste form without leaching that will remain stable for many thousands of years. In general borosilicate glass has been chosen as the medium for dealing with separated HLW. This HLW comprises highly radioactive fission products and some transuranic elements with long-lived radioactivity. To allow incorporation into the glass matrix the waste is initially dried to a granular powder. The product is then incorporated into molten glass, poured into a robust stainless steel canister, and allowed to cool, forming a solid matrix. The containers are then welded closed and are ready for storage and final disposal.

3.2 Application of vitrification and evaluation of applicability to North Korean nuclear facilities

Vitrification was found to be most suitable for the management of high level liquid waste generated in reprocessing facilities. For example, the Sellafield Waste Vitrification Plant(WVP) and AVH(Atelier de Vitrification de la Hague)[2], Hanford VIT Plant, etc., are the representative systems to treat the high radioactive liquid waste generated from reprocessing facilities. Of course vitrification system in Uljin NPP can treat both combustible and non-combustible LLW[3]. But foreign vitrification facilities have been mostly used to treat the liquid waste of reprocessing process. Thus vtrification can be also used for management of the waste by dismantlement of North Korean reprocessing facility.

4. Conclusion

As shown in Table 1, among the waste produced from dismantling of North Korean nuclear facilities, particular waste is high-level liquid waste from reprocessing facility. In order to safely manage these wastes for thousands of years, we can conclude that the best management practices for dismantling wastes of this facility must be vitrification, as can be seen in decades of experience in foreign countries. In addition Korean government should recognize that it is necessary to advance the technology of Uljin vitrification plant through further research for utilization in the dismantling of North Korea reprocessing facility.

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