

Estimation of the Decommissioning Waste Arising for a PWR

Jeong-keun Kwak* and Chang-lak Kim

KEPCO International Nuclear Graduate School, 1456-1 Shinam-Ri, Seosaeng-Myeon, Ulju-Gun, Ulsan

*Corresponding author : kjk9408@khnp.co.kr

1. Introduction

Since the EBR-1, which was the first nuclear reactor for the electricity generation, a lot of experimental and commercial nuclear reactors have been decommissioned. Therefore, in the life cycle of nuclear power plant, the decommissioning stage should be considered.

In Korea, Kori Unit 1(Pressurized Water Reactor, 587MW) began the first life extension operation since 2008 and Wolsong Unit 1(Canadian Deuterium Uranium Reactor, 679MW) has waited for the admission of life extension after license expiration since November 2012. However, after Fukushima Daichi nuclear power plant accident happened March 2011, the public support for the nuclear power plant life extension has been faded. This is reason why the preparation of nuclear power plant decommissioning is significant in this time.

When it comes to the decommissioning cost estimation, the waste treatment and disposal possess about 17% ~ 43% in the total decommissioning expense. Hence, the accurate analysis of the decommissioning cost has the immense influence on the determination of decommissioning strategy in later. Namely, as the fundamental investigation of the decommissioning outlay, the approach to the expected waste weight estimation is worth of study.

2. Reference Reactor

This research is based on Kori Unit 1 which is the PWR(Pressurized Water Reactor) type and the first commercial nuclear power plant in Korea. The capacity of Kori Unit 1 is 587MW and since 1978, it has been operated with planned preventative maintenance every 15 months and grand overhaul period in 2007. Additional technical information about Kori Unit 1 is elucidated in the Reference 1.

3. Decommissioning Waste Arising

3.1 Overall Waste Evaluation

Accurate waste inventory evaluation is the fundament of the treatment and disposal expense calculation during the decommissioning of nuclear power plant. Kori Unit 1 was built based on a turn-key base contract between KEPCO and Westinghouse.

Therefore, for the purpose of overall waste inventory estimation, the references listed at the end of this paper were quoted effectively.

The summary of estimated amount of decommissioning waste including both radioactive and non-radioactive materials for Kori Unit 1 is about 49,139 tons. In terms of nuclear power plant system division, this estimated data can be categorized as follows.

	Classification	Weight
1	Primary system waste	869 tons
2	Secondary system waste	646 tons
3	Others	47,624 tons

In the waste estimation, the weight of whole components is included. And the main factors of third item are the weight of the poured cement and the inserted reinforcing steel bar. In terms of waste weight of decommissioned nuclear power plant, the cement and the reinforcing steel bar are the dominant elements. In the construction of Kori Unit 1, the total used cement weight was 34,642 tons. Also, 10,797 tons reinforcing steel bar was applied during construction period.

3.2. Description of detailed Waste Weight

Through the references investigation, the detailed decommissioning waste of Kori Unit 1 could be classified as follows.

3.2.1 Primary side

Primary side components		(lbs)
1	Fuel and Fuel Transfer System	
	Fuel	107,984
	Zircaloy Tubes	26,356
	Others	16,604
2	Reactor Coolant System	
	Reactor Vessel	513,800
	Reactor Vessel Related	261,000
	Reactor Coolant Pumps	187,720
	Steam Generator Primary Side	532,657
	Pressurizer	116,000
	Others	7,000
3	Other Systems	
	Safety Injection	15,320
	Residual Heat Removal	6,900

	Steam Generator Blowdown	4,900
	Others	118,973
Total		1,915,214

3.2.2 Secondary side

Secondary side components		(lbs)
1	Main Cooling Water System	
	M.C.W. Circulating Motors and Pumps	557,769
	M.C.W. Valves	16,258
	Others	13,469
2	Auxiliary Boiler System	
	Pump 82 A&B	440,000
	Pump 83 A&B	60,000
	Others	6,600
3	Main Steam Supply System	
	Steam Generator Secondary Side	129,343
	Steam Converters	20,000
	Others	27,500
4	Other Systems	
	Condenser Cooling Water System	110,231
	Others	43,125
Total		1,424,295

3.2.3 Bulk materials

Material		(tons)
1	Cement	34,642
2	Reinforcing Steel Bar	10,797
3	Others	2,185
Total		47,624

According to the reference documents, the total weight of primary side components is 1,915,214 lbs. In case of secondary side, the amassed weight is 1,424,295 lbs. In addition, during the construction period, the cement and reinforcing steel bar were used in bulk without system division. The amount of used bulk materials are 47,624 tons.

4. Radioactivity Division of Primary Side Waste

According to the IAEA documents, the radioactive wastes are classified in the six stages from the 'Exempt Waste' to the 'High Level Waste'. Among them, 'Exempt Waste'(EW), 'Very Long Lived Waste'(VLLW), 'Low Level Waste'(LLW), 'Intermediate Level Waste'(ILW) and 'High Level Waste'(HLW) are the main interests in the decommissioning process. The characteristics of five classes are as follows.

a. EX : Exclusion from regulatory control for radiation protection purposes.

b. VLLW : No relation with high level of contamination and isolation.

c. LLW : Over the standard of self-disposal and the strict amount limitation of long-lived radionuclide.

d. ILW : Partial including of long-lived radionuclide and during storage, heat removal is unnecessary.

e. HLW : Generally, 2 ~ 20 kW/m³ thermal power and 10⁴ ~ 10⁶ TBq/m³ radioactive level.

Based on these classification, the assumed type of radioactive waste of primary side could be expressed as below.

Primary side components	Assumed Type of Waste
Zircaloy Tubes	ILW/LLW
Reactor Vessel and Related	ILW/LLW
Reactor Coolant Pumps	ILW/LLW
Steam Generator Primary Side	ILW/LLW
Pressurizer	ILW/LLW
Safety Injection Pumps and Valves	LLW
Residual Heat Removal Components	LLW
Steam Generator Blowdown	LLW
Others	VLLW/EW

The composition of fuel is about 3% enriched uranium. So, it can be grouped as the HLW. Some components which were contacted with reactor coolant directly during operation are assumed as the ILW and LLW. And the others can be classified as the VLLW and EW.

5. Conclusions

In this study, the arising of waste weight during the decommissioning of Kori Unit 1 was estimated with some documents listed in the reference. Finally, the total expected waste amount during the Kori Unit 1 decommissioning is about 49,139 tons. Among them, assumed radioactive waste material is 1,915,214 kg(869 tons). Based on IAEA standard, these wastes are divided in HLW, ILW, LLW, VLLW and EW respectively.

Future plan is to assess the radioactivity of primary side components and dose rate distribution of Kori Unit 1 using MCNP and ORIGEN-2 codes. This action will be helpful to design the reasonable decommissioning scenario in the future.

REFERENCES

- [1] KHNP, Final Safety Analysis Report of Kori Unit 1 Revision 13, 2013.
- [2] KEPCO, The Reactor Construction Application of Kori Unit 1, 1971.
- [3] KEPCO, The Data Book of Kori Unit 1, Vol.1, 2, 3, 1979.
- [4] KINS, Study on the Safety Evaluation Method Development for D & D of Nuclear Power Plant, KINS/HR-444, 2002.
- [5] IAEA, Safety Standard Series No. GSG-1, Classification of Radioactive Waste, 2009.