Evaluation of Spent Nuclear Fuel Transshipment for Kori Unit 1 during Decommissioning

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1. Introduction

Prior to decommissioning of Kori Unit 1 nuclear power plant (NPP), a temporary management strategy for spent nuclear fuel (SNF) need to be decided to facilitate the decommissioning activity, planned to start from 2017. As one of the options, transshipment of the SNF from Kori Unit 1 to other neighboring NPPs can be considered out of others (e.g. interim storage facility, etc.). Purpose of this paper is to review the transshipment of SNF from Kori Unit 1 NPP to other neighboring NPPs during the decommissioning in aspects of regulation, duration, cost, etc.

2. Transshipment Evaluation

2.1 Background

As SNF emits high levels of radiation and heat, it is placed in the spent fuel pool (SFP) adjacent to a reactor to reduce the radiation levels and initial heat at least for five years. Due to lack of capacity of the SFP, for instance, the SNF has been transported by road to the nearby NPPs. For successful decommissioning of Kori Unit 1, it is required the SNF be managed efficiently, and, as one of the options, transshipment of the SNF to neighboring NPPs can be suggested to empty the SFP.

2.2 Regulatory Framework of Korea

Relevant laws and regulations for transport of radioactive material are presented below.

- Nuclear Safety Act (Article 71~77), Decree of the Act (Article 108~114), and Regulation of the Act (Article 98~110)
- Regulations on Technical Standards for Radiation Safety Control, etc. (Article 89~128)
- NSSC Notice 2014-50, Regulations for the Packing and Transport of Radioactive Materials, etc.

2.3 The SNF Inventory of Kori NPP Site

The SFP of Kori Unit 1 has a capacity of 562 assemblies, and it is known that 328 assemblies are stored in the SFP as of June 2016. After permanent shutdown of Kori Unit 1, all the fuel assemblies in the reactor vessel will be removed to the SFP, and the total number of spent fuel assemblies in the SFP is expected to be 485. Status of the SFPs of Kori NPPs site is presented in Table 1.

Table 1. SNF Inventory of Kori NPPs (June 2016)

NPP	Total Capacity (Assembly)	Current Storage (Assembly)
Kori 1	562	328
Kori 2	920	684
Kori 3	2,260	1,987
Kori 4	2,262	1,940
Shin Kori 1	700	426
Shin Kori 2	1,450	312
Total	8,154	5,677

2.4 Overview of Transshipment Procedure

Fig. 1 shows sequence of stepwise procedures of the on-site transport process using two KN-12 transport casks based on the previous experience [1].

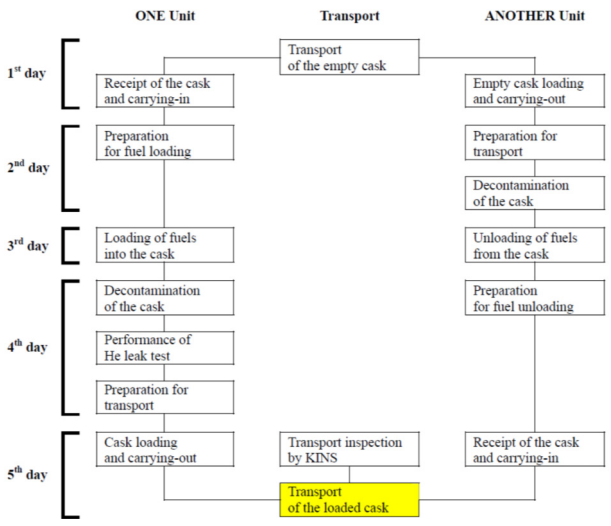

Fig. 1. Stepwise Procedures of On-site Transport Process [1].

As illustrated in Fig. 1, loading and unloading work were performed simultaneously, and total five days are required to complete one cycle of the on-site transport [1].

2.5 Overall Schedule and Cost Analysis

Following assumptions are made for the overall schedule and cost analysis.

a) The same conditions of Fig. 1 are applied.
b) There are 18 assemblies of damaged fuels.
c) 1 unit of KSC-1 for damaged fuel and 2 units of KN-12 casks for non-damaged fuel are used.
d) As a specification of KN-12 casks, 7 years of minimum cooling time of the SNF is required.
e) The weight of one cask including cask contents is assumed to be approximately 75 metric ton.
f) Distance from Kori Unit 1 to a neighboring NPP is assumed to be approximately 5 km.

2.5.1 Project Schedule

Based on the above assumptions, total 57 times of transshipment are arithmetically required to empty the SFP of Kori Unit 1 (39 times with KN-12 cask and 18 times with KSC-1 cask capable of 12 and 1 fuel assemblies, respectively). Moreover, minimum 40 weeks is required for non-damage fuels, and 36 weeks for the damaged fuel. Accordingly, total transshipment period is expected as approximately 19 months.

Approximate transport schedule, prepared by the *ProjectLibre,* is shown in Fig. 2. The first transportation was assumed to start in March 2023.

Name	Duration	Start	Finish
Preparation of transportaion	30 days	3/6/23 8:00 AM	4/14/23 5:00 PM
Transportaion of spent fuel	375 days?	**4/17/23 8:00 AM**	**9/20/24 5:00 PM**
1-10th transportaion	55 days?	**4/17/23 8:00 AM**	**6/30/23 5:00 PM**
1st Transportation	10 days	4/17/23 8:00 AM	4/28/23 5:00 PM
2nd Transportation	10 days	4/24/23 8:00 AM	5/5/23 5:00 PM
3rd Transportaion	10 days	5/1/23 8:00 AM	5/12/23 5:00 PM
4th Transprotation	10 days	5/8/23 8:00 AM	5/19/23 5:00 PM
5th Transprotation	10 days	5/15/23 8:00 AM	5/26/23 5:00 PM
6th Transprotation	10 days	5/22/23 8:00 AM	6/2/23 5:00 PM
7th Transprotation	10 days	5/29/23 8:00 AM	6/9/23 5:00 PM
8th Transprotation	10 days	6/5/23 8:00 AM	6/16/23 5:00 PM
9th Transprotation	10 days	6/12/23 8:00 AM	6/23/23 5:00 PM
10th Transprotation	10 days?	6/19/23 8:00 AM	6/30/23 5:00 PM
11-20th transportaion	55 days	**6/26/23 8:00 AM**	**9/8/23 5:00 PM**
21-28th transportaion	45 days	**9/4/23 8:00 AM**	**11/3/23 5:00 PM**
1-18th Damaged transportation	180 days	**10/30/23 8:00 AM**	**7/5/24 5:00 PM**
29-39th Transportaion of Intact	60 days	**7/1/24 8:00 AM**	**9/20/24 5:00 PM**
Follow-up measures	30 days	9/16/24 8:00 AM	10/25/24 5:00 PM

Fig. 2. Schedule for Kori Unit 1 SNF Transport.

2.5.2 Cost Analysis

The transshipment cost of spent nuclear fuel for Kori Unit 1 NPP was estimated based on the methodologies on the INL report [2]. Some data such as tariff, overhead factor, etc. were directly from the INL report, and, if possible, other data like as trip distance, cask type, etc. were adjusted as per the Kori Unit 1 conditions. Subsequently, the approximate cost in 2007 was evaluated first based on the reference [2], and then converted to the cost in 2016, as shown in Table 2, using the customer price index between 2007 and 2016.

Table 2. Approximate Transshipment Cost

	Value (2016 $)	Fraction
Total Cost	4,500,286	1.000
Packaging	0	0.000
Shipping	4,171,537	0.9269
Load & Unload	328,749	0.0731
Unit Cost	$12,001/MT-km	

3. Conclusion

This paper aimed at evaluating the transshipment of Kori Unit 1 for decommissioning in terms of legal framework, schedule, cost, etc. based on the previous experiences and the INL technical report. Applicability of the information on this paper will be enhanced in case the assumed data are specified considering actual decommissioning conditions.

4. Acknowledgements

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5. REFERENCES

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