Development of Exposure Scenarios for Dry Storage Spent Nuclear Fuel Retrieval Worker by Management Systems

Geon Woo Son , Hyeok Jae Kim, Shin Dong Lee, Kwang Pyo Kim*
Nuclear Engineering Dept., Kyung Hee Univ., Gyeonggi-do, Korea
**Corresponding author: kpkim@khu.ac.kr*

***Keywords :** Spent nuclear fuel retrieve, Dry storage, Concrete overpack, Concrete module, Exposure scenario

1. Introduction

Since domestic spent nuclear fuel storage facilities are about to be completely saturated, additional storage facilities are required to operate nuclear power plants continuously. The dry storage method for Spent Nuclear Fuel(SNF) is a management method with a lower operating cost than the wet storage method and less generation of secondary radioactive waste. The second basic plan for managing high-level radioactive waste also suggested the operation of dry storage facilities as a solution to the current status of SNF storage in Korea.

In Korea, there are no cases of operating dry interim storage facilities, and detailed policies on facility operation have not been finalized. Various exposure situations may occur in dry interim storage facility SNF managing operation, so studies for radiological impact assessment need to be preceded to ensure safety for workers and the public.

In this study, as part of the assessment of the radiological impact of workers, exposure scenarios for SNF retrieval workers of the concrete overpack system and concrete module system were developed and analyzed.

2. SNF Management Systems in Dry Storage Method

2.1 Review of SNF Management Systems Analysis

In this study, the 'retrieval work' was defined as a series of work procedures for transferring SNF from the storage facility to the Canister Transfer Building(CTB) using an appropriate transfer cask. The Final Safety Analysis Report (FSAR) is an open document that presents SNF management procedures for facility licensing and assess the estimated radiation dose of workers. Therefore, in this study, the FSAR of four types of concrete overpack management systems and one type of concrete module management system were investigated to establish procedures for retrieving SNF by management system.

The concrete overpack system is a way of storing canisters with SNF in concrete overpacks. In this study, the FSAR of HI-STORM 100 from Holtec International, NAC-UMS from NAC International, VSC-24, and Fuel Solutions from EnergySolutions, which are representative concrete overpack systems, were analyzed to develop exposure scenarios for retrieval workers.

The concrete module system is a way of storing a canister with SNF in a concrete module. In the case of concrete modules, they are divided into vertical and horizontal types according to the storage direction of the canister. In this study, a vertical module was selected for comparison with a concrete overpack, and the management system analyzed is HI-STORM UMAX from Holtec International.

2.2 Concrete Overpack System Procedure Assumptions

The four types of concrete overpack-based SNF management systems analyzed in this study followed generally similar work procedures, but there were some different procedures. In this study, several assumptions were introduced to develop a general-purpose concrete overpack system SNF retrieval worker exposure scenarios.

There are three assumptions, which are shown in Table 1. There are several ways to transport SNF casks, but, in this study, only Vertical Cask Transporter(VCT) was selected for simplification and uniformity of work. Auxiliary equipments are used for the safety and convenience of work, and the usage can be decided at the discretion of the facility operator. It is assumed that there are two spaces in which the retrieval work is performed. Although some systems have been shown to perform SNF transfer between casks outdoors, it is assumed that the SNF transfer is carried out only in CTB to give uniformity to the work.

Table 1: SNF retrieval procedure assumptions

	Assumptions
1.	Use VCT in cask transportations
2.	Consider the auxiliary equipments by usage frequency in each management methods
3.	Operations are taken only on storage facility and CTB

2.3 Concrete Module System

Since the concrete module-based SNF management system analyzed in this study is just single as the HI-STORM UMAX system, no other auxiliary equipments were considered other than that of UMAX system suggested. In addition, lifting the canister in the module

to the transfer cask is carried out in the storage facility, unlike the overpack system. Other assumptions were applied in the same way as the overpack system.

3. SNF Retrieval Worker Exposure Scenarios

3.1 Exposure Scenarios

In this study, the SNF retrieval work established as 15 procedures in the case of concrete overpack system and 8 procedures in the case of concrete module system. Figure 1 and 2 show the procedures for retrieving SNF based on concrete overpack and module, respectively. Table 2 shows the retrieval worker exposure scenarios according to the two types of management systems.

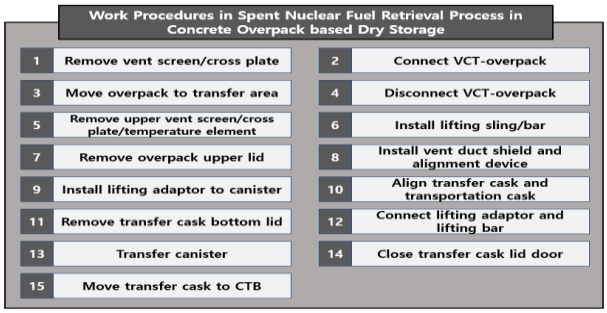

Fig. 1. SNF retrieval procedures of concrete overpack system

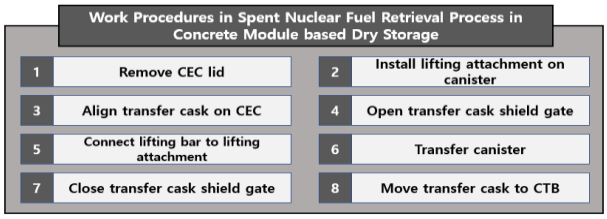

Fig. 2. SNF retrieval procedures of concrete module system

Table 2: Retrieval worker exposure scenario by each system

No.	Distance (cm)	Time (min)	No.	Distance (cm)	Time (min)
Concrete Overpack					
1	10	12	2	10	6
3	200	120	4	10	6
5	10	22	6	10	1
7	100	6	8	10	6
9	10	12	10	100	10
11	100	4	12	500	20
13	100	5	14	100	4
15	200	40			
Concrete Module					
1	100	60	2	10	12
3	200	10	4	100	4
5	200	20	6	100	5
7	100	4	8	200	120

In the case of concrete overpack, the storage overpack must be moved to CTB to perform the canister transferring operation. The module system simplifies the work procedure considerably because the corresponding work procedure is omitted.

It was found that both systems performed the longest time to transport the transfer cask to CTB. In addition, it was found that close distance work was performed in 7 procedures for the overpack system and 1 procedure for the module system. These close distance procedures take into accounts the surface dose rate of the cask, and the radiological impact on the worker is expected to be the highest.

4. Conclusions

In this study, we analyzed the procedures of retrieving SNF from concrete overpack-based and module-based dry storage facilities. Based on this, we developed an exposure scenario for SNF retrieval worker.

To this end, FSAR of 4 types of overpacks and 1 type of module were analyzed. In the case of concrete overpacks, multiple systems were investigated, so in this study, assumptions were introduced to generalize the work procedures. Based on the analyzed work procedures, an exposure scenario representing the working distance and working time was developed for future worker dose assessment. The results of this study are expected to be used as basic data for finding optimal management systems when introducing dry storage facilities in Korea in the future and assessing exposure doses of SNF retrieval workers.

ACKNOWLEDGEMENTS

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 2021171020001B).

REFERENCES

[1] Holtec International, “Final Safety Analysis Report for the HI-STORM 100 Cask System Rev.13”, Docket No.72-1014, (Mar. 31, 2016)
[2] NAC International, “Final Safety Analysis Report for the UMS Rev.11”, Docket No.72-1015, (Nov, 2016)
[3] BNG Fuel Solutions, “Final Safety Analysis Report for the VSC-24 Rev.0”, Docket No.72-1007, (Jun, 2005)
[4] EnergySolutions, “FuelSolutions Storage System Final Safety Analysis Reporrt Rev.4”, Docket No.72-1026, (Apr, 2007)
[5] Holtec International, “Final Safety Analysis Report on the HI-STORM UMAX Canister Storage System Rev.3”, Docket No.72-1040, (Jun. 29, 2016)