A Review on the Status of Spent Nuclear Fuel and Intermediate Level Waste Generated from NPPs Decommissioning

Hyung-Woo Seo [a*], Young-Il Na[a], Chan-Geun Park[a], and Gang-Woo Ryu[a]
[a]*Korea Hydro & Nuclear Power (KHNP) Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, Republic of Korea*
[*]*Corresponding author: sehywo1727@khnp.co.kr*

1. Introduction

The main factors that affect the safety of facilities and the exposure dose of workers in the decommissioning of Nuclear Power Plants (NPPs) can be Spent Nuclear Fuels (SNFs) and radioactive materials that are irradiated during the normal operation. Currently, the U.S. has a lot of experience in decommissioning NPPs around the world, and many other countries, including Europe, are carrying out or in progress as major countries with shutdown sites [1]. As can be seen from the cases of these countries, the first task that was performed when the site is shutdown is to remove SNFs from the reactor. In addition, materials corresponding to waste above the intermediate level are generated in the process of dismantling systems and components such as Reactor Vessel (RV) or Reactor Vessel Internals (RVIs). The waste management system may vary in each country, but in case of greater-than-Class C (GTCC) waste, even if a low and intermediate disposal site is available, should be managed in a temporary or intermediate storage facility that stores SNFs. Therefore, this study reviewed the management status of GTCC, which should be managed at a level similar to SNFs for NPPs in the U.S. as a country that experienced the decommissioning of shutdown sites.

2. Methods and Results

Cases of removing SNFs and GTCC waste from the U.S. decommissioning sites were investigated through literature research. Information on the amount of GTCC waste generated from shutdown sites and cask (i.e. canister) for storing them was collected. As a result, the types and quantity of casks required for the management of GTCC waste by NPPs in the U.S. were compared.

2.1 Characteristics of shutdown plants in the U.S.

Table 1 shows the characteristics of the NPPs decommissioning sites and this information represents the current status as of 2015 [2]. Among the sites, Maine Yankee, Yankee Rowe, Connecticut Yankee, Humboldt Bay, Big Rock Point, Rancho Seco, and Trojan have completed the project with immediate dismantling strategies, while some other sites are in progress. In case of immediate dismantling sites, SNFs have been removed and GTCC waste is also stored and managed in Independent Spent Fuel Storage Installation (ISFSI), and most sites under decommissioning have been removes SNFs from the reactor.

Table 1: Shutdown Site Reactors [2]

Site	Type	Operating Period	Status
Maine Yankee	PWR	1972-1996	DECON completed
Yankee Rowe	PWR	1961-1991	DECON completed
Connecticut Yankee	PWR	1968-1996	DECON completed
Humboldt Bay	BWR	1963-1976	DECON completed
Big Rock Point	BWR	1963-1997	DECON completed
Rancho Seco	PWR	1975-1989	DECON completed
Trojan	PWR	1976-1992	DECON completed
La Crosse	BWR	1969-1987	SAFSTOR
Zion 1	PWR	1973-1997	In progress
Zion 2	PWR	1974-1996	In progress
Cristal River	PWR	1977-2009	In progress
Kewaunee	PWR	1974-2013	In progress
SONGS 1	PWR	1968-1992	In progress
SONGS 2	PWR	1983-2013	In progress
SONGS 3	PWR	1984-2013	In progress
Vermont Yankee	BWR	1972-2014	In progress

2.2 Generation of GTCC waste

The management of SNFs and GTCC, which was not raised during the operation of NPPs, will emerge as an issue as it enters decommissioning after permanent shutdown. This is because, in order to carry out the decommissioning, SNFs must be removed, and GTCC waste generated during the dismantling activities must also have alternatives for transportation and storage. The typically generated GTCC waste from the decommissioning is shown in the table as below.

Table 2: Typical Radioactive Waste Volume [3]

	Class A (m^3)	Class B/C (m^3)	GTCC (m^3)
PWR	6,797	184	11
BWR	13,903	372	7

2.3 SNFs and GTCC storage casks

The storage systems or providers for the SNFs and GTCC waste from permanent shutdown reactors in the U.S. could be largely divided into NAC International, NUHOMS, HOLTEC, and EnergySolutions.

The NAC International offers three types of storage systems: UMS (Universal Storage System), MPC (Multi-Purpose Canister), and MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORage). UMS was the first U.S. system designed to meet the requirements of almost every U.S. utility and the worldwide fabrication team to ensure its successful launch and production. MPC is designed for storing and transporting spent fuel from older U.S. nuclear plants which will likely be the first to ship fuel to an interim storage facility. MAGNASTOR is a new-generation multipurpose canister system that stores between 16 and 28 percent more spent fuel than competing high-capacity licensed systems.

Orano TN provides HUHOMS used nuclear fuel dry storage systems, including dry shielded canisters that are built of durable stainless steel at the TN fabrication facility in North Carolina. The concrete overpacks are called horizontal storage modules, and are either cast on site or built at American manufacturer and shipped to the site for fabrication.

HI-STORM (Holtec International Storage Module) is Holtec International's Multi-Purpose Canister (MPC) system for the dry storage of used nuclear fuel. The Hi-STORM system consists of interchangeable sealed metallic MPCs which contain the used fuel. HI-STORM UMAX (Holtec International Storage Module Underground MAXimum Capacity) is and underground vertical ventilated module dry storage spent fuel storage system engineered to be fully compatible with all presently certified multi-purpose canisters.

EnergySolutions offers the largest fleet of industrial (IP), Type A and B shipping casks to the nuclear industry, with more than 90 casks of different sizes, shielding and certifications. They also provide shielded, disposable liners for the transport of radioactive materials.

Overall, the system applied to commonly used GTCC or higher level waste is shown in Fig. 1. It can be divided into a vertical concrete cask, a horizontal type, and an underground type.

Fig. 1 General Types of Storage Systems [2]

2.4 Storage Canisters Used at Each Site

As indicated by the case of the U.S. decommissioning NPPs, most SNFs and GTCC wastes after permanent shutdown are temporarily stored in ISFSI. Although the storage systems applied at the time of SNFs transportation differ in detail, most of the systems of NAC, HOLTEC, ORANO, and EnergySolutions were used within our literature review. If the ratio of GTCC per number of SNFs is calculated based on overseas cases (Table 3), it can be seen that one canister for GTCC waste per 14 SNFs can be considered.

Table 3: Storage Canisters Used at Each Site [2]

Site	Storage System/Canister	Canisters SNF/GTCC
Maine Yankee	NAC-UMS	60/4
Yankee Rowe	NAC-MPC/Yankee-MPC	15/1
Connecticut Yankee	NAC-MPC/CY-MPC	40/3
Humboldt Bay	Holtec HI-STAR HB/MPC-HB	5/1
Big Rock Point	Fuel Solutions W150 Storage Overpack/W74 Canister	7/1
Rancho Seco	TN NUHOMS/FO-DSC, FC-DSC, FF-DSC canisters	21/1
Trojan	TranStorage Overpack/Holtec MPC-24E and MPC-24EF	34/0
La Crosse	NAC MPC-LACBWR/MPC-LACBWR	5/0
Zion 1/2	NAC MAGNASTOR/TSC-37 TN Standardized NUHOMS/32PTH1	61/4
Cristal River	TN Standardized NUHOMS/32PT	39/5
Kewaunee	TN Standardized NUHOMS/32PT NAC MAGNASTOR/TSC-37	38/2
SONGS 1	TN Standardized Advanced NUHOMS/24PT1	17/1
SONGS 2/3	TN Standardized Advanced NUHOMS/24PT4 Holtec HI-STORM UMAX/MPC-37	106-112/11
Vermont Yankee	Holtec HI-STORM 100S/MPC-68	58/2

3. Conclusions

In this study, the amount of SNFs and GTCC waste from the decommissioning of NPPs and their management systems were reviewed. We mainly referred to reports describing the experiences of the U.S., and as a result, information on the applied casks and canister models could be compared. In addition, comparing the SNFs generation of each NPP with the canisters that stored GTCC, it was found that about one GTCC canister per 14 SNFs canister was used.

REFERENCES

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