Review of Spent Nuclear Fuel Dry Storage Demonstration Programs in US

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1. Introduction

US have carried out several notable demonstration programs for the initiation and license extension of dry storage of spent nuclear fuel (SNF). At the very early stage of dry storage, the demonstration programs were focused on the proof of the safety of dry storage systems and a demonstration project named dry cask storage characterization project (DCSCP) was performed for the license extension of low burn-up fuel dry storage. Currently, a demonstration program for the license extension of high burn-up fuel dry storage is under way and it is expected to continue at least 10 years from now. Korea has not begun the dry storage of PWR fuel yet and those programs of US can be a good reference and lessons to safely begin and operate dry storage in Korea. In this paper, the past and current of the demonstration programs of US are analyzed and several recommendations are provided on the demonstration programs for dry storage of spent nuclear fuel in Korea.

2. Regulations on SNF Integrity

2.1 Storage regulations

The regulatory requirements on the integrity of spent nuclear fuel are stipulated in 10 CFR 72, NRC Interim Staff Guidance (ISG) and NUREG documents. 10 CFR 72.122(h) states that (1)The spent fuel cladding must be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage, and (5) The high-level radioactive waste and reactor-related GTCC waste must be packaged in a manner that allows handling and retrievability without the release of radioactive materials to the environment or radiation exposures in excess of part 20 limits. The definition of the term “retrievability” is defined in ISG-2 which was recently revised in 2016 to accommodate the retrieval of spent fuel in canister and storage cask. The requirements on the retrievability do not apply to the accident conditions.

2.2 Transportation regulations

In the transportation regulation, 10 CFR 71, the requirements on the integrity of spent nuclear fuel is not explicitly stipulated. In the regulations for fissile material transportation, 10 CFR 71.55, it states that (1) The contents would be subcritical; (2) The geometric form of the package contents would not be substantially altered in normal conditions of transportation. As the degradation of fuel cladding and other structural parts of fuel assembly may lead to the gross rupture of fuel assembly in the presence of transportation loading such as vibration, the requirements on transportability shares some aspects with the requirements on retrievability.

3. SNF Dry Storage Demonstration Program

3.1 Demonstration at early stages

The purpose of the demonstration programs at early 1980’s was the verification of the performance and safety of the dry storage systems and set-up of the dry storage procedure at reactor site. This early stage demonstration was initiated by the Nuclear Waste Policy Act of 1982. It includes the demonstration with the Sealed Storage cask (Fig. 1) at Nevada Test Site (NTS) and the demonstration performed at Surry nuclear power plant with CASTOR V/21 cask, demonstration at H.B. Robinson power plant with NUHOMS system and the demonstration at INEEL(currently INL) with several types of casks (Fig. 3). Through these demonstration programs, the DOE staffs successfully validated and verified their computational model for shielding and computational fluid dynamic codes such as COBRA-SFS, HYDRA.

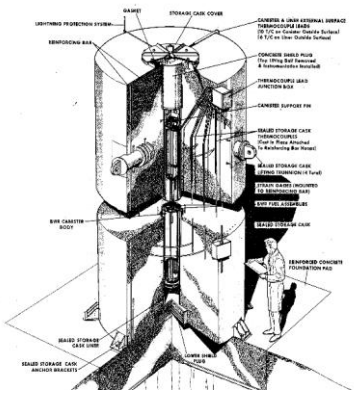

Fig. 1. Sealed Storage Cask used in NTS demo.

Fig. 2. Demo casks stored at INTEC of INL [1].

3.2 Dry Cask Storage Characterization Project

The purpose of DCSCP [2] was to produce data to support the license renewal of dry storage of SNF after the first 20 years of storage period. DOE, NRC and EPRI opened the CASTOR V/21 cask which was stored at INL after the first stage demonstration and performed examinations on the cask systems and the fuel elements to find any clue of degradation that can hinder the extension of license for dry storage. The Cask system and fuel assembly exterior were examined at INL and the fuel rods were examined at ANL for residual creep life and any sign of hydride reorientation. It was concluded that there was no sign of significant degradation of fuel and cask system and the license could be extended. However, the facts that the fuel was loaded dry in a hot-cell omitting the process of vacuum drying, and the 'before-storage' fuel condition was not characterized are the limitation of the data obtained by DCSCP.

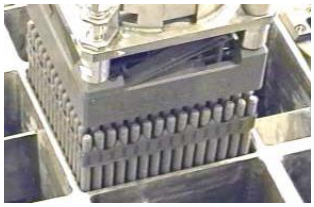

Fig. 3. Fuel assembly visual inspection at INL.

3.3 The High Burnup Confirmatory Data Project

Currently US DOE leads a joint project with NRC and EPRI named as high burnup confirmatory data project (HBU-CDP) [3]. The purpose of this project is to generate technical data to support the licensee extension of high burnup fuel dry storage. It is now under way and will continue at least 10 years from now. This demo focuses on the data acquisition during the loading and drying process of dry storage, which were missed in earlier demo, DCSCP. For this purpose, the lid of TN-32 cask were modified so that instruments for temperature and gas monitoring can be inserted into the cask (Fig. 4). 4 different types of fuel will be loaded into the cask. Sister rods, which have almost identical history and material with demo fuels were selected and sent to DOE labs for destructive examinations to characterize the 'before-storage' condition of the demo fuel's cladding. The loading of the demo cask is planned to start at latter part of 2017.

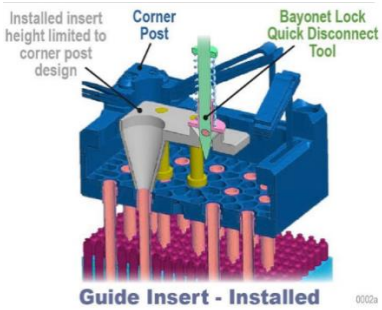

Fig. 4. Instrumentation for thermocouple insert.

4. Conclusions

Since Korea has not started the dry storage of PWR fuel yet, those demonstration programs of US can of great lessons to learn. Korea also needs such demonstration programs for various purpose: 1) to confirm the safe storage conditions of SNF that can guarantee retrievability of SNF after storage 2) to monitor the integrity of spent fuel in case the storage period is extended 3) to verify the performance and quality of the domestic storage systems.

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