High Radioactive Spent Fuel Management. Dual Purpose Metal Casks as a Current Optimal Solution

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I. Introduction

Nowadays, the management of high radioactive spent nuclear fuel (SNF) from light water reactors (LWR) has become a key topic of discussion in the nuclear community, and several technical solutions are available in the market. Its importance has risen since it involves political decisions, and governments around the world are currently planning different strategies basing their decisions in technical, economical and safety reasons.

External factors like the economic crisis which is striking Europe since the last 5 years, or the consequences of the accident suffered by the Fukushima Daiichi Nuclear Power Plant (NPP) in 2011, have encouraged governments, regulators and utilities to plan long-term fuel management strategies. However, utilities require short term dry storage solutions to continue operating their NPPs due to the limited size of their spent fuel pools.

This paper aims to show the benefits of metal casks for storage and transportation of SNF as a current technical, economic, safe and flexible solution, adaptable to any long and short-term SNF strategy.

II. Current Situation of Spent Fuel Storage

After the completion of burnup period of nuclear fuel in LWR, SNF assemblies are discharged from the reactor core and stored inside racks in spent fuel pools located at NPPs facilities.

Among other political factors, the long and deep economic crisis has made the construction of new NPPs, especially in Europe, a non-affordable financial challenge. Many NPPs in Europe and in the USA have planned to increase its operating design life over thirty years, and to achieve that requirement they need to empty their spent fuel pools to continue operating.

In addition, the catastrophic accident suffered by the Fukushima Daiichi NPP in March 2011 have made regulators to question if reducing the density of spent fuel pools will increase the safety of NPPs, in case of suffering a severe accident. The United States Nuclear Regulatory Commission (NRC), within its Japanese lesson learned program, has initiated an evaluation on the increase of the overall protection of public health and safety and the related costs, of transferring SNF to dry cask storage after five years of cooling in spent fuel pools [1].

Finally, the need for storage facilities is increasing worldwide due to several delays in the introduction of permanent disposal and/or reprocessing facilities. These delays have been usually motivated due to political, social and economic reasons, being the selection of the final repository location the main one. In Fig. 1 is shown a forecast of U.S. high radioactive SNF inventory in the coming years. In NPPs without interim storage facilities or reprocessing programs, utilities are re-racking their spent fuel pools to increase capacity. However, spent fuel pools limited capacity will be reached in a few years, and according to Fig. 1, dry storage inventory will predominant.

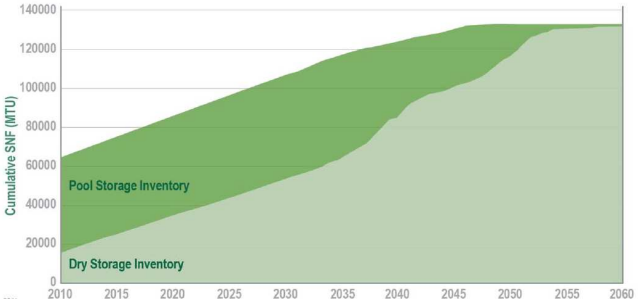

Fig. 1- Projected SNF Inventory in Wet and Dry Storage in the U.S. [2]

III. Temporary Dry Storage Alternatives

SNF dry storage has proven an efficient, safe and cost competitive solution, after the large number of cask loaded all around the world. Most NPPs sites include interim spent fuel storage installations (ISFSI) to store SNF after unloading from the spent fuel pools. After a storage period, SNF will be either transported to centralized interim storage facilities (like the one under construction in Spain, called ATC), permanent disposal facilities (i.e. deep geological repositories, DGR) or partially recycled in reprocessing facilities. Since these types of facilities are not already available in all countries, storage casks shall be able to secure store SNF during long periods. In most cases, interim storage facilities were initially designed to operate for periods of up to 50 years, but operational periods of 100 years or longer are now being envisaged [3].

The development of dry storage system has been also a key factor for the shutdown and decommissioning of NPPs.

One solution for interim dry storage of SNF available in the market is the *multipurpose canister* introduced in a concrete overpack. Besides the canisters where SNF is loaded, this

system requires a transfer cask for on-site transferring operations, a concrete overpack for storing fuel at ISFSI sites and a transport overpack for transportation the canister out of the NPP or the storage site. However, this solution entails several challenges:

- Canisters are lid welded packages and the confinement relies on the weld. Therefore, specific welding equipment is required for closing the canister, with the inconveniences of performing additional operations at facilities, controlling parameters, cleanliness, etc. Furthermore, when the SNF will be retrieved from the canister for final disposal, recycling or an accident, the welding shall be broken and the canister will not be able to be reutilized.
- Several components are required for a complete fuel management strategy (concrete overpack, transfer cask, transportation cask, etc.). It increases the number of safety-related operations, the doses to personnel and the cost of the entire process.
- A transfer pit requiring civil works is needed in the storage installation.

A second alternative available in the market are *dual purpose metal casks*, an integrated solution where one single cask is used for fuel loading and unloading operations in the spent fuel pool, for storing fuel at ISFSI sites and transportation to final disposal installations or reprocessing plants. The transportation of SNF can be carried out immediately after loading the casks or after a storage period inside the cask. These casks include bolted lids that facilitate the retrieval of the SNF from the inner cavity at any stage, and reutilization of the cask. Double-lid bolted casks allow the continuous monitoring of the pressure in the cavity between lids, which has proven an excellent and immediate technique to detect leaks from the fuel cavity.

This solution provides high versatility suitable for any SNF fuel management strategy. There is no need to perform any additional fuel transfer operation once the cask is loaded, and the cask can be directly used for interim storage. The overall advantage of this solution is highly enhanced in situations where the user may have different storage sites, if the interim storage site is not decided yet, or if the interim storage or final disposal site is not close to the NPP.

Another advantage of the use of dual purpose metal casks is their minor interference with NPPs or storage facilities. Casks can be stored vertically over a horizontal concrete pad, and in most cases permanent ancillary equipment is not required since these types of cask are designed to withstand the hardest design basis earthquakes required by nuclear regulations. Another possibility is to store the casks horizontally, lying on a metal skid. Apart from a horizontal concrete pad, no additional civil works must be performed on the storage site, which results in a reduction of costs, time, dose rates and simplicity of operation.

Spent fuel storage regulations (i.e. 10 CFR 72.122(l) [4]) require that storage systems must be designed to allow ready retrieval of SNF, after any normal, off-normal or accident condition. Bolted closure systems are the simplest and fastest mechanisms to retrieve SNF fuel at any time during storage and transportation, with reduced and controlled dose rates to personnel. Furthermore, casks can be reutilized afterwards since the retrieval process is a non-destructive operation.

IV. Long Term and Permanent Dry Storage

Dry storage is also being currently preferred for the long term storage of SNF. One of the options most widely developed is repackaging SNF in small canisters that will be further stored either in temporary long-term sites or in permanent deep geological repositories.

However, there is an ongoing project financed by the U.S. Department of Energy (DOE) which is evaluating the possibility of direct disposal of canisters and other types of storage casks [5]. This means that potentially, double-purpose metal casks could be also used to permanently dispose SNF, and therefore cover all the back end operations in an open fuel cycle strategy.

V. Example of a Dual-Purpose Metal Cask

Within this complex scenario, Ensa has recently launched the ENUN cask family, a dual purpose metal cask concept design (see Fig. 2) to securely storage and transport low and high burnup SNF from PWR and BWR light water reactors. This modular, double-lid bolted, storage and transportation solution is perfectly compatible with any SNF management strategy, from interim storage, final disposal or fuel recycling.

Fig. 2- The Ensa ENUN Dual-Purpose Metal Cask Family

VI. Conclussions

Current situation in spent fuel management requires technical solutions that allow secure, temporary dry storage of SNF and versatility to transport and retrieve it, until governments decide its long-term strategies and permanent installations start operating.

Dual-purpose metal casks have proven a current technical, economic, safe and flexible solution, adaptable to any long and short-term SNF strategy.

References

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