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Update on R&D for Disposal of Dual Purpose Canisters

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Summary

The growing inventory of spent nuclear fuel from U.S. commercial nuclear reactors in dry storage dual-purpose canisters (DPCs) at both operating and decommissioned power plants has necessitated the need to explore the possibility of directly disposing of these canisters even though they were neither designed nor are licensed as disposal canisters. Since 2012, the U.S. Department of Energy's Office of Nuclear Energy has funded R&D to address three main issues related to the direct disposal of DPCs: size and weight, thermal output and criticality. This paper is a brief summary of the planned R&D to address these issues in 2018-2019 and the expected results.

Introduction

In the absence of an operating repository for permanent disposal of commercial spent nuclear fuel (SNF), United States (U.S.) nuclear utilities have been storing spent nuclear fuel on site. To manage the growing inventory of SNF of ~2200 Metric Tons (MT) generated per year, and with storage pools at capacity, utilities are transferring older, cooler fuel from pools to dry storage canisters. Most of these canisters are certified by the U.S. Nuclear Regulatory Commission (U.S. NRC) for both storage and transportation; hence, the name dual-purpose canisters or DPCs. DPCs are large canisters, typically measuring ~2 meters in diameter and ~5 meters in length, and heavy, weighing up to about 50 tons when loaded, and some of the newer designs can accommodate as many as 37 Pressurized Water Reactor or 89 Boiling Water Reactor fuel assemblies.

At present there are ~40000 MT of SNF stored in over 2700 DPCs at Independent Fuel Storage Facilities located at both operating and decommissioned nuclear power plants across the U.S. Approximately 160 new DPCs are loaded each year. Figure 1 (Bonano, et al., 2018) shows the projected estimates of SNF in storage, both in pools (blue curve) and in DPCs (green curve), with the red curve representing the total SNF inventory in storage. There are several assumptions embedded in the projections shown in Figure 1: (1) the nine existing nuclear power plants that had announced shutdown dates as of the end of 2017 will continue operating until those dates; all others receive license renewals and are decommissioned after 60 years of operation, (2) no new reactors are built, (3) no spent nuclear fuel is reprocessed, and (4) there are no options for permanent disposal and all spent nuclear fuel remains in temporary storage (Bonano et al., 2018).

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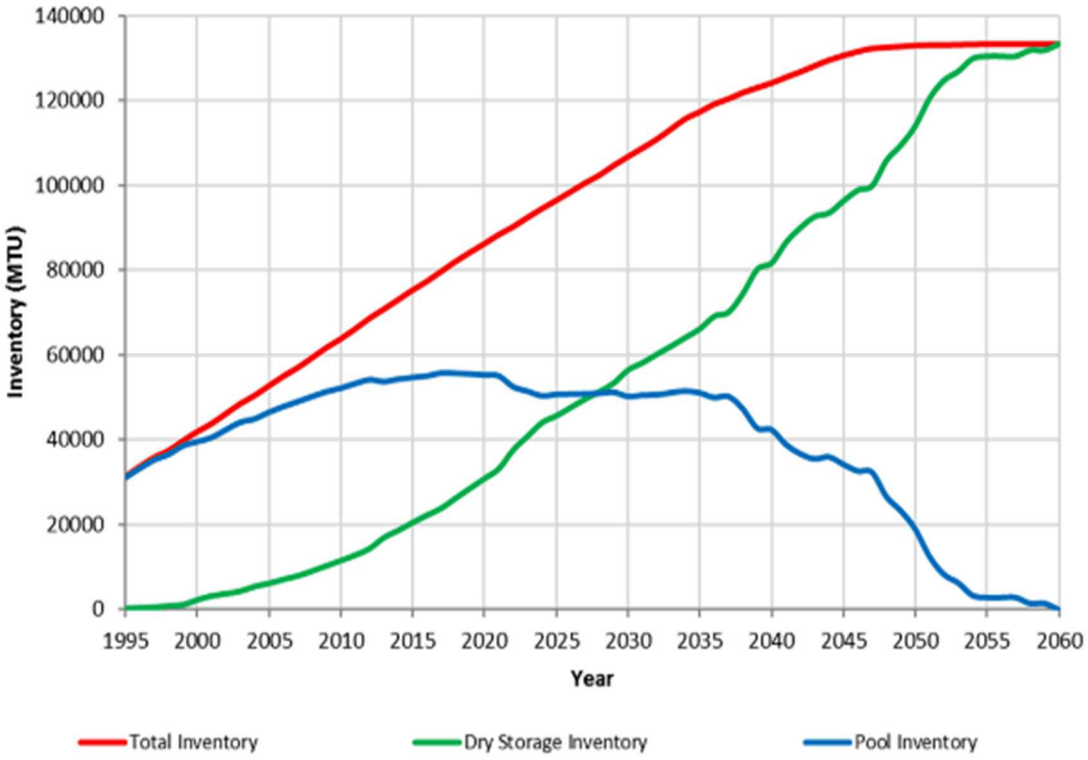

Figure 1. Projected inventory of US commercial spent nuclear fuel in storage (Bonano et al, 2018) based on data from Carter et al. (2016)

At present the majority of the SNF inventory in storage is in pools, but sometime between 2025 and 2030 the SNF inventory in DPCs will surpass the inventory in pools and by mid-century practically all of the inventory (~135,000 MT) will be in ~8,000 DPCs. The U.S. is faced with three basic SNF management options, or combinations thereof (Bonano et. al., 2018):

1. Opening the DPCs and repackaging the SNF in canisters suitable for disposal sometime in the future
2. Constructing one or more repositories that can accommodate DPCs as disposal canisters
3. Storing SNF at surface facilities indefinitely and repackaging as needed

The focus of this paper is Option 2: the direct disposal of DPCs can potentially could be considerably less expensive than opening the DPCs and repackaging the SNF either into disposal-specific canisters or into new DPCs and may not pose risks to workers, the public or the environment.

R&D for Direct Disposal of DPCs

As stated earlier, DPCs are certified by the U.S. NRC for both storage and transportation; however, they are not designed as disposal canisters. Thus, a major question facing the U.S. is whether DPCs can be left untouched and directly disposed as is. Since 2012, research on this topic has been sponsored by the U.S. Department of Energy Office of Nuclear Energy's Spent Fuel and Waste Science and Technology (SFWST) Campaign (Hardin et al., 2015).

There are three major challenges that must be addressed when considering the direct disposal of DPCs: (Hardin et al., 2015: Bonano et al., 2018);

1. Size and weight: DPCs are much larger and heavier than more conventional disposal waste packages for most repository designs, perhaps other than the proposed Yucca Mountain repository;

2. Thermal management: DPCs are getting bigger and, with utilities going to higher burn-ups, hotter than most conventional disposal waste packages; and
3. Criticality control: because they were not specifically designed for disposal, DPCs may not have adequate criticality controls for the disposal timeframes of interest (hundreds of thousands of years).

Under the SFWST Campaign, the following R&D activities related to direct disposal of DPCs are being planned for 2018 and 2019:

- Technical/Programmatic Solutions for Direct Disposal of SNF in DPCs;
- Probabilistic Post-Closure DPC Criticality Consequence Analysis;
- DPC Filler and Neutron Absorber Degradation R&D, and
- Multi-Physics Simulation of DPC Criticality.

Expected Outcomes from this R&D includes:

- DPC disposition alternatives, R&D and resource needs;
- Generic (non-site specific) preliminary probabilistic risk assessment;
- Preliminary multi-physics coupled models; and
- Feasibility of thermal-setting phosphate cement as filler.

References

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