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Canister Design for Spent Fuel Disposal in a Range of Geologic Disposal Environments

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Commercial spent nuclear fuel (SNF) continues to accumulate in dry storage, sealed into welded dual-purpose canisters (DPCs). This practice is well underway in the U.S. and is beginning to take hold in other countries such as the UK. Whereas these canisters have been design and licensed only for storage and transportation, direct disposal without cutting them open could be technically feasible. Options for DPC direct disposal are based on a 3-year study by the U.S. Department of Energy.

A parallel design activity is underway to develop a multi-purpose canister suitable for storage and transportation, and purpose-designed for disposal in a wide range of geologic disposal environments. Repository R&D in the U.S. is expanded to consider such a range of environments (crystalline, argillaceous, salt). The design approach begins with a survey of all possible canister or fuel features that could ensure disposability. Spent fuel remains reactive for many thousands of years, and the most significant technical issue is postclosure criticality control, should the waste packages breach from corrosion and become flooded in the repository. The range of possible design solutions includes limitation of canister size, use of bolted instead of welded closures, corrosion-resistant structural and neutron absorbing materials, and additional nuclear reactivity controls installed in the spent fuel assemblies. The U.S. is forming a long-range plan to change the designs of dry-storage canisters so that they are more broadly disposable. That plan is likely to leave the U.S. with at least 4,000 loaded DPCs (>50,000 MTU) of existing designs.

DPC direct disposal options have been developed for salt, crystalline and sedimentary geologic host media. For disposal in salt formations, the prevalence of natural chloride provides a strong neutron absorbing response. For disposal environments where breached waste packages could be flooded by fresh water, high-reliability disposal overpacks and/or other engineered barriers are one option. Use of corrosion resistant materials such as borated stainless steel is another. Injecting fillers into loaded DPCs has also been investigated, as has the addition of reactivity improvements (e.g., control rods for disposal) in loading of new DPCs.

From these investigations we conclude that for disposal of spent fuel, larger waste packages require mitigation of the potential for criticality. The only design solution that has received licensing review is that for the proposed Yucca Mountain repository in the U.S. The corrosion testing data that could support a more general solution are not available in the literature, and represents a potential area of international collaboration. Nonetheless, strategies for multi-purpose canister disposability can be formulated based on probabilistic risk analysis taking into account multiple engineered and natural barriers. Such an approach is currently being evaluated for the U.S.