Risk Assessment of Structural Integrity of Transportation Casks after Extended Storage: Aging Effect on the Cask Components Mechanical Performance

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Program: FCR&D: Used Nuclear Fuel Disposition, Transportation

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ABSTRACT:

This study will assess the risk and potential consequences of loss of structural integrity of transportation casks and fuel cladding after extended storage. Currently, the spent nuclear fuel (SNF) at nuclear power plants (NPPs) is transferred from pools to dry cask storage (DCS) at sites contiguous to the plant, known as Interim Spent Fuel Storage Installations (ISFSIs). Thereafter, the spent fuel will be placed in spent fuel shipping containers to be transported to disposal sites. The ISFSIs were initially licensed as temporary facilities for 20-year periods. The suspension of the licensing process of the geologic repository at Yucca Mountain has triggered a reevaluation of DCSs as a potential mid-term solution, in which their operating period may be extended for hundreds of years.

One of the main components of a reliable risk assessment process is the incorporation of the detrimental effects of degradation mechanisms present in fuel cladding and transportation cask components. Although it is known that fuel rods discharged from NPPs have a small percentage of rod cladding defects, the behavior of fuel cladding and the structural elements of assemblies during transportation after long-term storage is not well understood. The integrity of the used fuel after transportation cannot be ensured because of the potential presence of long-term degradation processes, as well as uncertain transportation loading conditions for aged fuels that have not been verified. An increase understanding of degradation processes is important because if the fuel degrades during extended storage, it could be susceptible to damage from vibration and impact loads during transport operations, releasing fission-product gases into the canister or the cask interior (NWTRB 2010).

To address this need, the proposed risk assessment will be conducted via experimental tests and simulations with advanced numerical models developed as part of this study to evaluate the structural performance of fuel, fuel assemblies, canister, and cask components exposed to transportation risks after extended storage. The main goal of this study is to determine whether the containment, shielding, criticality safety, and heat management cask functions are expected to be preserved during cask transportation after extended storage. A novel contribution of this study will be the evaluation of the combined effect of component aging and vibration/impact loads in transportation scenarios. Emphasis will be placed on the structural integrity of fuel cladding and canisters.