Potential Uncertainties Associated with Performance Evaluation in Extended Storage and Transportation of Spent Nuclear Fuel and High-Level Waste

T. Ahn, J. Gwo and Z. Li

U.S. Nuclear Regulatory Commission,

Office of Nuclear Material Safety and Safeguards, Washington, DC 20555, USA

Contact: Tae Ahn, tae.ahn@nrc.gov, +1-301-492-3150

Abstract

Currently, the U. S. Nuclear Regulatory Commission (NRC) staff is assessing potential technical and environmental issues associated with interim storage (EST) of spent nuclear fuel (SNF) and high-level waste (HLW) for extended periods of time. The studies include ramifications to transporting the materials for newer and higher burnup fuel designs. This paper reviews possible uncertainties and issues associated with the performance of the waste package, SNF, and HLW, under the expected EST conditions. For example, one area of review is in radionuclide release and in criticality and shielding control from potential mechanical cracking and corrosion of the canister. Mechanical failure of the canister may be excluded if the likelihood of occurrence is sufficiently low. Otherwise, the opening area from mechanical failure of the canister or configuration changes of the SNF or HLW may need to be evaluated to assess the magnitude and consequences of potential radionuclide release (e.g., gas pressure release), and criticality and radiation shielding control. In a coastal or industrial environment, the canister might be exposed to aggressive chemical deposits (e.g., salts). These deposits might lead to stress corrosion cracking (SCC) and potentially be followed by localized corrosion through salt deliquescence. Deliquescence of the salts might form concentrated aqueous solutions that could cause such corrosion. Reviews will assess if SCC failure can be excluded or its consequences need further consideration. The second review is associated with potential cladding failure and an assessment of its failure probability. A potential failure event that could be considered includes hydrogen-induced embrittlement (e.g., hydride reorientation or delayed-hydride cracking). If the likelihood of embrittlement is high, a consequence analysis might be needed (i.e., radionuclide release, and criticality and radiation shielding control). The third review is associated with the degradation of the canister internals. Degradation might occur from galvanic corrosion among various internal components (e.g., coating materials, basket materials, neutron absorbers, and cladding), and localized corrosion and SCC of each internal material. The last review is associated with potential SNF or HLW matrix failure, which might occur from high burnup rim effects, oxidation/hydration, and possible impact effects that might increase the release fraction of the radionuclides. These process-level failure mechanisms can be analyzed in a system performance (or risk) assessment code to understand the sensitivities of the uncertainties associated with these potential failure mechanisms in term of probability, radionuclide release, dose, the criticality potential, or shielding capacity. Such an analysis will also help identify early potentially risk-significant issues.

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