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MELT-DILUTE FORM OF Al-BASED SPENT NUCLEAR FUEL DISPOSAL CRITICALITY SUMMARY REPORT

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ABSTRACT

Criticality analysis of the proposed melt-dilute (MD) form of aluminum-based spent nuclear fuel (SNF), under geologic repository conditions, was performed [1] following the methodology documented in the *Disposal Criticality Analysis Methodology Topical Report* [2]. This methodology evaluates the potential for nuclear criticality for a waste form in a waste package. Criticality calculations show that even with waste package failure, followed by degradation of material within the waste package and potential loss of neutron absorber materials, sub-critical conditions can be readily demonstrated for the MD form of aluminum-based SNF.

INTRODUCTION

The 5-DHLW/DOE SNF waste package for repository disposal of the melt-dilute form of aluminum-based SNF is comprised of one 18-in.-outer diameter DOE standardized SNF canister containing the MD ingots, surrounded by five defense high-level radioactive waste (DHLW) glass canisters. Criticality analysis of the proposed MD-SNF form, under geologic repository conditions, was performed [1] following the methodology documented in the *Disposal Criticality Analysis Methodology Topical Report* [2]. This methodology evaluates the potential for nuclear criticality as determined by the composition of the waste and its geometry, namely waste form configuration, including presence of moderator, reflecting structural material, and neutron absorbers. The intact waste package design is subjected to degradation scenarios comprised of a combination of features, events, and processes (FEPs) that can result in degraded configurations to be evaluated for criticality. There are three

primary paths or degradation scenarios that encompass the range of potential events (see Fig. 1). Consideration is further given to the evolution of the geochemical environment within the waste package and the effect of the geochemical changes on the degradation characteristics of the waste package components including the spent fuel and the package internals. The integrated analysis results in configurations that are evaluated for criticality with the goal of maintaining k_{eff} less than 0.93. The goal for k_{eff} less than 0.93 has been set to allow for a 5% safety margin and uncertainty in the experiments used to validate the method to calculate k_{eff} . This paper provides a summary of the criticality analysis and supporting analyses in evaluating the MD-SNF form for criticality during the post-closure period of the Monitored Geologic Repository (MGR).

SOURCE TERM FOR THE CRITICALITY ANALYSIS

The DOE standardized canister that will be placed in the center of the codisposal WP will contain three to six MD ingots that are both homogenous and monolithic, depending on the dimensions of the individual ingots. These ingots will range in height from 15 to 30 inches and will likely be contained in a plain carbon steel crucible liner. The crucible liner will be standardized at approximately 20 to 30 inches. The maximum outer diameter of the crucible liner will be 15.5-16.5 inches and it will have a thickness of up to 0.5 inches. Due to uncertainty in the presence of a crucible liner, the criticality analysis considered a range of crucible liner thickness from 0.0 inches (i.e., no liner) to 0.5 inches. The outer diameter of the MD-SNF form will be dictated by the crucible dimensions.