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U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
Two White Flint North
11545 Rockville Pike
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Washington, DC 20555

Subject: Programmatic Review of Extended Summary

Dear Mrs. DeMarco:

The enclosed extended summary is being submitted for programmatic review. This extended summary will be submitted for presentation at the 2003 International High-Level Radioactive Waste Management Conference, to be held March 30–April 2, 2003 in Las Vegas, Nevada. The title of the extended summary is

> "Review Methodology for Preclosure Safety Analysis of Proposed Geologic Repository" by Biswajit Dasgupta, Asad Chowdhury, Roland Benke, and Banad Jagannath.

Please advise me of the result of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely yours,

Budhi Sagar
Technical Director

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2. AUTHOR(s)

B. Dasgupta, A.H. Chowdhury, R. Benke and B. Jagannath

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Review Methodology for Preclosure Safety Analysis of Proposed Geologic Repository

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Extended Summary

Introduction

The proposed geologic repository at Yucca Mountain (YM) will be designed for the permanent disposal of about 70,000 MTU of spent nuclear fuel and high-level nuclear waste (HLW). In its license application to construct and operate the proposed geologic repository, the U.S. Department of Energy (DOE) is required to conduct preclosure safety analysis for the period before permanent closure. During the preclosure period, the proposed facility will receive and handle casks containing the waste in sealed disposal canisters or in the form of fuel assemblies. Using a combination of manual and remote operations, the waste will be transferred into disposal waste packages (WP) and transported underground for emplacement into drifts. Through preclosure safety analysis, DOE is required to demonstrate that the facility can be designed and operated to meet the preclosure performance objectives defined in 10 CFR 63.111. U.S. Nuclear Regulatory Commission (NRC) staff will review the license application to ensure that the proposed activities will meet preclosure performance objectives to protect the public health and safety. The Yucca Mountain Review Plan (YMRP) [1] provides staff with guidance for determining whether the facility can be designed, constructed, and operated in compliance with the applicable NRC regulations to ensure repository safety before and after permanent closure. The YMRP will be used by the staff to review the license application for construction authorization and subsequent amendments to receive and possess waste.

This paper describes the risk informed, performance-based review methodology for the repository safety before permanent closure. DOE approach to the preclosure safety analysis has been outlined in Preclosure Safety Analysis Guide [2]. NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) have developed a software package called PCSA Tool [3] to support the implementation of YMRP for the review of DOE preclosure safety analysis. The PCSA Tool will be used by the NRC to assess, through independent confirmatory analysis, DOE evaluation of potential hazards, event sequences and radiological consequences and identification of those engineering features that are required to ensure safety of the public and facility workers. The application of the PCSA Tool is demonstrated through an example in the paper.

Yucca Mountain Review Plan

The YMRP is a site-specific review guidance document that implements the site-specific risk-informed and performance-based regulation, 10 CFR Part 63. The YMRP outlines a risk-informed review philosophy that requires (i) DOE to demonstrate through its preclosure safety analysis that the repository will be designed, constructed, and operated to meet the specified performance objectives throughout the preclosure period; (ii) NRC staff to focus the review on the design of the SSCs important to safety in the context of the ability of the design to meet the performance objectives; and (iii) NRC staff to proportionately focus its review on high-risk significant SSCs that are important to safety.

As defined in 10 CFR 63.2, preclosure safety analysis is a systematic examination of the repository site and evaluation of potential hazards, initiating events, event sequences, and radiological consequences to the public and workers. Section 10 CFR 63.21 (c)(5) requires a preclosure safety analysis to ensure compliance with performance objectives. The objective of preclosure safety analysis is to identify those structures, systems, and components that are relied on to meet the performance objectives in 10 CFR 63.111. The performance objectives in 10 CFR Part 63 stated in terms of permissible doses to the workers and the public.

Each section of the YMRP provides guidance on what is to be reviewed, the review basis, how the staff review is accomplished, what staff will find acceptable in a demonstration of compliance with regulations, and conclusions that are sought regarding the applicable sections in 10 CFR Part 63. A sequence of evaluations leading from site characterization to compliance with 10 CFR Part 63 preclosure performance objectives involve assessment of (i) site description as it pertains to preclosure safety analysis; (ii) description of structures, systems, components, equipment, and operational process activities; (iii) identification of hazards and initiating events; (iv) identification of event sequences; (v) consequence analysis methodology and demonstration that the design meets 10 CFR Parts 20 and 63 numerical radiation protection requirements for normal operations and Category 1 event sequences; (vi) identification of structures, systems, and components important to safety, safety controls, and measures to ensure availability of the safety systems; (vii) design of structures, systems, and components important to safety and safety controls; and (viii) meeting the 10 CFR Part 20 as low as is reasonably achievable requirements for normal operations and Category 1 event sequences.

The YMRP does not identify or designate any specific process or methodology for demonstrating preclosure safety. DOE has flexibility in how it chooses to meet the performance-based regulation. In addition, the licensing review is intended to focus its evaluation on aspects of facility operations and design that have higher risk-significance. PCSA Tool, which implements the review requirements of the YMRP, provides risk-informed review capabilities to facilitate staff to identify safety related SSCs for detailed review and most importantly to determine compliance with performance objectives in the DOE preclosure safety analysis.

PCSA Tool

The PCSA tool developed at the CNWRA provides the NRC and CNWRA staff the ability to review DOE safety analysis through independent confirmatory analyses of risk-relevant aspects. This tool combines the useful components of the integrated safety analysis methodologies used in the chemical industry, and the probabilistic risk assessment (PRA) capabilities and tools used in the safety assessment of nuclear power reactors [4]. The PCSA tool has been structured in a modular fashion to address the applicable review methods and acceptance criteria in each section of YMRP pertaining to preclosure safety.

Review of site specific information and details of the facility design, operations, human activities, and waste characterization following the YMRP provides input to the PCSA Tool. This information is required to review DOE natural and human-induced, and operational hazard analyses and its consequences. The operational hazard analysis module of the tool uses several standard qualitative hazard analysis methodologies, such as Failure Modes and Effects Analysis, What-If analysis and Human Reliability Analysis to review operational hazards. The tool provides an additional module to review identification of the natural and human-induced hazards. The analysis of natural and human-induced, and operational hazard form the basis for postulating initiating events that have the potential to cause radiological consequence to the public and facility workers. Event trees and fault trees are used to develop scenarios that can lead to radiological release.

The frequency analysis module uses a code called SAPHIRE [5], developed for the NRC for use in PRA of nuclear reactors. Preclosure safety analysis considers probability of potential hazards taking into consideration range of uncertainty associated with the data that support probability calculations. The tool groups the event sequences into category 1 and 2 based on the likelihood of their occurrence. The regulation at 10 CFR Part 63 defines Category 1 as those event sequences that have the potential to occur at least once during the preclosure period, and Category 2 are those event sequences that have the probability of occurrence of at least one in ten thousand during the preclosure period.

The consequence module of the PCSA Tool uses RSAC code [6] calculate radiological consequences to an off-site member of the public from an atmospheric release of radioactive material using point estimate and probabilistic approaches. The tool also uses MELCOR code [7] estimate building discharge fraction, which serves an input to the public dose calculation. Inhalation, ingestion, ground surface and submersion doses are calculated and combined to obtain total effective dose equivalent to whole body and also to individual organs. The probabilistic approach is incorporated to assess the uncertainty and variability in the consequence analysis. In addition, the tool also has the capability to evaluate worker doses.

The safety assessment module combines the frequencies and consequences of event sequences to evaluate the preclosure safety and compare it with regulatory dose limits for Category 1 and 2 event sequences. The tool is used to identify structures, systems and components (SSC) that are relied on for safety. This

is done through a dose-based importance analysis in which the performance of the system is reevaluated assuming that the SSC under evaluation has failed to perform its intended function. The preclosure safety analysis results will be used by NRC to review the design bases and design criteria established by DOE for SSCs important to safety.

The full paper will demonstrate the applicability of the PCSA Tool to review DOE preclosure safety analysis through an example.

Acknowledgment

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