March 16, 2017

MEMORANDUM TO: Michael Case, Director
Division of Systems Analysis
Office of Nuclear Regulatory Research

FROM: Michael C. Layton, Director **/RA/**
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

SUBJECT: USER NEED MEMORANDUM – UPDATED GUIDANCE FOR VALIDATION OF CRITICALITY SAFETY ANALYSIS K_{EFF} CALCULATIONS

The Office of Nuclear Material Safety and Safeguards (NMSS) requests assistance from the Office of Nuclear Regulatory Research (RES) in developing a NUREG/CR report to provide updated guidance on validation of criticality analysis k_{eff} calculations. The purpose of this guidance is to provide a single reference report that includes modern examples and recommendations for a uniform approach for performing and documenting k_{eff} calculation validation. Because the report will cover validation of all types of criticality safety analyses, the guidance will be applicable to any fissile material system that requires criticality safety analyses.

Background

The Nuclear Regulatory Commission (NRC) requires criticality safety analyses for fissile material systems in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71, "Packaging and Transportation of Radioactive Material," and 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste." Criticality safety analysis validation methods are discussed in American Nuclear Society (ANS) Standards, such as ANSI/ANS-8.1, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," and ANSI/ANS-8.24, "Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations." Validation methods are also discussed in several NRC documents, including NUREG/CR-5661, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages," NUREG/CR-7108, "An Approach for Validating Actinide and Fission Product Burnup Credit Criticality Safety Analyses—Isotopic Composition Predictions," and NUREG/CR-7109, "An Approach for Validating Actinide and Fission Product Burnup Credit Criticality Safety Analyses—Criticality (k_{eff}) Predictions."

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These previously developed guidance documents are either too general (ANS Standards), too narrowly focused (NUREG/CRs on burnup credit), or are in need of updating (NUREG/CR-5661 and -6361 were published nearly 20 years ago). Staff from the NMSS Division of Spent Fuel Management (DSFM) would benefit from efficiencies gained by a single, comprehensive reference NUREG/CR report that provides modern examples and recommendations for a uniform approach for performing and documenting k_{eff} calculation validation. Although this report is being requested to address criticality validation for radioactive materials transportation and spent fuel dry storage systems, it will cover validation of all types of criticality safety analyses, and the guidance will be applicable to any system involving fissile material that requires a criticality safety analyses.

Area of Needed Assistance

The report should address deficiencies present in the currently available collection of reports and guidance documents for criticality safety analyses validation. Deficiencies noted during reviews of fissile material transportation package and spent nuclear fuel dry storage cask licensing submittals have included:

(1) Inappropriate critical experiment selection,
(2) Insufficient trending analysis,
(3) Incorrectly calculated 95/95 uncertainties,
(4) Failure to address applicability of validation to safety analysis,
(5) Lack of goodness-of-fit testing for trending analysis,
(6) Poor attempted use of commercial reactor critical data for validation,
(7) Failure to meet bias determination methodology prerequisites,
(8) Inappropriate extrapolation of bias and uncertainty,
(9) Failure to identify validation analysis gaps and weaknesses, and
(10) Inadequate validation analysis documentation.

Additionally, there is little or no guidance available for:

(1) Use of trending analysis results,
(2) Acceptable confidence levels for normality testing and trending analysis,
(3) Handling of validation analysis gaps and weaknesses,
(4) Use of sensitivity and uncertainty analysis in the validation analysis process, and
(5) The potential impact of correlations among the critical experiments used in validation.

The report should address all of the above identified deficiencies, and update and consolidate guidance from current criticality validation guidance documents. This effort may also require criticality validation-related computer code and nuclear data development.

Regulatory Benefits

The value of the guidance to NRC staff is a clear comprehensive report on acceptable validation methods. The report will also provide recommendations for content in criticality safety analysis validation documentation. In addition, the proposed NUREG/CR report will increase

predictability in the licensing process, reduce NRC requests for additional information, reduce NRC review time, and improve the quality of applicant submittals. Based on our discussion with your staff, it is our projection that the completion of these tasks will take approximately 15 months. This work is partially completed, and RES estimates that it can be completed using fiscal year 2017 shortfall funds. Therefore, no DSFM funding will be required for this effort.

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