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COMMENTS ON THE U.S. DEPARTMENT OF ENERGY DISPOSAL CRITICALITY ANALYSIS METHODOLOGY TOPICAL REPORT YMP/TR–004Q REVISION 1

Prepared for

U.S. Nuclear Regulatory Commission
Contract NRC–02–97–009

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November 2001

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ACKNOWLEDGMENTS

This paper was prepared to document work performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA) for the U.S. Nuclear Regulatory Commission under Contract No. NRC–02–97–009. The activities reported here were performed on behalf of the NRC Office of Nuclear Material Safety and Safeguards, Division of Waste Management. The paper is an independent product of CNWRA and does not necessarily reflect the views or the regulatory position of the NRC.

The authors gratefully acknowledge R. Benke for technical review, the programmatic review of B. Sagar, and the editorial reviews of A. Woods and C. Cudd. Appreciation is due to J. Gonzalez for assistance in preparing this report.

QUALITY OF DATA: Sources of data are referenced in each chapter. No CNWRA-generated data are contained in this report. Data from other sources should be consulted for determining levels of quality assurance.

ANALYSES AND CODES: No computer codes were used in the development of this report.

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1 INTRODUCTION

The U.S. Congress charged the U.S. Department of Energy (DOE) with managing the geologic disposal of high-level radioactive waste and spent nuclear fuel through the Nuclear Waste Policy Act of 1982 and the Nuclear Waste Policy Amendments Act of 1987. As part of the DOE investigations at Yucca Mountain, Nevada, a topical report has been submitted for review to the U.S. Nuclear Regulatory Commission (NRC) on the methodology that will be utilized in a potential license application to demonstrate the potential for, and consequences of, the materials within the repository achieving a critical configuration. This methodology has been proposed to be applied to all waste forms that will be placed in the repository including commercial spent nuclear fuel, DOE spent nuclear fuel, immobilized plutonium, and vitrified high-level waste glass. NRC staff agreed to review this topical report to expedite the review of the DOE license application. NRC acceptance of this topical report will constitute acceptance at the staff level of the methodology utilized by the DOE to demonstrate postclosure criticality safety inside the waste package, in the near field and in the far field. Any DOE license application must demonstrate that the methodology has been used to analyze all types of fuel that will be disposed in the repository and that the probability and consequences of criticality are considered in the DOE performance assessment. The criticality potential of Naval spent nuclear fuel will be evaluated using a methodology described in an addendum to the topical report, which is currently being reviewed by the NRC staff.[1]

In fiscal year 1999, NRC and Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs conducted a review of the topical report. The focus of the CNWRA initial review was on the following aspects of the topical report: (i) master scenario list, (ii) methodology for developing configurations, (iii) probability of critical configurations occurring, and (iv) degradation models of the waste package and waste forms. The results of this review were documented in a request for additional information that was submitted to the DOE.[2] Following the submittal of the request for additional information to the DOE, NRC staff met with DOE staff to clarify the request. DOE then submitted a response to the request for additional information on November 19, 1999.[3] Based on the information in the topical report and in the response to the request for additional information, NRC staff wrote a safety evaluation report, which contained 28 open items. These open items covered important issues the topical report did not sufficiently address to ensure the methodology would be sufficient to determine the risk from postclosure criticality events. In November 2000, the DOE submitted Revision 1 of the topical report (DOE, 2000), which was intended to address the open items in the safety evaluation report and request NRC acceptance of additional portions of the methodology, such as the principal isotope selection methodology. This report documents the results of the CNWRA review of Revision 1 of the topical report.

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[1]Mowbray, G.E. "Naval Nuclear Propulsion Program Addendum to the Yucca Mountain Site Characterization Office: Disposal Criticality Analysis Methodology Topical Report." Letter (October 29) to C.W. Reamer, NRC. Washington, DC: NRC. 1999.

[2]Reamer, C.W. "NRC request for additional information on the DOE Topical Report on Disposal Criticality Analysis Methodology." Letter (August 18) to S. Brocoum, DOE. Washington, DC: NRC. 1999.

[3]Brocoum, S. "DOE Responses to the NRC request for additional information on the DOE Topical Report on Disposal Criticality Analysis Methodology." Letter (November 19) to C.W. Reamer, NRC. Washington, DC: NRC. 1999.

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Section 3.5.2.1.1

1. The principal isotope selection neglects light activation/fission products with small thermal neutron cross sections that may increase the moderation within the system. Because the system within the waste package is expected to be undermoderated, it is possible that these additional light elements could increase the reactivity of the system. DOE needs to demonstrate that neglecting these moderation effects of activation/fission products does not significantly underestimate the calculation of the reactivity of the system.

2. The list of fissile and fissionable isotopes in the principal isotope selection list appears to be sufficient. Acceptance of the list of neutron-absorbing principal isotopes is dependent on the DOE demonstration that the computer codes used to predict isotopic concentrations in the fuel can accurately predict the quantity and location of these isotopes in the spent nuclear fuel, including any losses of radionuclides that may occur following removal of the fuel from the reactor. This demonstration will be provided in the validation report for the isotopic concentration prediction computer code and the geochemical analyses to predict losses of radionuclides through small holes and cracks in the cladding.

Section 3.7

3. The consequence calculations in Section 3.7 of the topical report are proposed to be validated with experimental data. Comparisons with experimental data may lead to a conclusion that the model or code yields a nonconservative prediction of the actual consequences of a criticality event. It is not clear how DOE proposes to include bias identified during the validation process into the consequence calculations.

Section 3.7.1.2

4. In the Consequences of Steady-State Criticality Section, it is not clear whether increased spent nuclear fuel degradation or cladding failure caused by higher temperatures is considered a possible consequence of a criticality event. Also, there is no indication that the radiolytic creation of nitric acid from the increased radiation fields from the criticality event will be included in the consequence calculations. The calculation performed to assess these consequences indicates that this process could lead to increased degradation of the fuel cladding (Bechtel SAIC Company, 2001).

Section 3.7.2.3

5. In the Consequences of External Criticality Section, it is not clear whether the DOE will investigate if any additional radionuclides need to be considered following a criticality event. For a criticality event in the alluvium in the saturated zone, short-lived fission products that transport rapidly to the location of the receptor could be formed before they decay to stable nuclides, which could lead to larger doses than the doses from the long-lived radionuclides that are considered significant under nominal conditions.

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Section 3.7.3.2

6. The experiments listed as examples of tests to validate the computer code are used to assess the consequences of external transient criticality do not appear to include any experiments with a silica-based moderator. The computer code proposed to perform the external transient criticality consequence calculations accounts for changes in the physical properties to the rock, such as mechanical strains, dilation, and melting caused by the criticality event. It is not clear from the methodology described how the code will be validated to ensure that these effects are calculated properly.

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2 REFERENCES

Bechtel SAIC Company. "Radiolytic Specie Generation from Internal Waste Package Criticality." CAL–EBS–NU–000017. Revision 00. Las Vegas, Nevada: Bechtel SAIC Company. 2001.

DOE. "Disposal Criticality Analysis Methodology Topical Report." YMP/TR–004Q. Revision 1. Las Vegas, Nevada: Civilian Radioactive Waste Management System Management and Operating Contractor. 2000.