February 14, 2002

Dr. Stephan Brocoum, Assistant Manager
Office of Licensing and Regulatory Compliance
U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 364629
North Las Vegas, NV 89036-8629

SUBJECT: KEY TECHNICAL ISSUE AGREEMENTS RELATED TO CRITICALITY

Dear Dr. Brocoum:

During a Technical Exchange and Management Meeting held on October 23-24, 2000, the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE) reached agreement on criticality issues within the Radionuclide Transport (RT), Evolution of the Near-Field Environment (ENFE), and Container Life and Source Term (CLST) Key Technical Issues (KTIs). By letters dated November 1, 2000; and February 2, February 21, March 22, and October 12, 2001, DOE provided documents pertaining to NRC/DOE agreements, including a number of documents pertaining to the criticality agreements. The NRC staff has reviewed these documents as they relate to the RT, ENFE, CLST KTIs and the results of the staff's review are enclosed.

After you have reviewed this letter, please contact Mr. James Andersen of my staff to discuss these issues further. He can be reached at (301) 415-5717.

Sincerely,

/RA/

Janet Schlueter, Chief
High-Level Waste Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated
cc: See attached distribution list

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Letter to S. Brocoum from J. Schlueter dated February 14, 2002

cc:

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NRC Review of DOE Documents Pertaining to
Key Technical Issue Agreements Related to Criticality

The U.S. Nuclear Regulatory Commission (NRC) goal of issue resolution during this interim pre-licensing period is to assure that the U.S. Department of Energy (DOE) has assembled enough information on a given issue for NRC to accept a license application for review. Resolution by the NRC staff during pre-licensing does not prevent anyone from raising any issue for NRC consideration during the licensing proceedings. Also, and just as importantly, resolution by the NRC staff during pre-licensing does not prejudge what the NRC staff evaluation of that issue will be after it's licensing review. Issues are resolved by the NRC staff during pre-licensing when the staff has no further questions or comments about how DOE is addressing an issue. Pertinent new information could raise new questions or comments on a previously resolved issue.

This enclosure addresses several NRC/DOE agreements made during the Criticality Technical Exchange and Management Meeting on October 23-24, 2000 (see NRC letter dated October 27, 2000, which summarized the meeting). By letters dated November 1, 2000; and February 2, February 21, March 22, and October 12, 2001, DOE submitted a number of documents to address some of the criticality agreements. The documents submitted and associated Key Technical Issue (KTI) agreements are discussed below:

1) Radionuclide Transport Agreement 4.01
Evolution of the Near-Field Environment Agreement 5.01
Container Life and Source Term Agreement 5.01

Wording of the Agreement: Provide Revision 1 to the Topical Report. DOE stated that it will provide the Disposal Criticality Analysis Methodology Topical Report, Revision 01, to NRC during January 2001.

NRC Review: DOE provided the Disposal Criticality Analysis Methodology Topical Report on February 21, 2001 and in a letter dated December 10, 2001, the NRC staff stated that it had accepted the document for detailed review. In the enclosure to the NRC's letter, the staff outlined the review schedule (final amendment to the safety evaluation report targeted for December 2002). These agreements will continue to be characterized as received until the NRC completes its review and issues the Final Amendment to the Safety Evaluation Report.

Additional Information Needed: None at this time.

Status of Agreement: Radionuclide Transport (RT) Agreement 4.01, Evolution of the Near-Field Environment (ENFE) Agreement 5.01, and Container Life and Source Term (CLST) Agreement 5.01 will continue to be characterized as "Received."

2) Radionuclide Transport Agreement 4.02
Evolution of the Near-Field Environment Agreement 5.02

Wording of the Agreement: Provide the updated FEPs [features, events, and processes] database. DOE stated that it would provide the FEPs AMRs [analysis and model reports] and the FEPs database to NRC during January 2001.

NRC Review: DOE provided, and NRC reviewed the following documents as they pertain to this agreement: Features, Events, and Processes: Disruptive Events (ANL-WIS-MD-000005, Rev 00, ICN 01), Features, Events, and Processes: System Level and Criticality (ANL-WIS-MD-000019, Rev 00, ICN 00), and FEPs Database (TDR-WIS-MD-000003, Rev 00, ICN 01). These FEPs documents were discussed during the two Total System Performance Assessment and Integration (TSPAI) technical exchanges held in May and August 2001, as well as the Range of Operating Temperatures technical exchange in September 2001. During these technical exchanges, the NRC and DOE reached a number of separate agreements pertaining to FEPs (see TSPAI Agreements 2.01 to 2.04) and criticality (CLST.5.03). The main issue is that, in light of the Supplemental Science and Engineering Report, DOE can no longer screen out in-package, near-field, or far-field criticality based on no waste package failure before 10,000 years (as indicated in the FEPs and Probability of Criticality Before 10,000 years reports). With the specific TSPAI and CLST agreements in place, the NRC believes this agreement can be listed as complete. Note that CLST Agreement 5.03, although not specifically stated, addresses near-field, far-field, and in-package criticality. Resolution of the criticality subissues depend on the satisfactory resolution of the remaining CLST Subissue 5, ENFE Subissue 5, and RT Subissue 4 agreements, as well as the criticality related portion of TSPAI Agreements 2.01 through 2.04.

Additional Information Needed: None at this time.

Status of Agreement: RT Agreement 4.02 and ENFE Agreement 5.02 are complete.

3) Container Life and Source Term Agreement 5.02

Wording of the Agreement: Provide the Disruptive Events FEPs AMR, the FEPs database, and the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation. DOE stated that it will provide the FEPs AMRs, the Analyses to Support Screening of System-Level Features, Events, and Processes for the Yucca Mountain Total System Performance Assessment-Site Recommendation AMR, and the FEPs database to NRC during January 2001.

NRC Review: DOE provided, and NRC reviewed the following documents as they pertain to this agreement: Features, Events, and Processes: Disruptive Events (ANL-WIS-MD-000005, Rev 00, ICN 01), Features, Events, and Processes: System Level and Criticality (ANL-WIS-MD-000019, Rev 00, ICN 00), and FEPs Database (TDR-WIS-MD-000003, Rev 00, ICN 01). These FEPs documents were discussed during the two Total System Performance Assessment and Integration (TSPAI) technical exchanges held in May and August 2001, as well as the Range of Operating Temperatures technical exchange in September 2001. During these technical exchanges, the NRC and DOE reached a number of separate agreements pertaining to FEPs (see TSPAI Agreements 2.01 to 2.04) and criticality (CLST.5.03). The main issue is that, in light of the Supplemental Science and Engineering Report, DOE can no longer screen out in-package, near-field, or far-field criticality based on no waste package failure before 10,000 years (as indicated in the FEPs and Probability of Criticality Before

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Additional Information Needed: None at this time.

Status of Agreement: CLST Agreement 5.02 is complete.

4) Radionuclide Transport Agreement 4.03
Evolution of the Near-Field Environment Agreement 5.03
Container Life and Source Term Agreement 5.04

Wording of the Agreement: Provide the list of validation reports and their schedules. DOE stated that the geochemical model validation reports for "Geochemistry Model Validation Report: Degradation and Release" and "Geochemistry Model Validation Report: Material Accumulation" are expected to be available during 2001. The remainder of the reports are expected to be available during FY2002 subject to the results of detailed planning and scheduling. DOE understands that these reports are required to be provided prior to LA. A list of model validation reports was provided during the technical exchange and is included as an attachment to the meeting summary.

NRC Review: The NRC reviewed the Geochemistry Model Validation Report: Material Degradation and Release Model (ANL-EBS-GS-00001) and Geochemistry Model Validation Report: External Accumulation Model (ANL-EBS-GS-00002) and determined that the documents do not satisfy the intent of the agreements. The NRC review focused on model validation discussions. The staff's concerns are outlined below. The staff notes that some of these issues can be resolved by clarifying statements from DOE, or future revisions of these or other documents.

It is not clear whether the validation approach in the Geochemistry Model Validation Report: Material Degradation and Release Model is consistent with language in DOE's November 19, 1999, response to the NRC's August 18, 1999, request for additional information (RAI) on the DOE Disposal Criticality Analysis Methodology Topical Report. In that response, DOE stated that they would use the following comparisons for degradation model validation: analytical solutions, "chaining" several EQ6 runs, and other codes. In the model validation report, DOE only used the first comparison. It is not clear if those other validation reports (which have not yet been submitted) are oriented to the needs of criticality modeling.

In addition, the comparisons in this report appear to straddle the line between validation and calibration. For example, in the glass test comparison, several smectite precipitation rate models are used in the effort to match experimental Mg concentrations. Similarly, for the archeological glass comparison, two dissolution rate models are employed, one yielding a better result. In the fuel model discussion, the log K for PuO_2 solubility is varied, and the model is "refined" to better fit uranium concentrations.

Finally, validation discussions are not always related to how they may affect criticality modeling. The results of validation exercises should be discussed in the context of how uncertainties in the models would be reflected in criticality model conclusions.

Regarding the Geochemistry Model Validation Report: External Accumulation Model, as discussed above, the validation approach is not consistent with DOE statements in its November 19, 1999, RAI response. In the RAI response, Attachment 2 (see also SER Rev 00, section 3.4.2.3), DOE described its approach as follows: "...comparison between codes (both EQ3/6 and PHREEQC), comparison with experimental data, and comparison with natural analogs." The methods are not included in this report. Again, it may be that the validation report for PHREEQC (which has not been reviewed) contains the complete validation, but it is not clear from this report.

This report contains a single validation comparison exercise. Predicted precipitated phases are compared to experimental results, but the agreement does not appear to be as good as claimed. For example, none of the identified iron phases were predicted, and matches of uranium phases were poor in one case. If these mismatches are not significant to model results, the reports should explain why the apparently poor predictions are not important.

Two other components of validation were contained in the report: a discussion of the fact that the model includes all important aspects of the fracture system, and a justification for neglecting other accumulation mechanisms. These exercises may be more properly classified as model development and scenario analysis, respectively, rather than validation.

Additional Information Needed:

1) Provide the complete validation approach for both models, to be consistent with discussions in both the Topical Report and the DOE RAI Response.

2) Provide justification that the exercises in these reports constitute model validation independent of model development and calibration. If they do not, then provide model validation results.

Status of Agreement: RT Agreement 4.03, ENFE Agreement 5.03, and CLST Agreement 5.04 need additional information to support a potential licensing review. Since additional validation reports must be submitted as discussed in the agreements, the agreements will continue to be characterized as "Partly Received."

5) Container Life and Source Term Agreement 5.03

Wording of the Agreement: DOE will provide an updated technical basis for screening criticality from the post-closure performance assessment. The technical basis will include (1) a determination of whether the formation of condensed water could allow liquid water to enter the waste package without the failure of the drip shield, and (2) an assessment of improper heat treatment, if it is shown to result in early failure of waste packages, considering potential failure modes. The documentation of the technical basis is comprised of (1) Analysis of Mechanisms for Early Waste Package Failure AMR, (2) Probability of Criticality Before 10,000 years calculation, and (3) Features, Event, and Process System Level and Criticality AMR. The first document will be provided to NRC in FY02, the second and third documents will be provided in FY03.

NRC Review: During the October 23-24, 2000, meeting on criticality, DOE agreed to provide the calculation Probability of Criticality Before 10,000 Years (CAL-EBS-NU-000014, Rev 00). NRC reviewed the calculation and discussed it during the Total System Performance Assessment and Integration meeting on August 6-10, 2001. As a result of that meeting, CLST Agreement 5.03 was

modified and DOE agreed to provide an updated technical basis for screening criticality from the post-closure performance assessment. Note that CLST Agreement 5.03, although not specifically stated, addresses near-field, far-field, and in-package criticality.

Additional Information Needed: None at this time, DOE agreed to provide the information in FY02 and FY03.

Status of Agreement: CLST Agreement 5.03 is currently categorized as "Not Received."

6) Container Life and Source Term Agreement 5.05

Wording of the Agreement: Provide information on how the increase in the radiation fields due to the criticality event affects the consequence evaluation because of increased radiolysis inside the waste package and at the surfaces of nearby waste packages or demonstrate that the current corrosion and dissolution models encompass the range of chemical conditions and corrosion potentials that would result from this increase in radiolysis. DOE stated that the preliminary assessment (calculation) of radiolysis effects from a criticality event will be available to NRC during February 2001. The final assessment of these conditions will be available to NRC prior to LA.

NRC Review: The NRC reviewed the Radiolytic Species Generation from Internal Waste Package Criticality (CAL-EBS-NU-000017). The conclusion of this report is that the generation of nitric acid from the increased radiation fields associated with the criticality event could significantly change the pH of the water in the waste package and potentially increase the degradation rate of cladding in the waste package, pending further analysis of the scavenging effects of other materials in the waste package. This could lead to significant increases in the dose rate at the receptor group location and, therefore, this process needs to be incorporated into analyses of the consequences of a steady-state criticality event unless further analyses are sufficient to show that this process is not important.

In an update to this calculation or the in final assessment (to be provided by license application), consider the following:

1) The power level of the criticality in the calculation is 1 kW, which is lower than the power level calculated in Rev. 0 of the Topical Report (2.2 kW). A higher power level would lead to greater production of nitric acid.

2) The report assumes that the generation factor for nitrogen dioxide for neutrons is equal to the generation factor for gamma rays without sufficient basis. This assumes that the linear energy transfer (LET) of the radiation does not affect the quantity of nitrogen dioxide produced per unit energy absorbed by the material. However, for the radiolytic generation of hydrogen, Spinks and Woods (1990)[1] found that the G-value for alpha radiation (a high-LET radiation) is about three times higher than the G-value for beta/gamma radiation. Additional basis needs to be provided to support the G-value for high-LET radiation for the production of nitrogen dioxide.

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[1]Spinks, J.W.T. and R.J. Woods. An introduction to radiation chemistry, 3rd edition. Wiley-Interscience, New York. 1990.

3) The report does not consider the potential for the generation of nitrogen dioxide by alpha radiation. This could be a significant contribution to the total nitric acid generation due to the higher G-values associated with alpha radiation.[2]

Additional Information Needed: DOE should consider the above points in the next update to this calculation or the in final assessment (to be provided by license application). No additional information is needed at this time.

Status of Agreement: CLST Agreement 5.05 will continue to be characterized as "Partly Received."

[2] Ibid