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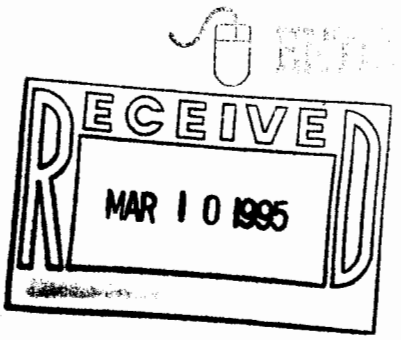

Lindsay A. Lovejoy, Jr.
Assistant Attorney General
P.O. Drawer 1508
Santa Fe, N.M. 87504-1508

Dear Mr. Lovejoy:

This letter answers the questions raised regarding the Rock Mechanics Position Paper. I appreciate your interest and continued participation in the Systems Prioritization Method.

If you have any questions regarding this response, please contact Mr. Robert Bills at (505) 234-7481.

Sincerely,

Michael H. McFadden
Assistant Manager
Office of Regulatory Compliance

Enclosure

cc w/ enclosure:
R. Lark, CAO
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RESPONSE TO STAKEHOLDER COMMENTS: ROCK MECHANICS POSITION PAPER

AG-1. The draft presents what is deemed by the writer to be a defensible position which would be advanced for compliance (see abstract and draft, 4). It is not clear whether any revision is planned. Please explain. Any revision should be provided to stakeholders, comment should be received on the revision, and a meeting should be held.

Response. Performance assessment is an iterative process. Substantive changes in modeling the rock mechanics of the WIPP will be documented as updates to this Position Paper and will be briefed to the stakeholders. We believe that we can best answer the stakeholders' concerns by conducting a completely open and scientifically sound process, using future versions of the Position Papers to communicate changes in modeling the performance of the repository.

AG-2. The draft states that model definitions and parameter values are too extensive to set forth and cites a volume of the 1992 Performance Assessment (PA) (at 2). The approach of citing large volumes of multi-volume works as references, without specifying the intended page, is inadequate.

Response. Comment acknowledged. The specific location in the 1992 Performance Assessment is Volume III, Appendix A, page 109.

AG-3. Several potential improvements in creep technology are mentioned (at 7), but there is no statement of DOE's plans to achieve these. Please provide such information.

Response. The status of distribution functions for argillaceous salt is described in the response to Comment AG-10. The status of the fast probability integration methodology is discussed on page 18, lines 15-22 of the Position Paper. Any significant computational improvements in speed or capabilities will be reported in future updates of this Position Paper.

AG-4. It is stated that the M-D model has successfully simulated room closure. However, the cited reference (Munson et al., 1989a) mentions the need to reevaluate stratigraphy (at 40, 51, 58) and refers to its approach as a "preliminary attempt" (at 61). Does DOE propose further efforts to resolve these qualifications?

Response. As noted on page 7 of the Position Paper, the M-D model has successfully simulated *in situ* room closure data using the recommended updated stratigraphy defined in Munson et al., 1989a. The successful simulations using this recommended stratigraphy supersede the concerns discussed in the 1989 report by Munson et al..

AG-5. Is the M-D model in a simplified form, omitting consideration of recovery, to be applied in examination of seal designs, contrary to the caution noted in Munson et al., 1989a, at 22?

Response. Consideration of recovery has not been omitted from the M-D model; however, higher order effects are not included because they are unnecessary for representing the salt response under the slow unloading conditions found in the WIPP. Technical details of the recovery model are contained in:

Munson, D.E., 1993. *Extension of the M-D Model for Treating the Stress Drops in Salt,* Proceedings of the Third Conference on the Mechanical Behavior of Salt, Ecole Polytechnique, Palaiseau, France, pages 31-44. September 14-16, 1993.

It is our intention to use the full M-D model whenever possible, including for the evaluation of seal designs. In a few cases it may be necessary to use a simpler model because of computational limitations.

AG-6. The continuum creep model does not include fracture and cannot simulate roof failure (draft at 10). Does this shortcoming affect any contemplated application of the model?

Response. No. The multimechanism deformation continuum creep model coupled to fracture, denoted as the MDCF model in the Position Paper, can simulate fracture and roof failure and will be used as necessary.

AG-7. What "similar results" are referred to (at 10 1.16); if such results are not published, they should be made available.

Response. The references for the "similar results" are identified in Table V of the Position Paper.

AG-8. There is reference (at 15) to use of the M-D model with the SPECTROM-32 code to calculate closure of the EATF baseline configuration. Please provide a reference for this statement or, if unpublished, data supporting the statement.

Response. The successful calculation of the EATF baseline configuration with the M-D model in the SPECTROM-32 code is described in:

Butcher, B.M. and F.T. Mendenhall, 1993. *A Summary of the Models Used for the Mechanical Response of Disposal Rooms in the Waste Isolation Pilot Plant with Regard to Compliance with 40 CFR 191, Subpart B.* SAND92-0427. Albuquerque, NM: Sandia National Laboratories.

AG-9. The draft says that in certain circumstances the model described in Morgan et al., 1986, will be used to calculate creep (at 14 1.10-22). What are these circumstances?

Response. It is our intention to use the full M-D model whenever possible. The model described in the cited Morgan reference will be used in cases where the refinements of the M-D model are not required and the computational time for the M-D model is excessive relative to the accuracy required.

AG-10. The draft states that distribution functions for parameters with respect to argillaceous salt still have to be determined (at 16). Until such is done, the white paper is incomplete.

Response. Theoretical work on the distribution functions has been completed and a draft manuscript has been prepared. We expect approval and publication in the very near future.

AG-11. The draft also states that additional evaluations of shaft closure have to be made and that comparisons must be made of the fast probability integration method with Monte Carlo sampling (at 16). The white paper is incomplete without the resulting data.

Response. The Position Paper presents a "snapshot" of the Rock Mechanics Program as of September, 1994. The results of ongoing work will be reported to the stakeholders as soon as studies are completed and reports or papers are reviewed and approved for publication

AG-12. Concerning the fracture model, the draft notes that there is ongoing work on several fronts:

a. theoretical inputs to define the cleavage modes of fracture and complete the fracture model.

b. development of the capability to handle bed separation.

c. generation of the experimental data base for argillaceous salt.

d. final parameter selection.

e. comparison to underground observations of damage.

(draft at 20, see also 21-22). Until these processes are completed and the data reported, it is premature to comment on the fracture model.

Response. Details of the ongoing work in the areas a.-e. are as follows:

a. The theoretical aspects of the cleavage mode have been completed. A draft manuscript describing this work has been prepared and we expect approval and publication in the near future.

b. Bed separation cannot occur in the shaft and therefore is not a critical aspect of the fracture model for use in seal performance assessment. The theoretical work to include bed separation in the general model is currently in progress.

c. The experimental database for the fracture characteristics of the argillaceous salt is available, although not extensive. Based on these data, a model of argillaceous behavior has been developed which is not documented in a draft manuscript. We expect approval and publication of the manuscript in the near future.

d. The final parameter selection will be made as further data become available and are analyzed and used in the validation exercises. The final parameter selection will be performed to meet the appropriate milestones for the compliance submittal process.

e. A comparison of the underground observations of damage has already been accomplished. The paper describing the comparison has been accepted for a technical symposium in June, 1995. The work will be published in the symposium proceedings and made available at the time of the symposium.

AG-13. It is stated that the technology of discrete fracture formation and propagation is still less well developed (at 23, 26). Again, it is premature to comment without a published model and supporting data.

Response. The modeling of discrete crack formation and propagation is described in Chan et al., 1992. Additional work is in progress to address the localization of the damage to produce a discrete fracture, as noted in the Position Paper.

AG-14. Concerning the DRZ, the draft notes the need for certain additional information viz: water saturation, porosity, and permeability (at 27, 29, 30, 31, 32). The absence of such data creates a concern. What efforts will be made to obtain such data?

Response. The development of models for the DRZ has been documented in three references:
(i) Chan et al, 1992,
(ii) Brodsky et al., 1994, and
(iii) Chan, K.S., Bodner, S.R., Fossum, A.F. and D.E. Munson, *Constitutive Representation of Damage Development and Healing in WIPP Salt,* to be published in the 35th U.S. Rock Mechanics Symposium, 1995.

At the present time, the key objective of DOE efforts is to define the permeability-damage relationship. A model for the permeability-damage relationship exists and will be validated with *in situ* data from small scale sealing experiments in the near future.

AG-15. The DRZ model, described as a process model, incorporates the creep model, the MDCF fracture model, a model of the healing of micro-fractures, and a model relating damage to permeability (at 20). These models are not complete, making it premature to comment on the DRZ model.

Response. The intent of the Position Paper is to present the status of the models in the Rock Mechanics program. While the models are in varying stages of development and validation, they have a solid theoretical basis and are indeed capable of producing sound technical information.

AG-16. The discussion at page 28, lines 13-24, lacks citation or data support for the assertions concerning the DRZ process model. The assertions, therefore, cannot be accepted.

Response. The appropriate citations for the DRZ process model are listed in the response to Comment AG-14.

AG-17. The draft also notes controversial unresolved issues of the relation between DRZ deformation and Salado and DRZ hydrology and the effect of chemical precipitation in fractures and pores of the DRZ (at 31). These issues should be pursued, and the results may raise additional concerns.

Response. The permeability-damage relationship for the DRZ hydrology is an area of on-going study, as noted in the response to Comment AG-14. There currently are no plans to evaluate the effect of chemical precipitation in the fractures and pores of the DRZ because this is believed to be a secondary effect that will probably reduce, rather than increase, the permeability of the DRZ.