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June 14, 1985

Dr. M. S. Nataraja
Engineering Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Dr. Nataraja:

The enclosed monthly report summarizes the activities during the month of May for FIN A-1755.

If you have any questions, please feel free to contact either myself at FTS 844-8368 or E. J. Bonano at FTS 844-5303.

Sincerely,

R. M. Cranwell

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Supervisor
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PROGRAM:	Coupled Thermal-Hydrological-Mechanical Assessments and Site Characterization Activities for Geologic Repositories	FIN#: A-1755
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD 10/84-9/85
DRA PROGRAM MANAGER:	M. S. Nataraja	BUDGET AMOUNT: 365K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE: 844-8368
PRINCIPAL INVESTIGATOR:	E. J. Bonano	FTS PHONE: 844-5303

PROJECT OBJECTIVES

To provide technical assistance to NRC in the assessment of coupled thermal-hydrological-mechanical phenomena and site characterization activities for high-level waste repositories.

ACTIVITIES DURING MAY 1984

Activities and Accomplishments

Primary activities during May consisted of a review of ONWI-545 ("Performance Assessment Plans and Methods for the Salt Repository Project"), and ONWI-547 ("BORHOL: A Computer Code to Evaluate Dissolution, Precipitation, Creep, and Temperature"); attendance to a shaft drilling conference in Las Vegas, Nevada; and frequent telephone conversations with NRC staff on a number of issues related to thermal and thermo-mechanical effects. The review of ONWI-545 was completed and a hand-written draft forwarded to the NRC; a typed copy of the review comments is attached. The review of ONWI-547 is still in progress. A trip report from the Las Vegas conference will be forwarded within two weeks.

Travel

Krishan Wahi traveled to Las Vegas, Nevada to attend the 1985 Conference of the Institute of Shaft Drilling Technology on May 22-24.

Problems Encountered

None.

SNLA REVIEW COMMENTS FOR ONWI-545

General Comments

1. Many important terms have not been defined or are defined poorly and ambiguously. Terms such as validation, verification, benchmarking need to be defined clearly and unambiguously. Further, their use in the document should be consistent. Multiple definitions of the same term (e.g., validation) within this document detract from the need for such terms in the first place.

2. Several different types of models are mentioned and discussed in the document. For example, physical, mathematical, conceptual, and numerical models are all planned to be used in the performance assessment. However, the term "model" by itself is used frequently to mean conceptual models. All the model types need to be defined clearly, including the terms "model" and "code".

3. Possible dependence on temperature of many parameters and properties is not adequately addressed.

4. The phenomenon of creep is extremely important for salt repositories both during preclosure and post closure periods. Very little attention has been given to the fact that the uncertainties in quantifying creep and its parameters are very large. No means have been identified that would reconcile large differences between measured and predicted creep rates.

5. Very brief mention is made of the potential couplings between processes at a given spatial scale (e.g. far field). It is not at all clear how and what couplings will be made between scales. For example, what couplings will be necessary in relating the very-near field response to the near-field response and how will the couplings be accomplished.

6. Despite the stated plans to "validate" all the models (codes?), it is unrealistic to expect that even half of the models can be validated within the time and monetary constraints. This limitation must be recognized and reconciled. The need for a standard definition of validation (at least for the purpose of this document) is underscored. No reference time-scale is provided for validation.

7. The criteria for having selected the performance assessment codes given in Table A-1 are not identified. The issue is not whether the best codes have been chosen, but whether the codes chosen are adequate to perform their intended performance assessment function.

SNLA REVIEW COMMENTS FOR ONWI-545

Specific Comments

Chapter 1

1. The expression "acceptability criteria" is used twice in section 1.1. The first paragraph under section 1.1 on p. 1 uses it in the context of consequences; the second paragraph (p.2) uses it for design requirements. It is not clear whether these are DOE's or NRC's criteria.

2. The last paragraph on p.6 (section 1.3) asserts that water intrusion is the most important scenario for radionuclide transport. The basis for this assertion should be identified; if determined from studies, those studies should be referenced.

3. The second paragraph on p.7 (section 1.3) states that: "Every code used in an assessment must undergo verification and validation to demonstrate the reliability of its results." It further states, "validation usually entails a comparison of model results to available data." If the more commonly accepted definition of validation is used, the first of the two statements quoted could have enormous implications. The definition of validation, as given on p.7, is inconsistent with that(or those!)used in the waste management community. It is also not consistent with the usage elsewhere in the document (e.g., p. 46). The definition of validation provided by 10CFR 60 is given in chapter 11, but it is unclear whether this is the definition DOE intends to use.

4. In Table 1-1 on p.8, item 4 refers to "benchmarking". This term needs to be defined. Again, the definition given elsewhere in the document is different from the usual context in which benchmarking consists of: defining a hypothetical problem, solving it with more than one code, and cross-comparing the results.

5. Figure 1-4, allegedly a Logic Chart, is not only out-of-date, but extremely cluttered to serve as a visual aid.

Chapter 2

6. Subsection 2.2.1, titled "Very Near-Field Analysis," states on p.25 that mechanisms by which radionuclides may move through the solid salt will need to be investigated. In the very near-field, it is more important to understand and investigate the mechanisms that control movement through the backfill or unconsolidated salt.

7. The last paragraph in subsection 2.2.1 (p. 25) states that, "Nonuniform corrosion could result in early package failure--."
This statement is not consistent with the ones in salt EAs that implied that uniform and non-uniform corrosion rates were approximately the same.

Chapter 3

8. The first paragraph on p.31 identifies DOE documents (NWTS-33 (1) thru (4a)) that establish general preclosure and postclosure performance objectives. It is noteworthy that DOE's "Issue Paper" on performance goals (April '85) states that performance and design goals for the preclosure system will not be shown in the SCPs.

9. The performance criteria summarized in Table 3-1 (pp.32-38) do not specify performance requirements for engineered barriers. Effects of site characterization on the long-term isolation capability are not addressed by the performance criteria.

Chapter 4

10. The various types of models need to be defined at the start of this chapter on p.41. Subtle differences between certain model types need to be elucidated. Differences between models and codes need to be described.

11. Under 4.1.2 (Development and Modification) on p.42, the process of "Modifying the model to test the assumptions made" is unclear. An example is needed to make the point.

12. The last paragraph on p.42 under 4.1.2 appears to have confused benchmarking with verification. Specifically it states that, "The correctness of results predicted by a model will be tested against similar models (verification)---."
This type of testing is more commonly known as benchmarking.

13. The discussion on numerical methods (section 4.3.2, p.46) is very limited and somewhat misleading. It is implied that all numerical methods are iterative; which is not the case. Explicit finite difference techniques, for example, require a stability criterion rather than a convergence criterion, and frequently do not use iteration. In some applications hybrid solution schemes (e.g., boundary element and finite element) are used. Certain integrals can only be evaluated numerically but do not involve iteration in the solution algorithm.

14. The discussion on Data Uncertainties (section 4.4.2) does not address the types of statistical distributions (e.g., log normal) that can be assigned to input parameters. Certain parameters are known to follow a given distribution.
It is also not clear whether natural variability uncertainty can or should be lumped with other types of uncertainties. If enough data do not exist for an input parameter, how will a distribution be assigned to it?

Chapter 6

15. In Section 6.3 (p.62), the data needs have been grouped into seven areas. Missing from this list are areas of Rock Mechanics and/or Geomechanics. The in-situ stress, rock strength, rock mass characteristics etc., all need to be a part of the data list for performance assessment.

16. The requirements given on p.63 (section 6.3) do not include one that is extremely important; namely, Unambiguous parameter definition. For example, the term "porosity", if not qualified (and sometimes even if qualified), can be interpreted to mean effective, total, matrix or other types. A Young's modulus for anisotropic rock could be its value in one direction, an average of values in different direction or something totally meaningless, unless defined a priori.

17. The discussion in section 6.3.3, pp.68-70 (Thermomechanical Data) does not address the very likely dependence of creep paramenters on temperature; neither does it say anything about the creep behavior of the crushed backfill.

18. The Data List (section 6.3.3.1, pp.69-70) contains in-situ stress at repository depth. It is important to know the state of stress above and below the repository horizon as well. In fact, the ambient state of stress should be known all the way to the surface for proper modelling of thermomechanical response in the far-field.

Chapter 7

19. In the Thermal Analysis discussed under section 7.2, it is not clear what thermal boundary assumptions will be used for the un-backfilled rooms. Adiabatic, isothermal, or convective conditions could be presecribed. In the first few decades, the temperature predictions can vary significantly depending on the choice of the boundary condition.

20. The first sentence on p.90 refers to an "axisymmetric generalized plane strain formulation". It is not clear whether this refers to a one-dimensional analysis in which the radial distance is the only variable dimension. For a two-dimensional model the above formulation is not meaningful.

22. Section 8.3 (Thermomechanical Analysis, p.105) refers to use of computational methods to quantify the disturbed zone under in-situ and excavation stresses. Since the method of excavation has a large influence on the excavation stresses, the computational method(s) would need to numerically simulate and distinguish between different excavation methods. It is not known whether the SRP performance assessment codes have such capability.

23. The thermomechanical analyses noted in Figure 8-2 will include a creep model. It is not given whether transient, steady-state or both types of creep laws will be included in the models. The transient heat source in combination with open drifts may make it necessary to include transient creep.

24. Section 8.4.2 addresses resaturation and suggests first, simple bounding calculations, to be followed by a few simulations with complex modeling. No analytical tools or computer models are identified as having the capability to do these resaturation calculations.

25. Section 8.4.3 (p. 112) mentions three conceptualizations of a fractured system. On p. 113 it is stated that the performance assessment capabilities include codes for analysis using the above approaches (i.e., Conceptualization). None of these codes have been identified in the document

26. Item 2 in section 8.5 on Geochemical Reactions (p. 113) makes reference to nonsalt materials used for repository backfilling. This is the only instance, to the best of our knowledge, where a nonsalt backfill is envisioned in a salt repository design concept. If a nonsalt backfill is used, numerous implications result with respect to the assumed characteristics of reconsolidation, fracture healing, and heat transfer. Likewise, different analytical tools may be needed to perform the analyses.

Chapter 10

27. On p. 155, it is stated that the methodology for assessing transportation related exposures is given in NUREG-0170. It is not made clear, however, if DOE intends to use that specific methodology.

28. In discussing radiological exposures and dose calculations no mention is made of inevitable uncertainties in the input and output parameters. Will the treatment of uncertainty be affected by the incorporation of the ALARA concept?

29. Section 10.2.1 (p. 166) discusses the "credible" events lists. The criteria or probability cut-offs for credible events are not given. Likewise, the criteria for deciding what is high-consequence as well as knowing a priori (without having performed the analysis) which low probability scenarios are high consequence have not been mentioned.

31. Section 10.2.3.4 (pp. 172-174) presents a discussion on Radiological Dose Consequences. The assertion that only those modes that have little or no time delay are important (for accidental conditions) is debatable. Accidental releases can conceivably create multiple sources that release radioactivity at higher "background" levels for long times; these levels could be above non-accidental or threshold levels.

Appendix A - General

1. Table A-1 lists codes that can model processes relevant to HLW repositories. The table should clearly identify the mode (i.e., 1-D, 2-D, 3-D) or modes in which each of these codes can be run.

2. The codes that can model resaturation behavior need to be identified. If none of the ones in Table A-1 can simulate resaturation, efforts should be made to include such a code in that table.

Appendix A - Specific Comments

1. BORHOL (pp. 208-211)
For creep response calculations, it is not clear whether the stress field consists of overburden (in-situ) stresses only or whether appropriate thermomechanical stresses induced by the repository are also considered. The findings or conclusions regarding "limited attempts" at verifying portions of BORHOL are not stated.

2. CFEST (pp. 214-222)
It is not clear whether the energy transport capability is restricted to heat transfer, although that appears to be the case. Rock density and heat capacity are stated as being constants, but it is not explicitly stated that thermal conductivity can be a function of temperature. Thermal conductivity of salt is a strong fucntion of temperature and it is important that any codes chosen to model heat conduction have that capability.

3. SWENT (pp. 286-293)
Temperature dependence of thermal properties is not addressed (see comment #2). Limitation on the number of grid blocks or nodes should also be specified.

4. VISCOT (pp. 299-302)
Considering that large deformations cannot be simulated accurately, the appropriateness of VISCOT in predicting creep deformation and room-closure rates is questioned. It is also not clear if a viscoelastic or viscoplastic approximation represents the creep process adequately. Finally, the input parameter needs of VISCOT must be examined carefully because nearly all of the creep data available to date is for an empirical power law formulation.

A-1755
1628.010
May 1985

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	0.7	5.3
II. Direct Loaded Labor Costs	8.0	53.0
Materials and Services	0.0	1.0
ADP Support (computer)	0.0	2.0
Subcontracts	28.0	163.0
Travel	0.0	1.0
Other	2.0	0.0
TOTAL COSTS	38.0	220.0

Other = rounding approximation by computer

III. Funding Status

Prior FY Carryover	FY85 Projected Funding Level	FY85 Funds Received to Date	FY85 Funding Balance Needed
115K	365K	250K	None