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OVERNIGHT MAIL

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RESOLUTION OF U.S. NUCLEAR REGULATORY COMMISSION (NRC) SITE CHARACTERIZATION ANALYSIS (SCA) COMMENT 55 AND COMMENT RECORD FOR U.S. DEPARTMENT OF ENERGY (DOE) STUDY PLANS 8.3.1.15.1.1 (LABORATORY THERMAL PROPERTIES), REVISION 1, AND 8.3.1.15.1.2 (LABORATORY THERMAL EXPANSION TESTING), REVISION 1. (SCPB: 8.3.1.15.1.1 AND 8.3.1.15.1.2)

References: (1) Ltr, Holonich to Milner, dtd 8/22/94
(2) Ltr, Holonich to Milner, dtd 8/22/94
(3) Ltr, Brocoum to Holonich, dtd 12/13/94

In this package the DOE proposes to resolve SCA comment 55, and reconcile a comment response dialog on the two subject study plans that has arisen from mistakes in past correspondence made by both agencies.

This package contains separate enclosures with updated responses to NRC questions on Study Plans 8.3.1.15.1.1 (enclosure 1), 8.3.1.15.1.2 (enclosure 2), and SCA comment 55 (enclosure 3). All three enclosures form the basis of our proposal to resolve SCA comment 55.

SCA Comment 55: The discussion and/or use of statistics in Investigation 8.3.1.15.1 (Spatial Distribution of Thermal and Mechanical Properties) is not clear.

Resolution of SCA Comment 55: The DOE believes that the updated information provided in Enclosures 1, 2, and 3 is sufficient to resolve the questions on Study Plans 8.3.1.15.1.1 and 8.3.1.15.1.2, and SCA comment 55. The statistical approach in the study plans was based on the original approach anticipated in the Site Characterization Plan, which has since become obsolete and unnecessary. The sampling programs will be performed in a manner consistent with case histories of relevant construction projects, professional judgement, and sound engineering practice. The DOE, therefore, requests that the NRC close this SCA open item, the three questions on Study Plan 8.3.1.15.1.1, the four questions on Study Plan 8.3.1.15.1.2, and document this action.

Background on Study Plans: On August 22, 1994, the NRC provided the DOE with three questions on Study Plan 8.3.1.15.1.1, Revision 1 (reference 1), and four questions on

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Study Plan 8.3.1.15.1.2 plus a restatement of SCA Comment 55 (reference 2). The list of "open item questions in Study Plan 8.3.1.15.1.1 (Laboratory Thermal Properties), Revision 1," appear to be inappropriate to this study plan. Rather, these questions appear to involve subjects appropriate to Study Plan 8.3.1.15.1.2 (Laboratory Thermal Expansion Testing). In addition, the enclosure to Reference 2 listed the questions as directed at Revision 2 of Study Plan 8.3.1.15.1.2, and the revision number of Study Plan 8.3.1.15.1.2 was also apparently incorrectly listed in Reference 3. The current version of Study Plan 8.3.1.15.1.2 is Revision 1. In any case, thermal expansion characteristics are being investigated in Study Plan 8.3.1.15.1.2, (Laboratory Thermal Expansion Testing), Revision 1.

If you have any questions, please contact Thomas W. Bjerstedt of my staff at (702) 794-1362 or William J. Boyle in the office of the Assistant Manager for Scientific Programs at (702) 794-5506.

Stephan J. Brocoum
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AMSL:TWB-2501

Enclosures:
1. Responses to Questions on Study Plan 8.3.1.15.1.1
2. Responses to Questions on Study Plan 8.3.1.15.1.2
3. Supplemental Response to SCA Comment 55

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Enclosure 1

Responses to NRC Questions on Study Plan 8.3.1.15.1.1:
(Laboratory Thermal Properties) Revision 1

NRC Question 1

Will this study plan investigate the effects of anisotropy and natural fractures on the thermal expansion characteristics of the samples collected from the ESF Main Access, ESF Main Drifts, and additional sampling locations and the thermal/mechanical units other than TSw2?

Basis

Scoping studies will be conducted to examine the effects of confining pressure, sample size, and the saturation level on thermal expansion behavior, and establish test baseline conditions.

For each new core hole, the presence of anisotropy, natural fractures, and their effects on the coefficient of thermal expansion will be examined for the Unit TSw2. However, the study plan does not address whether the anisotropy and natural fractures will be examined on the ESF Main Access samples (Section 2.2.2.2), ESF Main Drifts samples (Section 2.2.2.3), and additional location samples (Section 2.2.2.4). It is unclear whether the anisotropy and natural fractures will be examined on the thermal/mechanical units other than Unit TSw2.

DOE Response

It appears that the NRC intends for the question to pertain to thermal conductivity and heat capacity rather than thermal expansion. The study plan (DOE, 1993a) identifies scoping studies that will be used to assess the effects of anisotropy and natural fractures on thermal conductivity of Unit TSw2. Outside of the TSw2 the thermal perturbations are substantially reduced (CRWMS M&O, 1994). Test specimens for the scoping study are to come from existing core or outcrops. Pending the results of the scoping study, data needs for investigations of anisotropy and natural fractures in additional locations or other units may be identified. The orientation of the specimen is not expected to affect measurements of heat capacity. If data needs requiring additional investigations are identified, the DOE will evaluate the additional data needs in the context of the scopes and schedules of existing study plans to determine how to best collect the needed additional data.

NRC Question 2

Does the program described in Table 2.2-4 provide enough flexibility to accommodate the DOE's high thermal loading option for the repository design?

Basis

DOE has not decided to use the hot- or cold-thermal-loading option on the repository design (NWTRB, 1992). The multi-purpose canisters (MPC) design concept suggests that DOE may choose the high-thermal-loading option. If DOE decides to choose a high thermal loading for the repository design, the maximum temperature on the surrounding rock may be higher than the current 300°C design level. Therefore, the proposed 300°C thermal range of the laboratory experiments of the current study plan may need to be revised.

DOE Response

Table 2.2-4 of Study Plan 8.3.1.15.1.1 (DOE, 1993a) provides a summary of the DOE's sampling plans to support this study. The DOE believes that this question arose from Table 2.2-4 of Study Plan 8.3.1.15.1.2 (DOE, 1993b) which provides the maximum test temperatures to be used for thermal expansion testing of each thermal/mechanical unit. The closest comparable table in Study Plan 8.3.1.15.1.1 is Table 3.3-2 for heat capacity. No temperature dependence has been observed for the thermal conductivities of the solid components of the samples.

The DOE is evaluating a range of possible thermal loads that could be used in the design of the potential repository. Table 2.2-4 of Study Plan 8.3.1.15.1.2 (DOE, 1993b) provides sufficient flexibility to accommodate the DOE's high thermal-loading option for the repository design. While it is true that some combinations of proposed waste streams and thermal loadings would be capable of producing maximum drift wall temperatures, DOE has developed thermal goals to keep emplacement drift wall temperatures below 200°C (CRWMS M&O, 1993). (For additional descriptions and discussions of the thermal goals, refer to (CRWMS M&O, 1996). The purpose of these goals is to limit the thermal and thermomechanical response of the host rock and surrounding strata, and the groundwater system. Other thermal goals limit temperatures in access drifts and in adjacent units to within the temperature ranges listed in Table 2.2-4. Given the thermal goals, the testing program described in Table 2.2-4 is sufficiently flexible to accommodate the high thermal loading option.

NRC Question 3

What is the rationale for applying the confining pressure normal to the fractures?

Basis

The study plan states that all tests on fractured samples will include a small stress (≤ 7 MPa) normal to the fracture in order to simulate *in-situ* conditions. The fractures in Yucca Mountain are nearly in the vertical direction. The overburden stress is nearly parallel to the fractures. DOE does not provide the rationale why the confining pressure is normal to the fractures. DOE does not explain why the overburden stress 7 MPa is a small stress. DOE does not explain why higher stresses are not considered.

DOE Response

The term "small stress" was a nominal term which was intended to indicate that the stress regime for the tests should be less than the stress necessary to close the fractures. If a "large stress" were used, fractures might be closed, and the effects of fractures on thermal expansion could not be investigated. Hence, the study plan description specifies a "small stress" to ensure that fractures remain open during the testing.

The application of normal compressive stress to the fracture surface is described in section 2.2.3 of Study Plan 8.3.1.15.1.1 (DOE, 1993a). The fractures in Yucca Mountain are nearly vertical and will be subjected to increasing normal compressive stresses as the host rock is heated. Normal compressive stresses reduce the fracture aperture and increase the contact area, and thereby, affect thermal conductivity. Consequently, the determination of normal compressive stresses are considered important. Studies of joint closure (Olsson and Brown, in prep) for fractures in Yucca Mountain tuffs have shown that at normal compressive stresses greater than approximately 5 MPa, the normal stiffness approaches that of the intact rock. Therefore, the effects of fractures are expected to be negligible when the normal compressive stresses exceed 5 MPa. To ensure adequate testing, the Study Plan (8.3.1.15.1.1 Section 2.2-3) specifies a range of normal compressive stresses from 0 to 10 MPa.

NRC Comment on Technical Integration Between Studies

Additionally in light of the review of this and other related study plans (e.g., Laboratory Thermal Expansion Testing (8.3.1.15.1.2) and Laboratory Thermal Properties (8.3.1.15.1.1)), the staff is concerned about the continuing need for improved technical integration and coordination of similar information-gathering activities and procedures.

DOE Response

The study plan identifies data from other studies needed to support the studies described in this plan and describes the uses of data collected by this study in other studies. The data needs are summarized in Section 1.0, and data uses by other studies and activities are described in Sections 1.1.1 and 2.3.8. Rather than restate the information, the study plan refers the reader to these sections for descriptions of the relevant information needs and uses.

Summary

The DOE believes that the foregoing responses demonstrate that the testing methods summarized provide sufficient experiment control and flexibility to resolve the three questions on Study Plan 8.3.1.15.1.1. The responses to the first and second questions indicate that although the testing program described in the study plan is constrained, it provides the data that are needed. The response to the third question demonstrates that the test plan summarized provides sufficient experiment control and flexibility to resolve this open item. Therefore, the DOE requests that the NRC staff close the three open items relevant to Study Plan 8.3.1.15.1.1, and notify the DOE by letter that the comments have been closed.

REFERENCES

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1993. Site Characterization Plan Thermal Goals Re-evaluation, B00000000-1717-5705-00005 Rev. 00, Table 3: TRW Environmental Safety Systems, Inc., September 8, 1993, p 22.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1994. FY 1993 Thermal Loading Systems Study Final Report, Volume II, Appendix F, Rev. 1, B00000000-0717-5705-00013: TRW Environmental Safety Systems, Inc., August 29, 1994.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1996. Mined Geologic Disposal System Advanced Conceptual Design (Revised) Report, Volume III, Engineered Barrier Segment/Waste Package, Required Assumptions EBDRD 3.7.G.2, 3.7.G.3, and 3.7.G.6, B00000000-01717-5705-00027, TRW Environmental Safety Systems, Inc.

DOE (U.S. Department of Energy), 1993a. Study Plan 8.3.1.15.1.1: Laboratory Thermal Properties, Revision 1, effective August 27, 1993.

DOE (U.S. Department of Energy), 1993b. Study Plan 8.3.1.15.1.2: Laboratory Thermal Expansion Testing, Revision 1, effective August 27, 1993.

Olsson, W.A. and S.R. Brown, in prep. Mechanical Properties of Fractures from Drillholes UE-25 NRG-4, USW NRG-6, USW NRG-7, and USW SD-9 at Yucca Mountain, Nevada: SAND95-1736, Sandia National Laboratories Report, Albuquerque, NM.

Enclosure 2

Responses to NRC Questions on Study Plan 8.3.1.15.1.2 (Laboratory Thermal Expansion Testing) Revision 1

NRC Question 1

Will this study plan investigate the effects of anisotropy and natural fractures on the thermal expansion characteristics of the samples collected from the exploratory studies facility (ESF) Main Access, ESF Main Drifts, and additional sampling locations and the thermal/mechanical units other than Unit TSw2 of the Topopah Spring?

Basis

Scoping studies will be conducted to examine the effects of confining pressure, sample size, and the saturation level on thermal expansion behavior, and establish test baseline conditions.

For each new core hole, the presence of anisotropy, natural fractures, and their effects on the coefficient of thermal expansion will be examined for the Unit TSw2. However, the study plan does not address whether the anisotropy and natural fractures will be examined on the ESF Main Access samples (Section 2.2.2.2), ESF Main Drifts samples (Section 2.2.2.3), and additional location samples (Section 2.2.2.4). It is unclear whether the anisotropy and natural fractures will be examined on the thermal/mechanical units other than Unit TSw2.

NRC Recommendation

It is recommended that DOE should include a discussion in the study plan on whether the anisotropy and natural fractures will be examined while testing samples from the ESF Main Access, additional locations, and the units other than Unit TSw2 in new core holes.

DOE Response

The DOE has identified no data needs that would require the investigation of anisotropy and natural fractures in units other than TSw2. Outside of the TSw2 the thermal perturbations are substantially reduced (CRWMS M&O, 1994). Therefore, as indicated in the sampling plan presented in Table 2.2-2 of Study Plan 8.3.1.15.1.2 (DOE, 1993b), and discussions in the last paragraph of Section 2.1 and Section 2.2.1, the present plan limits investigations of anisotropy and fracture effects to unit TSw2. However, if data needs requiring investigations in other units are identified, the DOE will evaluate the additional data needs in the context of the scopes and schedules of existing study plans to determine how best to collect the needed additional data.

NRC Question 2

Does the program described in Table 2.2-4 provide enough flexibility to accommodate the U.S. Department of Energy's (DOE's) high-thermal-loading option for the repository design?

Basis

DOE has not decided to use the hot- or cold-thermal-loading option on the repository design (NWTRB, 1992). The multi-purpose canisters (MPC) design concept suggests that DOE may choose the high-thermal-loading option. If DOE decides to choose a high thermal loading for the repository design, the maximum temperature on the surrounding rock may be higher than the current 300°C design level. Therefore, the proposed 300°C thermal range of the laboratory experiments of the current study plan may need to be revised.

NRC Recommendation

It is recommended that the DOE's alternatives on thermal-loading option be considered in the study plan.

DOE Response

The DOE is evaluating a range of possible thermal loads that could be used in the design of the potential repository. Table 2.2-4 of Study Plan 8.3.1.15.1.2 (DOE, 1993b) provides sufficient flexibility to accommodate the DOE's high thermal loading option for the repository design. While it is true that some combinations of proposed waste streams and thermal loadings would be capable of producing maximum drift wall temperatures, DOE has developed thermal goals to keep emplacement drift wall temperatures below 200°C (CRWMS M&O, 1993). The purpose of these goals is to limit the thermal and thermomechanical response of the host rock and surrounding strata, and the groundwater system. Other thermal goals limit temperatures in access drifts and in adjacent units to within the temperature ranges listed in Table 2.2-4. Given the thermal goals, the testing program described in Table 2.2-4 is sufficiently flexible to accommodate the high thermal loading option.

If the thermal goals are changed, the study will be modified, as necessary, to reflect the changes, and Table 2.2-4 could be changed, as necessary, to accommodate the changes.

NRC Question 3

What is the rationale for applying the confining pressure normal to the fractures?

Basis

The study plan states that all tests on fractured samples will include a small stress (≤ 7 MPa) normal to the fracture in order to simulate *in-situ* conditions. The fractures in the Yucca mountain are nearly in the vertical direction. The overburden stress is nearly parallel to the fractures. DOE doesn't provide the rationale why the confining pressure is normal to the fractures. DOE doesn't explain why the overburden stress 7 MPa is a small stress. DOE doesn't explain why higher stresses are not considered.

NRC Recommendation

It is recommended that DOE provide appropriate rationales for the magnitude and direction of the confining stresses considered.

DOE Response

The basis for this question notes that "the study plan [p. 16] states that all tests on fractured samples will include a small stress (≤ 7 MPa) normal to the fracture in order to simulate in-situ conditions." The term "small stress" was a nominal term which was intended to indicate that the stress regime for the tests should be less than the stress necessary to close the fractures. If a "large stress" were used, fractures might be closed, and the effects of fractures on thermal expansion could not be investigated. Hence, the study plan description specifies a "small stress" to ensure that fractures remain open during the testing.

Under in-situ conditions, a confining stress component is oriented normal to fractures. The confining stress in rock is a function of several variables including depth, rock density, coefficient of lateral earth pressure, and elevated temperatures. Stock et al. (1985) show that under ambient conditions the vertical compressive stress exceeds the maximum horizontal stress by at least 10 percent. However, horizontal compressive stresses are expected to exceed vertical compressive stresses because of thermal expansion caused by heat from the emplaced waste. Since these horizontal stresses will be normal to the nearly vertical fractures in Yucca Mountain, it is logical to apply normal compressive stresses to the fractured samples. Results of investigations indicate that closure of fractures in tuff comprising the repository horizon occurs at a compressive stress of about 5 MPa. For example, studies of joint closure (Olsson and Brown, in prep.) for fractures in Yucca Mountain tuffs have shown that at normal stresses above 5 MPa, the normal stiffness approaches that of intact rock. At normal stresses greater than 5 MPa, the effects of fractures are expected to have a negligible effect on the coefficient of thermal expansion. Since fracture openings are most affected by compressive normal stresses ranging from 0 to 7 MPa, it is likely that the field and laboratory measurements of the coefficient of thermal expansion will differ for this range of confinement. Therefore, the study plan states that stresses less than or equal to 7 MPa will be used, indicating that tests may be conducted with normal compressive stresses between 0 and 7 MPa. Based on in-situ conditions we expect stresses in the range of 2-5 MPa to affect the measurements of the coefficient of thermal expansion. Therefore, to ensure that the effects are adequately investigated, testing was purposely specified over a larger range of 0 to 7 MPa.

NRC Question 4

What is the rationale for heating up and cooling down the TSw2 Unit first, then using the same samples for examining the radiation effects on thermal expansion?

Basis

The study plan states that 20 TSw2 samples will be tested for thermal expansion. After thermal expansion test, ten TSw2 samples will be irradiated. Then, the ten irradiated and ten nonirradiated samples will be retested to examine the radiation effect on thermal expansion.

The thermal effects on the geochemical properties of fracture filling may be irreversible. After heating up the rock samples during thermal expansion measurement, the fracture filling such as clay may be dehydrated and more fractures may be induced during the heating and cooling process. Some uncertainty may be introduced after the first thermal cycle. It may not be meaningful to compare the thermal expansion results under first and subsequent thermal cycles because the initial conditions such as degree of saturation, number of fractures, and fracture filling for the later thermal cycles could change. Therefore, the radiation effects on thermal expansion may be very difficult to quantify.

NRC Recommendation

DOE needs to address the uncertainty of multi-cycle thermal effects on the thermal expansion test. Some test methods may be used to eliminate the uncertainty for the thermal expansion tests. One method may be to vertically split a [sic] larger-diameter TSw2 rock sample into two sets of smaller diameter samples for examining the radiation effects on thermal expansion. It is also feasible to re-core a larger diameter sample into two sets of smaller diameter samples. One set of smaller-diameter samples could be subjected to gamma radiation while the other set could be the base case. The two sets of samples should be tested under the same test control conditions to examine the radiation effects on thermal expansion.

DOE Response

This question apparently addresses the description, on page 19, of an additional concern to be addressed in the scoping study--the potential effects of sample irradiation on the thermal-expansion behavior of Unit TSw2. The DOE wishes to emphasize three points. First, the method described in this section of the study plan is for the scoping study. The intent of the scoping study is to determine whether the testing method is appropriate, and if it is not, to determine possible alternative testing methods which can be applied to accommodate the test characteristics of the parameter in question. Second, the study plan (p. 19) notes the following:

> "If the scoping studies indicate that one or more of the parameters discussed above have a significant effect on the thermal-expansion behavior of the tuffs, the sampling and testing program described in Sections 2.2.1 and 2.2.2 will be modified to include characterization of the parameter effects. Details of such modification cannot be specified until the results of the scoping studies are available."

Finally, the DOE notes that experiments conducted to date indicate that significant differences in thermal-expansion properties do occur between the first and subsequent thermal cycles, and DOE and NRC agree that some thermal effects may be irreversible. Differences in thermal expansion properties have also been observed in samples located near each other. The intent of the scoping study is to provide data to evaluate the assumptions used to design the scoping study and optimize subsequent studies, if additional studies are needed. The DOE does not plan to compare results under first and subsequent cycles as stated in the NRC basis. Rather, the tests introduce the thermal cycles to induce the irreversible thermal effects so that these effects will not play any role during subsequent cycles. Only data from subsequent cycles on irradiated and non-irradiated samples will be compared.

The technique described in the study plan is simply a reliable way to make a laboratory measurement. An alternative might be to take some specimens, test half of them as is and test the other half after irradiation as the NRC suggests. However, even with the precautions listed by the NRC, such as splitting a large specimen into multiple smaller specimens, specimen-to specimen variations would be superimposed on irradiation effects. Another approach is to take a single sample and measure its behavior before and after irradiation. If differences between the first and subsequent heating cycles are found, however, the results may be ambiguous--as recognized in the NRC comment. For these specimens, dehydration occurs (even for oven-dried specimens) during the first heating cycle to 300°C. Work has shown (Martin et al., in prep) that the first heating cycle is different than subsequent cycles for Yucca Mountain tuffs. In fact, ASTM D4535, *Standard Test Method for Measurement of Thermal Expansion of Rock Using a Dilatometer*, calls for performing at least two complete heating and cooling cycles on each sample. If large hysteresis is observed, the method specifies that additional cycles may be necessary. A better approach to testing, therefore, is to take a single specimen, cycle it thermally until the strain-vs-temperature curves are reproducible, then irradiate it and measure expansion again. This method isolates the radiation effects. The method described in the study plan is this last method. The only difference is that the study plan method includes the determination that data on thermal expansion are reproducible after the first cycle, and this conclusion is now supported by data in Martin et al. (in prep.).

Summary

The DOE believes that the foregoing responses demonstrate that the testing methods summarized provide sufficient experiment control and flexibility to resolve the four comments on Study Plan 8.3.1.15.1.2. The DOE therefore requests that the NRC staff close open items relevant to Study Plan 8.3.1.15.1.2 and notify the DOE by letter that the comments have been closed.

REFERENCES

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1993. Site Characterization Plan Thermal Goals Re-evaluation, B00000000-1717-5705-00005 Rev. 00, Table 3: TRW Environmental Safety Systems, Inc., September 8, 1993, p 22.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor), 1994. FY 1993 Thermal Loading Systems Study Final Report, Volume II, Appendix F, Rev. 1, B00000000-0717-5705-00013: TRW Environmental Safety Systems, Inc.,

DOE (U.S. Department of Energy), 1993b. Study Plan 8.3.1.15.1.2: Laboratory Thermal Expansion Testing, Revision 1, effective August 27, 1993.

Martin, R.J., J.S. Noel, M. Riggins, P.J. Boyd, and R.H. Price, in prep. Thermal Expansion of the Paintbrush Tuff Recovered from Borehole USW SD-12 at Pressures to 30 MPa: Data Report: SAND95-1904, Sandia National Laboratories Report, Albuquerque, NM.

Olsson, W.A. and S.R. Brown, in prep. Mechanical Properties of Fractures from Drillholes UE-25 NRG-4, USW NRG-6, USW NRG-7, and USW SD-9 at Yucca Mountain, Nevada: SAND95-1736, Sandia National Laboratories Report, Albuquerque, NM.

Stock, J.M., J.H. Healey, S.H. Hickman, and M.D. Zoback, 1985. Hydraulic Fracturing Stress Measurements at Yucca Mountain, Nevada, and Relationship to the Regional Stress Field: Journal of Geophysical Research, v. 90, no. B10, p. 8691 - 8706.

Enclosure 3

SCA Comment 55 and DOE Response (12/14/90)

NRC Evaluation of DOE Response (7/31/91)

NRC Evaluation of DOE's Study Plan 8.3.1.15.1.2 and Relationship to SCA Comment 55 (8/22/94)

Supplemental Response to Comment 55 Open Item

Section 8.3.1.15.1 Investigation: Studies to Provide the Required Information for Spatial Distribution of Thermal and Mechanical Properties, pages 8.3.1.15-23/31

COMMENT 55

The discussion and/or use of statistics in this chapter is not clear. A statistical approach has been suggested to determine numbers of tests required to determine various rock properties, but the approach suggested is confusing and apparently overlooks several considerations that should be factored into such an approach. Also, needed confidences of "low," "medium," or "high" have been assigned without explaining the basis for such assignments.

BASIS

- In response to CDSCP comment number 45, the DOE has revised Section 8.3.1.15.1 of the SCP to include some additional information on the statistical rationale for proposed experiments. However, this discussion is incomplete and relies heavily upon the results of future parametric or sensitivity studies. Appendix N of SNL, 1987, referenced in the SCP (p. 8.3.1.15-14), contains only a few analyses which can be considered sensitivity parametric analyses.

- The discussion regarding means and standard deviations of required properties is confusing. It is not clear from what sample population the mean and standard deviation are to be determined. Furthermore, the confidence to which these parameters must be known (the standard deviation) has apparently been estimated from "expert judgment" and may not be reliable.

- An acceptable way of determining test needs is to conduct sensitivity or parametric calculations of repository performance in which the input parameters are varied and the response examined. Only limited calculations have been referenced (see Comment 4).

- A statistical analysis is given to determine the number of measurements required to obtain a standard deviation of any given property. This analysis has apparently not considered the following:

  (1) The properties to be determined are not evenly distributed throughout the mass.

  (2) The measured values are a function of testing sample size (and possibly direction).

  (3) Populations may not be normally distributed.

  (4) Sampling may be biased due to jointing, hole direction, etc.

  (5) The determination of the necessary number of samples is based on a Gaussian tolerance interval. The Gaussian assumption may not be appropriate for most of the variables of interest. Also, the method outlined in the text ignores spatial correlation.

Section 8.3.1.15.1 Investigation: Studies to provide the required information for spatial distribution of thermal and mechanical properties, pages 8.3.1.15-23/31

SCA COMMENT 55

The discussion and/or use of statistics in this chapter is not clear. A statistical approach has been suggested to determine numbers of tests required to determine various rock properties, but the approach suggested is confusing and apparently overlooks several considerations that should be factored into such an approach. Also, needed confidences of "low," "medium," or "high" have been assigned without explaining the basis for such assignments.

EVALUATION OF DOE RESPONSE

- DOE states that the validity of assumptions concerning the statistical basis for determination of sample size would be checked as new information (i.e., site-characterization data and results of additional sensitivity studies) becomes available. DOE's response therefore defers any changes in the technical bases for site characterization until new information is available.

- DOE's response does not clarify any of the specific points raised in Comment 55. The staff is concerned that if DOE waits until the data is collected to evaluate the approach to determine the number of tests required to determine various rock properties, several consequences may follow:

    (1) The ability to find "surprises" in the data may be lost; and
    (2) Data which "makes sense" may be accepted, and data which does not "make sense" may be rejected arbitrarily.

- Progress toward closure of this comment will require DOE to submit for NRC staff review results of on-going and future sensitivity studies as the bases for assigning needed confidence levels. DOE also needs to present its evaluation of such studies in assessing the validity of the statistical basis for the determination of sample size.

- The NRC staff considers this comment open for two reasons: (1) DOE has deferred any changes in the technical bases for site characterization until new information is available, and (2) DOE's response did not clarify any of the specific points raised in Comment 55.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

AUG 22 1994

Mr. Ronald A. Milner, Acting Director
Office of Program Management and Integration
Office of Civilian Radioactive Waste Management
U.S. Department of Energy, RW 30
1000 Independence Avenue
Washington, D.C. 20585

Dear Mr. Milner:

SUBJECT: REVIEW OF THE U.S. DEPARTMENT OF ENERGY (DOE) STUDY PLAN ON "LABORATORY THERMAL EXPANSION TESTING, REVISION 1" (8.3.1.15.1.2)

On September 7, 1993, DOE transmitted the subject study plan to the Nuclear Regulatory Commission for review and comment. The NRC staff has completed its review of the subject study plan using the "Review Plan for the NRC Staff Review of DOE Study Plans, Revision 2" (dated March 10, 1993). Based on its review of the study plan, the staff considers the material submitted to be generally consistent, to the extent possible, at this time, with the revised NRC-DOE "Level of Detail Agreement and Review Process for Study Plans" (letter from Shelor to Holonich; dated March 22, 1993).

A major purpose of the review is to identify concerns with studies, tests, or analyses that, if started, could cause significant and irreparable adverse effects on the site, the site characterization program, or the eventual usability of the data for licensing. Such concerns would constitute "objections," as that term has been used in earlier NRC staff reviews of DOE documents related to site characterization (e.g., "Consultation Draft Site Characterization Plan" and the "Site Characterization Plan (SCP) for the Yucca Mountain Site"). It does not appear that the conduct of the activities described in this study plan will have adverse impacts on repository performance and the review of this study plan identified no objections with any of the activities proposed.

As part of its study plan review, the NRC staff also determines whether or not detailed comments or questions are warranted. The NRC staff's review of the subject study plan has resulted in the identification of four questions. The enclosed questions will be tracked by the NRC staff as open items similar to those previously raised by the NRC staff in its 1989 Site Characterization Analysis (SCA).

Additionally, in light of the review of this and other related study plans (e.g., "Excavation Investigations" (8.3.1.15.1.5)) and "Laboratory Thermal Properties" (8.3.1.15.1.1)), the staff is concerned about the continuing need for improved technical integration and coordination of similar information-gathering activities and procedures. The NRC staff identified this concern

STUDY PLAN 8.3.1.15.1.2
LABORATORY THERMAL EXPANSION TESTING, REVISION 2

Question 1
Will this Study Plan investigate the effects of anisotropy and natural fractures on the thermal expansion characteristics of the samples collected from the exploratory studies facility (ESF) Main Access, ESF Main Drifts, and additional sampling locations and the thermal/mechanical units other than Unit TSw2 of the Topopah Spring?

Basis
Scoping studies will be conducted to examine the effects of confining pressure, sample size, and the saturation level on thermal expansion behavior, and establish test baseline conditions.

For each new core hole, the presence of anisotropy, natural fractures, and their effects on the coefficient of thermal expansion will be examined for the Unit TSw2. However, the Study Plan does not address whether the anisotropy and natural fractures will be examined on the ESF Main Access samples (Section 2.2.2.2), ESF Main Drifts samples (Section 2.2.2.3), and additional location samples (Section 2.2.2.4). It is unclear whether the anisotropy and natural fractures will be examined on the thermal/mechanical units other than Unit TSw2.

Recommendation
It is recommended that DOE should include a discussion in the Study Plan on whether the anisotropy and natural fractures will be examined while testing samples from the ESF Main Access, additional locations, and the units other than Unit TSw2 in new core holes.

ENCLOSURE

STUDY PLAN 8.3.1.15.1.2
LABORATORY THERMAL EXPANSION TESTING, REVISION 2

Question 3
What is the rationale for applying the confining pressure normal to the fractures?

Basis
The Study Plan states that all tests on fractured samples will include a small stress ($\leq$ 7 MPa) normal to the fracture in order to simulate *in-situ* conditions. The fractures in the Yucca Mountain are nearly in the vertical direction. The overburden stress is nearly parallel to the fractures. DOE doesn't provide the rationale why the confining pressure is normal to the fractures. DOE doesn't explain why the overburden stress 7 MPa is a small stress. DOE doesn't explain why higher stresses are not considered.

Recommendation
It is recommended that DOE provide appropriate rationales for the magnitude and direction of the confining stresses considered.

STUDY PLAN 8.3.1.15.1.2
LABORATORY THERMAL EXPANSION TESTING, REVISION 2

SCA Open Comment 55
The discussion and/or use of statistics in this chapter is not clear. A statistical approach has been suggested to determine numbers of tests required to determine various rock properties, but the approach suggested is confusing and apparently overlooks several considerations that should be factored into such an approach. Also, needed confidences of "low,""medium," or "high" have been assigned without explaining the basis for such assignment (see NRC, 1989).

DOE's Response

- In response to SCA Comment 55 on Section 8.3.1.15.1 of the 1988 Site Characterization Plan, DOE explained the rationale and basic assumptions of statistical analysis to determine the numbers of tests.

- The Study Plan makes the following assumptions:

  a. The thermal expansion properties are evenly distributed throughout the mass of each thermal/mechanical unit. This assumption will not apply to the entire rock mass.

  b. The measured values are not a function of testing sample size or direction. If scoping studies find that testing sample size or direction will have a significant effect on the thermal expansion behavior, the sampling and test program will be modified.

  c. The populations are normally distributed. The existing thermal expansion data show the populations are normally distributed.

  d. The sampling is not biased due to jointing, hole direction, etc. Each thermal/mechanical unit will be divided into n potential sampling intervals, where n is the number of samples specified in Table 2.2-2 of the Study Plan. If sampling locations are close to the center of each interval, the bias of sampling can be avoided. Adjustments of sampling program may be necessary.

  e. The determination of the necessary number of samples is based on a Gaussian tolerance level. Two-sided statistical tolerance limits are used in these estimates.

- The Study Plan also states that "data requirements and associated qualitative confidence levels were based on the expert judgement of repository personnel with little or no support in the form of sensitivity analysis. If additional analyses indicate a change in sensitivity to thermal expansion behavior from that assumed in the SCP, the numbers of samples required for experiments will be adjusted appropriately."

Supplemental Response to NRC SCA Comment 55

NRC SCA Comment 55

The discussion and/or use of statistics in this chapter [of the SCP] is not clear. A statistical approach has been suggested to determine numbers of tests required to determine various rock properties, but the approach suggested is confusing and apparently overlooks several considerations that should be factored into such an approach. Also, needed confidences of "low," "medium," or "high" have been assigned without explaining the basis for such assignment (see NRC, 1989).

DOE Supplemental Response

Case histories of relevant construction projects will be reviewed, and sampling will be performed in a manner consistent with these studies, professional judgement, and sound engineering practices. The statistical approach in the study plan came from the framework described in the SCP. It has been recognized for some time that DOE would not pursue every item laid out in the SCP or in the study plans based on the SCP. The statistical approach is one example of an item that will not be done. Although the approach may be statistically valid, it would not follow standard earth science and engineering practice. Hence, although laudable in principle, the study plan approach would have been overly ambitious and was found to be unnecessary. As part of the current planning strategy, sampling needs are evaluated in the context of technical requirements and then consider schedule and budget constraints.

Summary

The DOE considers that the method of determining numbers of samples and sample locations as described, for example, in Study Plan 8.3.1.15.1.2 (DOE, 1993b) is unnecessarily ambitious and no longer justifiable based on earth science and engineering practice, and cost considerations. DOE expects to revise the study plan, but the schedule for the revision has not yet been determined. The DOE considers that the above information provides a basis for closing this SCA open item. Therefore, the DOE requests that the NRC staff close SCA Comment 55 and document the action in a letter to the DOE.

REFERENCES

DOE (U.S. Department of Energy), 1993b. Study Plan 8.3.1.15.1.2: Laboratory Thermal Expansion Testing, Revision 1, effective August 27, 1993.

NRC (United States Nuclear Regulatory Commission), 1989. NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada: U. S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, NUREG-1347, published August, 1989.