UNITED STATES
NUCLEAR REGULATORY COMMISSION
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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

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earlier, in its SCA, following the review of DOE's 1988 SCP. The NRC staff expects DOE to address this concern in future SCP Progress Reports.

Finally, the NRC staff wishes to note that in its letter transmitting this study plan, DOE indicated that SCA Comment 55 was addressed; however, DOE did not request closure of this open item. Based on its review of the information contained in the study plan (see Enclosure), the NRC staff considers SCA Comment 55 still open.

If you have any questions concerning this review, please contact Michael P. Lee at 301/415-6677.

Sincerely,

/s/

Joseph J. Holonich, Chief
High-Level Waste and Uranium Recovery
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

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OFC	HLUR		HLUR							
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DATE	08/11/94		08/12/94							

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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 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 laboratory experiments of the current Study Plan may need to be revised.

Recommendation
It is recommended that the DOE's alternatives on thermal-loading option be considered in the Study Plan.

References
Nuclear Waste Technical Review Board, *Fifth Report to the U.S. Congress and the U.S. Secretary of Energy,* U.S. Government Printing Office, June 1992.

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

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.

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 larger-diameter TSw2 rock samples 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.

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."

Evaluation of DOE Response

- In response to SCA Comment 55, DOE doesn't explain how the *n* sampling intervals would be divided in a thermal/mechanical unit. It is unclear whether *n* sampling intervals will have equal thickness or not. If *n* equal intervals were selected in a nonuniform thermal/mechanical unit, an artificial bias may be introduced. There is no guarantee that the statistical bias will be eliminated even if the sampling location is close to the center of each interval. In the field, jointing may not be uniformly distributed in a thermal/mechanical unit. Therefore, best representative rock samples picked in a thermal/mechanical unit may not necessarily be in the central part of each interval. On the other hand, if unequal intervals will be selected, what are the criteria for selection of intervals? DOE should pay more attention on the samples which have fractures and joints and take into account their directions.

- NRC staff agrees that the sampling program needs to be modified, if core samples show that the statistical assumptions are invalid. Staff suggests that DOE explain how the *n* intervals are divided. Staff believes that SCA Comment 55 will not be resolved until the statistical assumptions are verified. Therefore, the NRC staff considers this comment open.

References

Nuclear Regulatory Commission, "NRC Staff Site Characterization Analysis of the Department of Energy's Site Characterization Plan, Yucca Mountain Site, Nevada," Office Of Nuclear Material Safety and Safeguards/Division of High-Level Waste Management, NUREG-1347, August 1989.