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

FEB 27 1986

MEMORANDUM FOR: King Stablein, Section Leader
NNWSI Project
Repository Projects Branch

FROM: Timothy C. Johnson, Section Leader
Materials Engineering Section
Engineering Branch

SUBJECT: REVIEW OF, "NNWSI PHASE II MATERIALS INTERACTION TEST PROCEDURE AND PRELIMINARY RESULTS", ANL-84-81, JANUARY 1985, BY J.K. BATES AND T.J. GERDING

As identified in the Agreements of the NRC-NNWSI Waste Package Meeting Summary, July 23-24, 1985, the NRC agreed to perform a review of the subject document.

Enclosed is the review performed by Brookhaven National Laboratory under our high level waste package contract. We concur with the BNL conclusions in as much as the description and procedures for the Interaction Test and Analog Test appear capable of generating short-term, repository relevant data. However, as recognized in the report, the quality of the results will depend on representativeness of the input assumptions, such as the groundwater flow rate, water chemistry and "aged" condition of the waste package components. Since these tests are not accelerated tests, the ability or the method with which data from these tests will be applied to predict future performance is not clear.

If you have any questions, please contact Tom Jungling at x74540.

Timothy C. Johnson, Section Leader
Materials Engineering Section
Engineering Branch

Enclosure:
As stated

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: September 11, 1985

TO: Files - NWM-MF-#32

FROM: P. Soo

SUBJECT: Review of "NNWSI Phase II Materials Interaction Test Procedure and Preliminary Results," ANL-84-81, January 1985, by J.K. Bates and T.J. Gerding

A review was carried out on the subject report, which describes a test methodology to obtain radionuclide release rate data for waste packages under tuff repository conditions. Below are given general and specific comments on the manuscript.

General Comments

1. The Interaction Test apparatus shown in Figure 1 of the report does not accurately simulate a waste package geometry. Container/glass interactions are addressed using a design in which the glass waste form is sandwiched between horizontal perforated Type 304L stainless steel retainer components. Any interactions between the waste form/container couple and the tuff in the borehole wall cannot be accurately measured since the tuff (in the form of a cup) lies below, and is separated from, the waste form.

2. The Analog Test, which is also being developed, consists of the waste form/stainless steel couple enclosed in a volume of tuff. Steam is forced through the tuff into the waste package cavity (Figure 10 of the report) and radionuclide release and migration is initiated. Water, after passing through the system, is analyzed for radionuclide content. Although it is clear that additional development is needed in the Analog Test, especially with respect to temperature control, it appears to be a more accurate simulation of actual waste package/near-field conditions in a tuff repository, when compared to the main Interaction Test apparatus being proposed. Provided that the radionuclide content of the tuff and the water in the Analog Test can be accurately measured, this would seem to be a more accurate and acceptable system for demonstrating compliance with the controlled release rate criterion.

3. A possible alternate analog test configuration is attached in which the waste form is completely surrounded by container material except for the top surface. The assumption made is that the top surface of the container will corrode most quickly because it has longer contact

with water percolating from above. After breaching of the container the space between the waste form and container will become filled with water giving rise to leaching. If the drip rate of water into the container is very slow the solution will become saturated with radionuclides. The rate of release of radionuclides will depend on the rate at which water overflows from the top of the container. These release rates will probably be conservative.

This configuration will also minimize the potentially serious problem of water evaporation from the waste form (which Bates describes in Section 5.0 of his report) since most of the leachant will be trapped within the container leaving a smaller free surface for evaporation.

The test procedures would also be acceptable for spent fuel evaluation.

Specific Comments

1. On page 6 of the report, a drop volume for the percolating water was given as ≈ 0.1 mL "based on in-situ measurements in tuff." Since this drip rate is very important with respect to determining radionuclide release rates, a reference for these measurements should be given.

2. On page 6 the stainless steel container material is to be "aged as required" prior to use in testing. This would appear to be too high a level of sophistication for the tests being developed. Aging may alter the amount of second phases present, and the amount of cold work, but these are very unlikely to give detectable effects. As-machined and cleaned material should be perfectly adequate.

3. On page 7 it is stated that "the test will not provide detailed radionuclide-migration information that can be used to predict transport though tuff." This is clearly true for the main test design, but the Analog Test, or some variant, can be used to obtain such information. Thus the Analog Test should be more useful, as stated above.

4. On page 12 it is stated that temperature gradients > 0.1°C will cause a potential for significant liquid evaporation. Thus a thermal gradient of < 0.01°C across the equipment would be needed to control this undesirable phenomenon. It is not clear that the required oven temperature control of $\pm$ 0.5°C is sufficient to guarantee such a low thermal gradient. Has Bates demonstrated that this is achievable in his tests?

5. In the design of the test vessel, page 12, a "dimension A" is cited for Figure 2 of the report. No such dimension is seen in this figure.

6. The actual assembly of the waste form/waste form holder configuration is unclear, page 14, section 5.2. Can water contacting the top of the waste form freely drip down the side of the latter, or will it be constrained by the stainless steel waste form holder? Such details must be very clearly described since water contact time with the waste form will strongly influence the leach rate. In addition, it may be desirable to place a specification on the degree of horizontalness for the glass top surface. In the report it merely states that the test apparatus should be placed on a horizontal surface. Because of faulty equipment assembly, it may be possible to have an accurately positioned test vessel but an inclined glass top surface. This would allow a fast loss of water as it runs "downhill" and off the waste form.

7. On page 20 detailed procedures are given for preparing the test solution (J-13 type). The NNWSI staff is aware of NRC's concerns about such a water chemistry. There is a potential for groundwater concentration effects if salts precipitated by groundwater evaporation are redissolved by percolating groundwater at a later time when the repository becomes cooler. More prototypic test solutions should be considered.

   In addition, it could save much time if actual J-13 well water was used in the tests. If this is in short supply, then it could be artificially prepared to the composition given in Table 2 of the report.

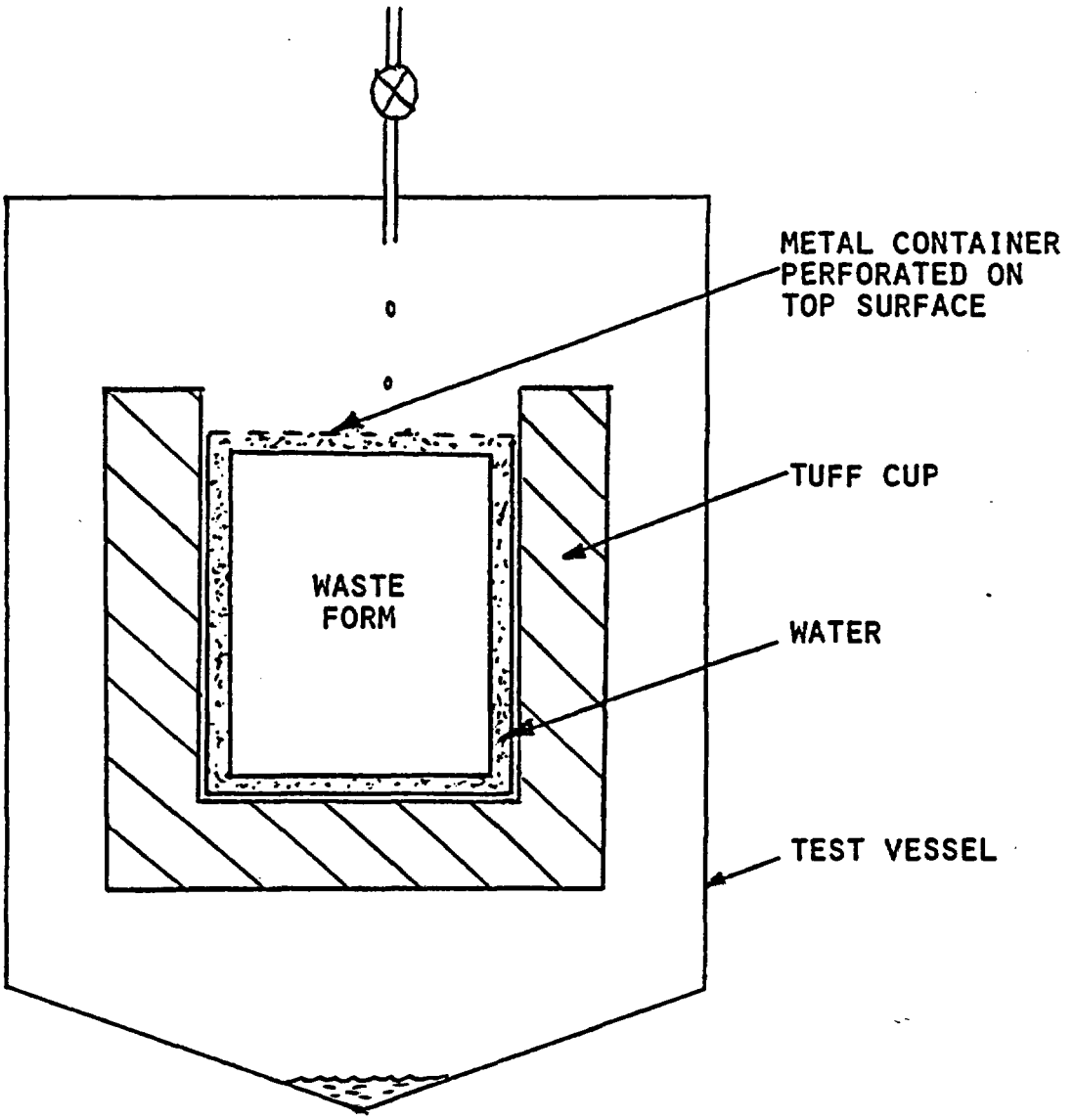
8. The details of the Analog Test given in Section V of the report are not sufficient. Information on the waste package temperature is not given. Does steam or water contact the waste? Also, it is stated that steam/water is forced through the tuff to the glass, rather than being short-circuited via the tuff/Teflon interface, but there is no supporting evidence.

9. On page 22 (Section 7.1) it is stated that the waste form composition must be representative of that induced by radioactive decay. This is very important and correct. It is not clear that the defense waste glass chemistry given in Table 8 takes into account decay, since significant Cs-137 is present.

10. The measured release rates for Eu-152, Ba-133, and Cs-137 are stated to be less than the required annual release rate of 10^{-5} (page 43). Presumably, the calculated values are based on the 1000 year inventory. A description of the calculations would be very valuable.

Summary

Bates and Gerding have shown imagination in designing a standardized test for estimating controlled release from a tuff repository waste package. It should, with some modification, prove capable of producing data to quantify controlled release values from an engineered barrier system. It is felt, however, that the Analog Test, which was designed to determine the accuracy of the Phase II Materials Interaction Test, is potentially superior, since it more closely simulates waste package/repository conditions.



SCHEMATIC OF POSSIBLE TEST APPARATUS