A4171 PDR-1
LPDR- WM-10 (2)
WM-11 (2)
WM-16 (2)

SEP 29 1987

426.1/A4171/EAW/9/25/87

Dr. Charles G. Interrante, Program Manager
Metallurgy Division - Corrosion Group
Center for Materials Science and Engineering
National Bureau of Standards
U.S. Department of Commerce
Gaithersburg, MD 20899

Dear Dr. Interrante:

We have reviewed NBS Draft Biannual Report (NUREG/CR-4735, Volume 3) for FIN A-4171, "Evaluation and Compilation of DOE Waste Package Test Data," and our comments are presented in Enclosure 1. Copies of marked-up pages containing typos are also enclosed.

Please call me if you have any questions or if you wish to discuss this.

Actions resulting from this letter are considered to be within the scope of FIN A-4171. No changes in costs or delivery of contracted products are authorized. Please notify me immediately if you feel this letter will result in additional costs or delay in delivery of contracted products.

Sincerely,

Everett A. Wick

Everett A. Wick
Technical Review Branch
Division of High-Level Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosures:
As stated

cc: Dr. Neville Pugh, Director
Metallurgy Division

Dr. William Ruff, Group Leader
Corrosion Group - Metallurgy Division

WM Record File WM-RES A4171 NBS

WM Project 10, 11, 16
Docket No.
PDR ✓
X LPDR ✓ (B, N, S)

Distribution:

(Return to WM, 623-SS)

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87295206
WM Project: WM-10, 11, 16
PDR w/encl
(Return to WM, 623-SS)

WM Record File: A4171
LPDR w/encl

NRC COMMENTS ON NBS DRAFT BIANNUAL REPORT
(NUREG/CR-4735, Volume 3) for FIN A-4171,
"EVALUATION AND COMPILATION OF DOE WASTE PACKAGE TEST DATA"

1. Page v - The list of figures should contain page numbers.

2. Page 1, Second paragraph, Line 5

   The Savannah River Plant is near Aiken, South Carolina.

3. Page 1, Last Paragraph

   The first sentence states that studies involving laboratory testing at NBS are continuing in four areas but that no reports are included here.

   The report should also state approximately when this work will be completed or reported.

4. Page 3, The first sentence describes the location of the site.

   The site should be referred to as the Yucca Mountain site.

5. Page 3, 4

   The last sentence on page 3 (and beginning of page 4) says the zircaloy corrosion experiments could be improved by adding appropriate electrochemical measurements.

   The purpose or benefit of adding these measurements should be stated.

6. Page 4, Second Paragraph, Third Sentence

   The sentence appears to omit the word "not." It should read, "This test procedure does not reveal conclusively the susceptibility of zircaloy to stress corrosion cracking (SCC)."

7. Page 5, Section 2.3, Spent Fuel

   The last sentence states that Oversby identifies six areas where new data are needed.

   Those six areas should be identified here.

8. Page 10, Land Acquisition

The last sentence states that condemnation proceedings, if required, could delay site characterization proceedings for the Deaf Smith site.

Please cite a reference for this showing that DOE has this authority.

9. Pages 10 & 11, Section 4.2, Reviews

The report states that five papers were reviewed which pertain to the Deaf Smith site and lists the papers.

The biannual report should show consistency in listing reports. The discussions of NNWSI and BWIP did not list the reports reviewed.

10. Page 12, Section 5.0, VITRIFICATION OF HLW

The first two sentences should be revised to reflect that NRC consults with DOE on the acceptability of vitrified HLW for disposal in a geologic repository. NRC does not license HLW vitrification facilities.

11. Page 12, Section 5.1, Technical Issues

The second sentence of the third paragraph states, "In general, the experimental evidence indicates that the leach rate may be lower in a repository than in laboratory tests."

The rationale for this statement should be given.

12. Page 13, Section 5.2, Reviews

The second paragraph of this section discusses the status of review of PNL 5157 but mentions only three of the seven chapters. This paragraph should discuss the review status of Chapters 2, 3, 5, and 6 as well as that of Chapters 1, 4, and 7. This discussion should also project an end date for completion of review of PNL 5157.

13. Page 14, Section 6.0, MCC

The last sentence on the page states, "The MCC is supported at approximately a sixty percent level by the DOE; the remainder of MCC's funding comes from other DOE offices dealing with repositories and other aspects of nuclear waste materials."

This sentence requires editing. It appears that MCC is entirely funded by DOE rather than 60% funding.

14. Page 15, Section 6.1, Program Administration

The second sentence states that, "Work was initiated for the Sandia National Laboratory, and this is reported in the Transportation Technology Section of this report."

The sentence should be revised to identify "this report."

15. Page 16, Section 6.3, Support to the Office of Geologic Repositories

The last sentence on the page states, "The test uses granite host rock with smectite and sand packing materials, and a SON 68 glass waste form in a volvic water leachant under lifetime repository conditions."

The terms "volvic water," "SON 68 glass waste form," and "lifetime repository conditions" should be defined.

16. Page 18

The single sentence in the middle of the page states that no funding was provided for ATM-18.

There should be some sort of description of ATM 18 to orient the reader. This comment also applies to the use of ATM-10 at the bottom of the page.

17. Page 18, Section 6.6, Transportation Technology Center

This paragraph discusses a Transportation Flaw Leak Test that was developed. Part of the reason for the conducting of the tests was to determine if respirable fines and glass material are released from the canister.

The discussion should summarize the results and state whether respirable fines were released from the canister.

18. Pages 21-30, Section 7.0, AN ILLUSTRATION OF UNCERTAINTIES IN THE CHOICE OF GLASS COMPOSITION

The plots in figures 1-4 are not clear to us. For example:

a. What is the term ECHIP at the top of each plot?
b. The last paragraph on page 23 states that the B's in the middle of plot indicate a minimum in the silicon release. How does the reader know that?
c. What is the significance of the scale for the letters shown at the right of each plot? What does each letter represent?

The rationale for the interpretations or analyses developed from each plot should be presented.

19. Pages 31-39, Section 8.0, STATUS OF CRYSTALLINE REPOSITORY PROJECT

    This section is not relevant to evaluation or compilation of DOE waste package test data and, therefore, should be deleted.

20. Page A-63, DATA SOURCE

    (b) Author(s), Reference, Reference Availability

    The correct literature reference is:

    Materials Research Society, 1983 Symposia Proceedings, Volume 26, Scientific Basis for Nuclear Waste Management VII, Edited by Gary L. McVay, North-Holland, 1984.

    The page numbers, 613-621, should be given.

EXECUTIVE SUMMARY

This is the third biannual progress report on the National Bureau of Standards (NBS) assessments of the Department of Energy (DOE) activities related to the waste package for disposal of radioactive high-level waste (HLW). It contains NBS reviews conducted over the period February 1, 1987 to July 31, 1987 on DOE reports. Status reports given here highlight the NBS assessments of DOE activities.

Eleven reviews of publications resulting from DOE-sponsored work in NNWSI (Nevada Nuclear Waste Storage Investigations) during this six-month period are divided into four categories: Zircaloy, copper, spent fuel, and glass. Three issues are emphasized. These deal with the possibility of stress-induced failure of Zircaloy, the possible high corrosion of copper and copper alloys, and the lack of site-specific characterization data.

In two previous biannual NBS reports, the major deficiencies in the available data pertaining to a waste repository in basalt (BWIP -- Basalt Waste Isolation Project) were noted with specific emphasis placed on the corrosion resistance of the candidate waste-package container materials. Four evaluations completed during this period indicate the following: AISI 1020 steel, a candidate waste-canister material, exhibits both localized corrosion and environmentally assisted cracking behavior at elevated temperatures (150°C), when immersed in basalt repository-like groundwater. If this material is to receive further consideration, much more work is required. Improvements to the simulation of repository environments for laboratory studies have been made. However, more data are needed to verify the exact chemical reactions to be expected to occur under repository conditions.

For the Salt Repository Project (SRP), an overview of the Deaf Smith site, and its potential problem areas, points up the importance of the duration of corrosion tests and some of the conditions that may preclude prompt initiation of needed long-term testing. Five reviews of SRP reports are presented. Three are concerned with colloidal sodium. A fourth on corrosion of A-216 demonstrates the considerably higher corrosion rates associated with high-magnesium brines. A fifth review concerns buckling of a container and it highlights the importance of mechanically induced stress on local corrosion processes.

A summary of the activities of the Crystalline Repository Project is given to complement the coverage of other DOE project offices. In addition to the sites that may be available from the first repository program and other sedimentary rock geologic formations not previously considered, crystalline rock is the primary geologic media under consideration for the second repository. Crystalline rock formations are located in 17 states in the north-central, northeastern, and southeastern regions of the United States.

Both the schedule and any site-specific activities for the second repository have been delayed. Nevertheless, the U.S. Department of Energy continues to cooperate with international groups (IAEA, NEA, and CEC), which are doing important research related to repositories in granite and crystalline rock formations.

Technical exchange meetings were held at two sites expected soon to produce vitrified HLW, the West Valley Demonstration Project (WVDP) and the Defense Waste Processing Facility (DWPF). These meetings concluded with the understanding that technical discussions in greater depth and sharper focus would be needed to keep abreast of current developments. The principal concerns are (1) verification of the composition of production runs and (2) leaching characteristics (in actual repository environments) of the specified glass composition.

Reviews of several reports on glass leaching are included here and many more have been initiated but not yet completed. The leaching characteristics of vitrified HLW can be affected by various factors, principal among which are the composition of the glass used to vitrify the HLW and the environment in which the leaching may take place. Repository environments are simulated in laboratory tests. Refinements in these simulated repository conditions are suggested, so as to assure that leach rates in a repository do not significantly exceed those predicted from the laboratory tests. In leaching of glass, a preliminary assessment of the role of redox potential (Eh) leads to the conclusion that solutions of a more reducing nature are less aggressive. This suggests that repositories in which reducing conditions persist in the vicinity of the waste package would be favorable, with low leaching rates of vitrified waste.

Pertinent activities of the Materials Characterization Center are ~~were~~ summarized and included here in eight categories, which correspond to categories of the MCC's monthly reports. These are Program Administration, Quality Assurance (QA), and support to various offices: the Office of Geologic Repositories, the Salt Repository Project (SRP), the Basalt Waste Isolation Project (BWIP), the Defense HLW Technology Program (DP-12), the Transportation Technology Center (TTC), and the West Valley Demonstration Project (WVDP). It appears that increased support and cooperation on the part of all repository offices and other pertinent DOE offices is needed.

words in

This to enable MCC to meet their objectives of ensuring materials data are available on waste materials, by developing standard test methods, testing waste (and other) materials, and publishing the Waste Materials Handbook.

An NBS alternate interpretation of published data is given here to stress the benefit and necessity of independent interpretation of data to be used to predict the performance of materials proposed for use in a nuclear waste package. This illustration contrasts published results with results obtained from an alternate NBS interpretation of the same data. A conclusion reached from the alternate analysis is that leach rates of glass recommended in the original report would be improved by changing the recommended composition, in particular, by substitution of Al_2O_3 for Na_2O.
An appendix on the NBS/NRC Data Center activities describes various software enhancements developed recently to aid in data handling and retrieval. For data retrieval, it highlights a menu system suitable for both novice and experienced users.

The statement is [illegible], but the reader should not be led to believe that dissolution is the only mechanism for release, i.e., gaseous release and release into liquid as colloids.

2.3 Spent Fuel

Once the Zircaloy sleeve (or cladding) of a fuel rod is breached, the release of radionuclides can occur. If the metal canister holding the fuel rods is also breached, moisture can contact the spent fuel. In the presence of moisture, dissolution of the spent fuel and the release of radionuclides follows. The oxidation state of the spent fuel affects the rate at which this dissolution will take place. Oxidation is one of many important factors in this process.

Oxidation of spent fuel contained in breached Zircaloy cladding can increase the solubility and concentration of specific radionuclides. Einzinger describes a series of tests to measure the degree of oxidation of spent fuel under various conditions of exposure (temperature, moisture, time). However, it is not clear whether the authors have taken into consideration the increased vapor pressure of water at elevated temperatures. An increase in vapor pressure could result in oxidation rates considerably different from those in dry air [Einzinger, 1986].

The rules and regulations for licensing a high-level nuclear waste repository, as set by NRC and EPA, are discussed by Oversby in UCRL-94659. Site-specific performance-assessment calculations are necessary in order to compare the behavior of the waste form under the conditions of exposure for all proposed sites. Oversby reviews the factors that affect radionuclide release rates, and identifies six areas where new data are needed [Oversby, 1986].

2.4 Glass

Another way in which DOE plans to dispose of HLW is to vitrify it in borosilicate glass and these vitrified waste materials will be placed in metallic canisters. The effects of radiation on this vitrified waste and its subsequent solubility are important.

(into)

Theoretical modeling calculations on the effects of radiation on waste glass described by Van Konynenburg result in reasonable agreement with experimental observations. On the basis of these modeling calculations, it is shown that the principal reactions result in the formation of H_2, O_2, NO_2^-, NO_3^-, and H^+ [Van Konynenburg, 1986]. Abrajano, et al., describe a more recent compilation of experimental data on which the modeling calculations of the Van Konynenburg reference are based in part. These experimental data emphasize that an important reaction during the irradiation of moist air is the production of nitric acid. However, dissolution of the glass waste and buffering action of the bicarbonate in tuff tend to limit the effect of the nitric been received at NBS and formal evaluations of them have been initiated. Four of these evaluations have now been completed and their results follow.

Anantatmula studied the corrosion behavior of AISI 1020 hot-rolled steel packed in 75 percent basalt, 25 percent bentonite (the packing material mixture proposed for the future repository in basalt) while immersed in various liquids [Anantatmula, 1984]. Twelve different tests were performed (six at 100°C and six at 200°C) using liquids comprised of deionized water and various combinations of Cl^{-1}, F^{-1}, SO_4^{-2} , and CO^{-2} ions; and weight losses were measured after four weeks immersion. A Plackett-Burman statistical analysis method was used to determine the significant variables. In addition, the exposed metal surfaces were studied by optical metallography, scanning electron microscopy, and X-ray diffraction. Only temperature, not the liquid chemistry, was found to be a significant variable here. However, since only twelve tests were run, and without replicate samples, the statistical relevance of this test is extremely limited. Higher corrosion rates were measured at 100°C than at 200°C, consistent with previous findings. It was concluded that the formation at higher temperatures of a partially protective iron-rich clay (iron saponite) on the surface of the metal caused this anomalous behavior [Anantatmula, 1984]. However, the corrosion mechanism is also undoubtedly different at the two temperatures as evidenced by the authors' finding the magnetite form of iron in the corrosion product of only the high-temperature tested samples. This result has not received much attention in the past and it certainly warrants further investigation.

In 1984 a study was completed by Brehm, Lutton, Rivera, Maffei, Bohringer, Paine, and Pingel concerning ~~of~~ the metallic corrosion likely to occur in a basalt repository. A series of 48 test specimens at 100°C and 200°C of Fe-9Cr-1Mo steel (normalized and tempered) were immersed for one month in liquids containing various concentrations of sulphate, carbonate, fluoride, and chloride ions; and weight loss measurements were performed [Brehm, 1984]. Unfortunately, the data measured in this initial well-planned study were not sensitive enough to indicate any general trends in the effects of either temperature or electrolyte on the corrosive attack of this steel. Further studies using more sensitive equipment were initiated. In this same study, the electrochemical passivation characteristics of various proposed waste-container materials immersed in synthetic Grande Ronde groundwater were studied. Similar types of passive regions (although at different potentials) were found for AISI 1020 steel, Fe-9Cr-1Mo steel, and cupro-nickel

7.0 AN ILLUSTRATION OF UNCERTAINTIES IN THE CHOICE OF GLASS COMPOSITION

An illustration of the importance of interpretation of data is given so as to stress the need for independent interpretation of data to be used to predict the performance of materials proposed for use in a nuclear waste package. This illustration contrasts published (Chick, et al. 1984) results with substantially different results obtained from an alternate NBS interpretation of these data.

The example used in this illustration involves a response surface model of the type that will be used for waste package decisions. Glass compositions for the vitrification of high-level nuclear waste are being chosen, in part, on the basis of empirical models of performance characteristics such as leaching. These models are response surface models. They describe a relation between glass performance and controlled variables that affect performance. The performance parameters in question are the leaching characteristics of the glass. Pertinent controlled variables are the glass composition and the processing (melting/cooling) conditions used in the production of the glass.

The NBS analysis assumed that glass containing greater than 25% Na_2O have leach rates that are so high that these glasses are undesirable. Further, the higher compositions would complicate the analysis and the model needed to portray the data. Thus, the NBS analysis is not applicable to glass above the 25% level for Na_2O. A conclusion reached from this alternate analysis is that leach rates of glass recommended in the original report would be improved by changing the recommended composition, in particular, by substitution of Al_2O_3 for Na_2O -- it is noted that there must be a trade off between leachability and producibility of borosilicate glass, and that the suggested addition of the alumina may be unwarranted when all factors are considered. Nevertheless, alternate interpretations of these data have led to alternative recommendations for the composition of glass for this application. Hence, the example serves its intended purpose of illustrating the benefit and necessity of independent interpretation of data taken to represent materials performance.

Empirical models entail a variety of uncertainties that must be assessed before conclusions are finalized. The uncertainties that are most difficult to assess are those connected with the choice of a parametric form for the model. Resolution of questions of the proper choice of the form of the model is the subject of this section.

1.0 INTRODUCTION

Current NBS activities related to reviews and evaluations of the Department of Energy (DOE) waste-package activities are detailed in this biannual report. Reviews related to research performed for the three DOE project offices, the Nevada Nuclear Waste Storage Investigations (NNWSI), the Basalt Waste Isolation Project (BWIP), and the Salt Repository Project (SRP) are discussed in sections ~~two~~ 2 through ~~four~~ 4, respectively.

DOE is actively engaged in programs for the vitrification of high-level radioactive waste in borosilicate glass. Both the West Valley Demonstration Project (WVDP) at West Valley, New York and the Defense Waste Processing Facility (DWPF) located at the Savannah River Plant in Savannah, Georgia are expected to vitrify HLW in the near future. NBS activities in this area have continued to increase with six reports being reviewed during this reporting period. The work on glass is presented in section 5. In section 7, an illustration of the uncertainties in the choice of glass composition is given to illustrate the importance of independent interpretation of data.

Activities of the DOE-sponsored Materials Characterization Center for the period January 1, 1987 through June 30, 1987 are discussed in section 6.

While DOE work sponsored to date has focused on the first repository, the second repository is still a viable part of the Nuclear Waste Policy Act of 1982, and a discussion of the current status of the second repository program is included as section 8.

Draft NBS reviews and evaluations conducted over the period February 1, 1987 through July 31, 1987 are included as Appendix A; contributing reviewers for these works are acknowledged as a group on the cover page of this report. As reviews are completed and approved for publication, they are included in the NBS/NRC Database for Reviews and Evaluations on High-Level Waste Data. One of the NBS goals is to make this database "user friendly". The system is designed so that it is easy for the novice searcher to find relevant information quickly and with a minimum of effort and training. Appendix B contains information on database activities for the period covered in this report.

Studies involving laboratory testing at the NBS are continuing in four areas, but no reports on this work are given here. The objective of these laboratory tests is to confirm the accuracy of DOE data and the validity of the

state reason why . . . ie, testing has just been initiated or whatever is appropriate.

improved by including other measurements, such as electrochemical polarization, a. c. impedance, and other appropriate electrochemical measurements [Smith, 1986b].

In the second report, Smith describes an experimental plan in which the stress corrosion failure of Zircaloy is studied. C-rings machined from "defueled" Zircaloy cladding are loaded to an unspecified stress level and exposed to the same environments described in the previous experiment. This test procedure does conclusively reveal the susceptibility of Zircaloy to stress corrosion cracking (SCC) because failure may occur through other means. Hydride formation, for example, may embrittlement the alloy and lead to failure. In the absence of failure in the proposed tests, slow-strain-rate measurements would provide a more severe test of susceptibility to SCC [Smith, 1986a]. Other workers have shown embrittlement of Zircaloy in gaseous iodine at 350°C with increased tendency to failure at low oxygen concentrations [Gangloff, 1979].

The third report in this section, "Attachment 1 to Letter Dated 8 March 1985 to M. Steindler, Argonne National Laboratory," is an early listing of a variety of proposed experiments and experiments in progress [Ballou, 1985].

2.2 Copper

Prior to emplacement in a repository, fuel rods will be placed in metal canisters that will facilitate handling and, thereby, prevent the movement of radioactive waste into the environment after the repository is closed. Copper is one of the metals being considered as a container material, and information on the rate of corrosion of copper in a tuff environment is important.

The first reference by L. B. Ballou and R. D. McCright, is an early description of plans for the testing of copper as a possible canister material. Implementation of these plans resulted in two-year study, which concludes that copper and two of its alloys appear to be good candidates for possible use as canister materials, but this report cautions that the effects of gamma radiation on the corrosion behavior of these metals has not been addressed [Ballou, 1986]. The authors point out that nitric acid is severely corrosive to copper and copper alloys, even in fairly dilute solutions of nitric acid. This consideration becomes extremely important because other workers, Van Konynenburg in 1986 and Abrajano in 1986, have indicated that nitrogen fixation by gamma radiation will lead to the formation of nitric acid [Abrajano, 1986; Van Konynenburg, 1986].

been received at NBS and formal evaluations of them have been initiated. Four of these evaluations have now been completed and their results follow.

Anantatmula studied the corrosion behavior of AISI 1020 hot-rolled steel packed in 75 percent basalt, 25 percent bentonite (the packing material mixture proposed for the future repository in basalt) while immersed in various liquids [Anantatmula, 1984]. Twelve different tests were performed (six at 100°C and six at 200°C) using liquids comprised of deionized water and various combinations of Cl^{-1}, F^{-1}, SO_4^{-2} , and CO^{-2} ions; and weight losses were measured after four weeks immersion. A Plackett-Burman statistical analysis method was used to determine the significant variables. In addition, the exposed metal surfaces were studied by optical metallography, scanning electron microscopy, and X-ray diffraction. Only temperature, not the liquid chemistry, was found to be a significant variable here. However, since only twelve tests were run, and without replicate samples, the statistical relevance of this test is extremely limited. Higher corrosion rates were measured at 100°C than at 200°C, consistent with previous findings. It was concluded that the formation at higher temperatures of a partially protective iron-rich clay (iron saponite) on the surface of the metal caused this anomalous behavior [Anantatmula, 1984]. However, the corrosion mechanism is also undoubtedly different at the two temperatures as evidenced by the authors' finding the magnetite form of iron in the corrosion product of only the high-temperature tested samples. This result has not received much attention in the past and it certainly warrants further investigation.

In 1984 a study was completed by Brehm, Lutton, Rivera, Maffei, Bohringer, Paine, and Pingel concerning ~~of~~ the metallic corrosion likely to occur in a basalt repository. A series of 48 test specimens at 100°C and 200°C of Fe-9Cr-1Mo steel (normalized and tempered) were immersed for one month in liquids containing various concentrations of sulphate, carbonate, fluoride, and chloride ions; and weight loss measurements were performed [Brehm, 1984]. Unfortunately, the data measured in this initial well-planned study were not sensitive enough to indicate any general trends in the effects of either temperature or electrolyte on the corrosive attack of this steel. Further studies using more sensitive equipment were initiated. In this same study, the electrochemical passivation characteristics of various proposed waste-container materials immersed in synthetic Grande Ronde groundwater were studied. Similar types of passive regions (although at different potentials) were found for AISI 1020 steel, Fe-9Cr-1Mo steel, and cupro-nickel

4.1 Potential Problem Areas

Land Acquisition -- In May 1986, when this site was selected for further study and characterization, all of the land at the site was privately owned. Acquisition of the land is under way and needs to be completed so that actual characterization of the site can proceed. Condemnation proceedings, if required, could delay site characterization. This would delay corrosion testing and decrease the available time for testing.

On-Site Characterization -- It is important to thoroughly characterize the salt environment and begin long-term corrosion testing on the entire range of expected environments as soon as possible. The accuracy of corrosion rate estimates and extrapolations used in making lifetime predictions of the container may be greatly affected by the duration of the tests.

Container Alloys -- At present, the primary candidate alloy for the waste container is A216 Steel. The reasons for the selection of this alloy and reservations with this selection have been discussed by NBS workers in previous reports [Interrante, 1987a; Interrante, 1987b]. Alloy selection was based on the assumption that, if uniform corrosion of the alloy proceeds uninhibited, then other corrosion-related failure mechanisms could be ignored. Localized corrosion, stress corrosion cracking, and hydrogen embrittlement are potential failure modes that must be evaluated by mechanistic modeling and/or experimental observations, and not by assumption.

The alternate alloy for container fabrication is Ti-code 12. Ti-code 12 was selected because of its corrosion resistance. The corrosion resistance of this alloy is the result of the formation of a passive film. As a result, the uniform corrosion assumption cannot be applied to this alloy. Also, Ti-code 12 is susceptible to hydrogen embrittlement and radiation-induced hydrogen evolution must be considered.

The limited-brine assumption is a critical issue in container alloy selection. If DOE can guarantee that only limited quantities of brine will ~~can~~ reach the containers, then alloys with very low resistance to corrosion can be used. However, if DOE is forced to assume unlimited brine, then more corrosion-resistant alloys must be considered.

4.2 Reviews

During the period covered by this report, five papers were reviewed which pertain to the Deaf Smith site.

simulation corresponds to the actual repository conditions. Thus, the issue of site characterization remains critical.

5.2 Reviews

Reviews of some key papers on the role of the redox potential (Eh) in glass leaching were completed as draft reviews. Background documents from Swedish research on this subject were also studied, and experts on Eh-pH (Pourbaix) diagrams were consulted to evaluate the work being carried out in the nuclear waste program. It was concluded (tentatively) that the basic qualitative conclusions of the work, i.e., that solutions of a more reducing nature are less aggressive in leaching the glass, appears to be valid. However, the experimental methodology and proper application of Eh, in describing the redox behavior of the leachant solutions, must be considered carefully in reviewing studies in this area.

Preliminary reviews of Chapters 1 and 7 of Pacific Northwest Laboratory Report PNL-5157, "Final Report of the Defense High-level Waste Leaching Mechanisms Program," were completed. Because of the importance of Chapter 1 as a summary of progress in glass leaching studies through 1984, a multiple review was conducted. Three independent reviewers have completed reviews which are being edited into a single, composite review. This composite review will then be returned to the reviewers for comments before being submitted for the formal NBS approval process. The preliminary review of Chapter 7 is being expanded. A second reviewer has been added at the request of the first, to provide expertise in evaluating the results of modeling studies. A preliminary review of Chapter 4 of PNL-5157 has been started and is expected to be completed during August 1987.

5.3 Technical Exchange Meetings

Plants at West Valley, New York and Savannah River, South Carolina are currently developing technology and facilities for vitrifying HLW. The West Valley Demonstration Project (WVDP) deals with commercial HLW, while the Defense Waste Processing Facility (DWPF) at the DOE Savannah River Plant is working on defense HLW. Technical Exchange Meetings attended by NBS contractors and personnel, were held at both West Valley and Savannah River during this semiannual reporting period. These meetings are summarized briefly.

The WVDP Technical Exchange Meeting took place in West Valley on February 18-19, 1987. NBS attendees included Charles Interrante, Melvin Linzer, Ernest Plante and NBS consultants Bruce Adams and John Wasylyk. Talks were presented on the processing, physical properties, and leaching behavior of the nuclear waste materials. The MCC prepares monthly reports in addition to project reports and other various reports submitted to its supporting agencies.

The MCC monthly reports are divided into the following categories.

A. Program Administration
B. Quality Assurance (QA)
C. Support to the Office of Geologic Repositories (OGR)(RW-23)
D. Support to the Salt Repository Project (SRP)
E. Support to the Basalt Waste Isolation Project (BWIP)
F. Support to the Defense HLW Technology Program (DP-12)
G. Support to the Transportation Technology Center (TTC)
H. Support to the West Valley Demonstration Project (WVDP)(NE-20)

This report is a brief summary of MCC activities from January 1, 1987 through June 30, 1987. The reader is referred to the monthly reports for further details or for information not discussed here.

6.1 Program Administration

The organization of the MCC stayed essentially the same as that reported earlier, in Figure 1 of NUREG/CR-4735, Vol. 2, 1987, page 18 [Interrante, 1987b]. Work was initiated for the Sandia National Laboratory, and this is reported in the Transportation Technology Section of this report. The MCC manager attended a program review at West Valley, New York and also met with Materials Integration Office (MIO) manager in Chicago, Illinois to discuss the status of the MCC. There were other reviews, planning meetings and submission of statements of work (SOW) and plans carried out under program administration. There was a midyear review of the MCC status in terms of budget, schedule, milestones and open issues held in May 1987. Also the manager of MIO and technical support staff from Argonne National Laboratory (ANL) visited PNL in May to discuss an MCC five-year plan and the 1988 program. No information pertaining to the findings of the review or the meeting was given.

6.2 Quality Assurance

Records were collected for all tasks and transferred to the PNL Record Center. SRP and also BWIP records were reviewed and turned over to the respective projects. Records for reference glasses, ATM-5, ATM-6, ATM-3, ATM-4, ATM-1 and MCC-76-68 were transferred to the PNL Record Center for life-time storage. Plans were started for archival storage of ATM-5 and ATM-6 reference glasses. Storage must meet requirements

Leach testing was completed on saw-cut round-robin specimens, cut by five different laboratories using a standard procedure, to determine if there were significant differences in leaching. Data were incorporated into MCC-1 Static Leach Test Procedure and the procedure was resubmitted to the MRB.

There are 597 papers in the glass thermal property database, and 370 of these are on borosilicate glass. There are approximately 400 papers either received or on order on glass durability. A comparison of this database activity with the National Bureau of Standards (NBS)/Nuclear Regulatory Commission (NRC) indicated that the NBS/NRC database was a highly refined literature search that tells where the data is but does not contain any tabulations of data. This is true, the NBS database is actually a data index, and the user of the NBS/NRC database must obtain the data from the referenced papers. The NBS/NRC database does give lists of all data available in a document; in addition, it gives a technical evaluation of the data and its relevance to issues dealing with nuclear-waste storage.

No funding was provided for the fabrication of ATM-18.

6.6 Transportation Technology Center

At the beginning of this reporting period in January 1987 insufficient funding was available for the TTC work. Funds were approved in April. A Transportation Flaw Leak Test was developed. This test uses nucleopore filters for collecting fine glass which exits flaws during a 2000 mile transport. Related work was conducted on the development of a Pressurized Flaw Leak Procedure. Part of the reason for developing and conducting these tests is to determine if any amount of respirable fines and glass material are released. Flaw leak testing was conducted on glass filled canisters which were transported from the Hanford Site to Cheyenne, Wyoming, and back to the Hanford Site, a distance of approximately 2000 miles. After the trip, filters and collected glass were removed and amounts released were correlated with the reference design flaw and its position on the canister. Size distribution of the fines ~~were~~ was shown for each filter number (reference design flaw). Data from these tests do not take into account effects on the glass of aging, decay heating or irradiation.

6.7 West Valley Demonstration Project

This activity deals with reference glass durability testing, characterization and documentation of some Approved Test Materials (ATMs), fabrication of some ATMs and a database. All reference glass tests are in progress or have been completed. MCC-1 and MCC-3 leach tests of ATM-10, CTS glass

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WASTE PACKAGE DATA REVIEW

DATA SOURCE

(a) Organization Producing Data

Vitreous State Laboratory, The Catholic University of America, Washington, D. C.

(b) Author(s), Reference, Reference Availability

X. Feng, R. Adiga, A. Barkatt, ~~A. Barkatt~~, W. Freeborn, P. Macedo, R. Mohr, C. Montrose, R. Mowad, E. Saad, and W. Sousanpour, "Effects of Composition On the Leach Behavior of West Valley HLW Glasses," September 1986

DATE REVIEWED: 4/21/87

TYPE OF DATA

Experimental data on glass leaching.
Measured viscosities at 1100°C.

MATERIALS/COMPONENTS

West Valley Demonstration Project reference glass WV-205 and 18 other compositional variants were studied. Six of the glasses contained radioactive uranium (0.5-1.0 weight percent UO_2) and thorium (3.2-3.6 weight percent ThO_2); the remainder contained Al and Zr surrogates.

TEST CONDITIONS

The 4-gram glass samples were ground into -100/+200 mesh powders. A static powder leach test (modified MCC-3 test) was used. The leaching environment was 40 mls of deionized water at T = 90°C.

METHODS OF DATA COLLECTION/ANALYSIS

Leaching Experiments:

Leachate concentrations were analyzed at 7 and 28 days. Dissolved boron was used to indicate the extent of glass dissolution. Boron concentration in leachant was plotted vs. reduced composition variable (referenced to WV-205 glass). No procedures were specified for determining viscosity.

Mathematical methods were used to calculate expected range? of canistered waste characteristics.

AMOUNT OF DATA

Twenty-three tables:

1. A. PUREX Insoluble Solids Chemical Composition.
   B. PUREX Solids Fission Products.
2. PUREX Supernatant Chemical Composition.
3. THOREX Waste Chemical Composition.
4. IE-96 Nominal Composition.
5. Glass Formers Added to West Valley HLW to Melt WV-205.
6. Reference 1987 Radionuclide Content (Curies) of West Valley Waste.
7. Composition of WV-205.
8. Reference Radionuclide Content of a Canister of WVDP HLW.
9. Composition of a Nonradioactive Analogue WV-205.
10. WV-205/SFCM MCC-1 Test Results, 200 Grit Cut Finish Specimens.
11. WV-205/SFCM MCC-1 Test Results, 600 Grit Polish Specimens.
12. WV-205/SM MCC-1 Test Results, 200 Grit Cut Finish Specimens.
13. WV-205/SM MCC-1 Test Results, 600 Grit Polish Specimens.
14. WV-205/SFCM Pulsed Flow Test Results.
15. WV-205/SM Pulsed Flow Test Results.
16. WV-205 Glass Physical Property Data: Summary.
17. Annealing Range Viscosity Data: WV-205.
18. High Temperature Viscosity Data.
19. Glass Transition Temperatures.
20. Heat Capacity (C_p) of WV-205.
21. Chemical Composition Requirements for Type 304 Stainless Steel.
22. Temperature Distribution in the Canister.
23. Fissionable Material Content of a Canister of WVDP HLW.

Eight figures:

1. West Valley High Level Waste Processing Flow Sheet.
2. Flow Test Results. (Leach rate of DWRG plotted vs. residence time in years.)
3. Viscosity vs. Temperature for WV-205.
4. Linear Thermal Expansion vs. Temperature for WV-205.
5. Heat Capacity vs. Temperature for WV-205.
6. CTS WVNS Canister. (Design drawing.)
7. West Valley High Level Waste Canister Labeling.
8. WVNS Canister Grapple.

UNCERTAINTIES IN DATA

Activities of fission products may vary from Table VI values as follows: U and Pu about 5 percent, Th about 20 percent, and other actinides about 50 percent.
Table VII contains composition ranges for major WV-205

Mathematical methods were used to calculate expected range? of canistered waste characteristics.

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