UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, Maryland 20899

December 15, 1986

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Mr. Everett A. Wick
Division of Waste Management
Office of Nuclear Materials Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Re: Monthly Letter Status Report for November 1986 (FIN-A-4171-6)

Dear Mr. Wick:

Enclosed is the November 1986 monthly progress report for the project "Evaluation and Compilation of DOE Waste Package Test Data" (FIN-A-4171-6). The financial information is reported separately.

Sincerely,

Charles G. Interrante
Program Manager
Corrosion Group
Metallurgy Division

Enclosures

Distribution:
NMSS PM (1)
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3592

Monthly Letter Report for November 1986

Published December 1986

(FIN-A-4171-6)

Performing Organization: National Bureau of Standards
Gaithersburg, MD 20899

Sponsor: Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Silver Spring, MD 20910

TASK 1 -- Review of Waste Package Data Base

WERB Reviews -- The semi-annual report was approved by the Washington Editorial Review Board (WERB) and the final report was submitted to NRC on November 30, 1986.

Appended to this report are copies of Draft Reviews for the following reports:

1. HEDL-TME-77-82, "Inventory and Characterization of Spent LWR Fuel," by C. W. Funk and L. D. Jacobson.

2. ANL-85-62, "The Reaction of Glass During Gamma Irradiation in a Saturated Tuff Environment, Part 1, SRL 165 Glass," by J. K. Bates, D.F. Fischer, T. J. Gerding.

3. LA-10188-MS, "Groundwater Chemistry Along Flow Paths Between a Proposed Repository Site and the Accessible Environment," by A. E. Ogard and J. F. Kerrisk.

Comments by NRC and its contractors are solicited.

SRP -- Review has been initiated on the following report this month.

1. BNL 32001, "Very Rough Preliminary Estimate of the Colloidal Sodium Induced in Rock Salt by Radioactive Waste Canister Radiation," 1984.

BWIP -- Reviews have been initiated on the following reports this month.

1. RHO-BW-SA-560-P, "Status of Environmentally Assisted Cracking Studies by the Basalt Waste Isolation Project," March 1986.

2. RHO-BW-SA-416-P, "Sorption and Desorption Reactions of Radionuclides with a Crushed Basalt-Bentonite Packing Material," April 1985.

3. RHO-BW-SA-509-P, "Thermal Analysis of Waste Package Preliminary Reliability Assessment," March 1986.

4. B047154, "BWIP General Corrosion Studies - Yearly Summary Report for FY-1984"

BWIP - Review is continuing on the following reports.

1. RHO-BW-SA-391P, "Effect of Grande Ronde Basalt Groundwater Composition and Temperature on the Corrosion of Low-Carbon Steel in the Presence of Basalt-Packing," August 1985.

2. B036177, "Analysis of the Effects of Radiation on the Chemical Environment of a Waste Package in a Nuclear Waste Repository in Basalt," March 1984.

3. SD-BWI-DP-060, "Interim Data Document for the Advanced Conceptual Design of High-Level Waste Packages for a Repository in Basalt," November 1984.

4. RHO-BW-SA-280P, "Conceptual Design of a Waste Package for Emplacement in Basalt," February 1983.

5. RHO-BW-SA-316, "Irradiation-Corrosion Evaluation of Metals for Nuclear Waste Package Applications in Grande Ronde Basalt Groundwater," November 1983.

6. SD-BWI-TI-235 (B032012), "Corrosion Evaluation of Candidate Iron-Based Nuclear Waste Package Alloys in Grande Ronde Basalt Groundwater," February 1984.

7. HEDL-7612, "Corrosion of Copper-Based Materials in Gamma Radiation," June 1986.

NNWSI -- Reviews have been initiated on the following reports this month.

1. NUREG/CR-4619, "Stress Corrosion Cracking Test on High-Level-Waste Container Materials in Simulated Tuff Repository Environments," June 1986.

2. UCRL-15825, "The Effect of Gamma Radiation on Groundwater Chemistry and Glass Leaching as Related to the NNWSI Repository Site," May 1986.

3. ANL-85-41, "One-Year Results of the NNWSI Unsaturated Test Procedure: SRL 165 Glass Application," August 1984.

NNWSI -- Reviews are continuing on the following reports.

1. MRB-0418/UCID-20172, "Attachment 10, Potential Corrosion and Degradation Mechanisms of Zircaloy Cladding..in a Tuff Repository"

2. HEDL-7546, "C-Ring Stress Corrosion Cracking Scoping Experiment for Zircaloy Spent Fuel Cladding," March 1986.

3. HEDL-7545, "Zircaloy Spent Fuel Cladding Electrochemical Corrosion Experiment at 170 C and 120 psiA H20," April 1986.

Using the Revelation software, a tracking system for the documents under review at NBS has been developed. The system will be refined in December and implemented in January 1987. With this system we expect to be able to furnish a more complete picture of the status of each of the NBS reviews performed under Task 1.

TASK 2 -- Identification of Additional Data Required and Identification of Tests to Generate the Data

NBS lead workers are continuing their studies concerning the types of additional data and verification tests needed to demonstrate that the DOE waste package designs will meet the performance objectives of 10 CFR 60. Presently, no parts of the NBS preliminary plans for laboratory tests to be conducted at the NBS under Task 3 of this contract have been approved.

In our November 30, 1986, semi-annual report, statistical considerations pertinent to experimental work for the high-level waste package were addressed. As a follow-up to that discussion, this month a proposal for a study which may be needed to assist in upgrading the experimental work being done by DOE was submitted as a memorandum from W. Liggett to C. Interrante on the subject "Designing Experiments for Error Assessment." In brief, the problem with DOE data seen to date is that the experiments have not been designed for proper assessment of the experimental error. Such experimentation leads to inconclusive results and may, therefore, lead to unnecessary repetitions of experiments. This memorandum was submitted to E. Wick (NRC) for discussion and consideration.

TASK 4 -- General Technical Assistance

Our review of the report by R. E. Thomas, titled "A Feasibility Study Using Hypothesis Testing to Demonstrate Containment of Radionuclides within Waste Packages," was submitted on November 14, 1986. This is our response to your technical assistance request of September 2, 1986, which contained an attachment titled, "Statistical Approach to Prediction of Waste Package Life."

A brief trip report on Dr. R. Ricker's visit to Battelle Columbus Laboratory on September 5, 1986 is attached. During this visit he attended discussions with BCL's staff working under FIN-B-6764 ("Long-Term Performance of Materials Used for High-Level Waste Packaging").

Draft Copy

NBS Review of Technical Reports on the
High Level Waste Package for Nuclear Waste Storage

DATA SOURCE

(a) Organization Producing Data

Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439

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

Bates, John K., Fischer, Donald F., and Gerding, Thomas J., "The Reaction of Glass During Gamma Irradiation in a Saturated Tuff Environment, Part 1, SRL 165 Glass", ANL-85-62. Should be available from NTIS.

DATE REVIEWED: 9/17/86

TYPE OF DATA

Leach data.

MATERIALS/COMPONENTS

SRL 165 glass containing U, Cs, and Sr, (SRL U glass), SRL U glass containing added ^{237}Np, ^{239}Pu, and ^{241}Am, (SRL A glass), PNL 76-68 glass ATM-1c which contained uranium, PNL 76-68 glass ATM-8 containing added ^{237}Np, ^{239}Pu, and ^{99}Tc, J-13 water pre-equilibrated at 90°C for two weeks with Topopah Spring tuff,(EJ-13), tuff, 304 L SS, air.

TEST CONDITIONS

Leach tests were run in type 304 L stainless steel reaction vessels which contained the sample in about 16 ml of EJ-13 water and at least 4 ml of air. These vessels were sealed from the environment with silicone gaskets and exposed to a gamma radiation field produced by a ^{60}Co source of $2x10^5$ rad/h as measured inside the reaction vessel. The temperature was maintained at 90°C. Samples consisted of two glass disks, two glass disks with tuff, or crushed glass. Tests for each of the four glasses were run in duplicate for 7, 14, 28, and 56 days for a total of 96 tests. Similar tests were run on two blanks containing EJ-13 water and EJ-13 water plus tuff for a total of 16 tests. When possible, the MCC-1 protocol was followed.

METHODS OF DATA COLLECTION/ANALYSIS

Solutions were cooled to room temperature and analyzed for pH, cations by inductively coupled plasma spectroscopy (ICP), anions by ion chromatography

(IC), uranium by atomic fluoresence (AF), Cs by atomic absorption spectroscopy (AA), and radionuclides by gamma and alpha counting. The solid test components were analyzed by scanning electron microscopy and associated energy dispersive X-ray analysis, and secondary ion mass spectroscopy.

AMOUNT OF DATA

Tables;
1. Composition of EJ-13 Water (ppm)
2. Composition of SRL Glasses Used in Testing
3. pH and Cation Analyses - Blank Samples
4. Normalized Elemental Mass Loss (Cations) from SRL Glasses U and A
5. Actinide Release from SRL A Glass
6. pH and Anion Analysis - Blank Samples
7. Anion Analysis - SRL Glass
8. Normalized Elemental Release of Actinides after 56 Days
9. Results of Gamma Irradiation Experiments Done with R > 3, where R = gas volume /liquid volume

C1. Actinide Content of SRL A Glass

Figures;
1. pH Trends Observed for SRL A and SRL U Glass; pH,6.4to 7.2, vs time in days, 0 to 60.
2. Average Cation Trends Observed for SRL Glass; Normalized Elemental Mass Loss , 0 to 3 g/m^2, vs time in days, 0 to 60.
3. Total Am, Pu, and U Release from SRL A Glass, Disk-Only Test; Normalized Elemental Mass Loss, 0 to 3 g/m^2, vs time in days, 0 to 60.
4. Micrographs of the Surfaces of SRL U Glass
5. Micrograph of the Polished Cross Section of Sample 15
6. EDS Spectra of SRL U Glass Surfaces
7. SIMS Profiles for Selected Elements in Reacted SRL U Glass
8. $(NL)_{Li}$ as a Function of $Time^{1/2}$; Normalized Elemental Mass Loss of Li, 0 to 3 g/m^2, vs $Time^{1/2}$, $Days^{1/2}$, 0 to 8.

Appendixes;

A. Preparation of Tuff and Prereacted J-13 Water

B. Glass Preparation and Test Procedures

C. Glass Characterization

D. Test Conditions and Weight Change Data for SRL Glass Testing

E. Complete Analytical Results for Gamma Irradiation Tests

UNCERTAINTIES IN DATA

The pH values were unstable because of outgassing of the solution. The lowest pH values were accepted. Anion measurements were affected when trapped gas was introduced during the measurement. Errors in Si analysis were possible because of solution reaction with the silicone gasket material. Errors in Si analysis may have been encountered also in using inductively coupled plasma spectroscopy (ICP). Weight changes for disks with tuff present could be in error because it was difficult to remove. Some error and difficulty in interpreting actinide data was due to inhomogeneity in the composition of SRL A. The degree of reaction is likely to vary between tests because the tests were based on a specific surface area-to-volume ratio (R) leading to a varying ratio R. This variance would lead to a different amount of nitric acid being formed in each test and this might affect the degree of reaction. Estimated standard deviations from scatter in the data were: Na, ±7%; B, ±4%; anions, ±5%; and actinides, ±15%. Standard deviations for other cations were < ±10%. Estimates of accuracy provided by the analysts were ±3 to ±10% for ICP, ±5% for the anions, ±10% for Cs and ±5% for U. In each case, the inaccuracy depends on the amount of an element present in the sample.

DEFICIENCIES/LIMITATIONS IN DATABASE

The current tests were not run long enough to allow long-term reaction trends to be established or to result in deductions of a mechanism for the glass/water interaction; however, no large increase in the extent of glass reaction was observed due to radiation.

APPLICABILITY OF DATA TO LICENSING:

[Ranking: key data ( ), supporting data (X)

(a) Relationship to Waste Package Performance Issues Already Identified.

Related to issue 2.3.2.1, regarding possible dissolution mechanisms of the waste form, in the ISTP for the Nevada Nuclear Waste Storage Investigation (NNWSI) Project.

(b) New Licensing Issues.

(c) General Comments.

KEY WORDS

air, ambient pressure, basic solution, borosilicate waste glass, experimental data, gamma radiation field, high temperature, J-13 water, laboratory, ^{237}Np, leach data, ^{239}pu, radiochemical analysis of solution, ^{99}Tc,weight change,

GENERAL COMMENTS

This report presents data on the influence of gamma irradiation on the reaction of actinide doped borosilicate glass (SRL 165) in a saturated tuff environment. The extent of the glass reaction results from a complicated interplay between the breakdown of the glass matrix, changes in the pH of the solution and interactions that occur with the metal and rock components of the test. In the gamma radiation field nitric acid is generated by radiolysis of air; thus the solution becomes more acidic. This effect is counteracted by dissolution of the glass. This report provides a lot of data on leaching of actinides from a borosilicate glass for a period of up to 56 days. There are a number of factors that the reviewer found problematical. The terms $(NL)_i$ and $(NL)_{wt}$ are used throughout the report assumptions used to determine the surface area in the crushed glass experiments. The discussion of (SA/V)xt, (surface area/volume of solution) x time, correlation is obscure. The explanation for lack of a correlation is merely a restatement of the observation that none was observed.

Draft Copy

NBS Review of Technical Reports on the
High Level Waste Package for Nuclear Waste Storage

DATA SOURCE

(a) Organization Producing Data

Hanford Engineering Development Laboratory, P. O. Box 1970, Richland, WA 99352

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

Funk, C. W. and Jacobson, L. D., "Inventory and Characterization of Spent LWR Fuel", HEDL-TME 77-82. Should be available from NTIS.

DATE REVIEWED: 9/12/86

TYPE OF DATA

An inventory of light-water reactor (LWR) fuel discharged from reactors and stored in water basins, with discussions of its condition. Data obtained from reactor discharge records. Inventory covers the period up to and including 1976.

MATERIALS/COMPONENTS

UO_2 pellets, zircaloy cladding, stainless steel cladding.

TEST CONDITIONS

Fuel rods stored in water.

METHODS OF DATA COLLECTION/ANALYSIS

Certain analyses of the data gleaned from the discharge reports are mentionned under amount of data. Ratios of failed rods to total number of rods are given.

AMOUNT OF DATA

Tables:
1 Inventory of Discharged LWR Fuel Assemblies.
2 Summary of Reprocessed LWR Fuel at NFS (Nuclear Fuel Services).
3 Estimate of Stored Commercial LWR fuel Assemblies.
4 Comparison of Stored LWR Fuel Assemblies at End of 1976 (based on several sources).
5 Inventory of LWR Fuel Assemblies Releasing Radioactivity.
6 Trend of LWR Defective Fuel Assemblies (with time).
7 Crud Thickness.
8 Post Reactor Observations of Cladding Oxidation.
9 Examples of Rod Gas Plenum Analysis.
10 Mechanical Properties of Dresden Zircaloy-2 Cladding.

11 Microhardness of Zircaloy Cladding as a Function of Flux.
12 PWR Fuel Performance Status Report (Third Quater 1976).
13 Long-Term Release of Activity in KWL (Kern Kraftwerk Lingen GmBh) Fuel Storage Pool.
14 Examples of Iodine Spiking.
15 Guidelines for Contamination Control.
16 Distribution of Generated Radioactivity for Typical LWR Spent Fuel Assembly.
17 Fission Product Generated Radioactivity Ranking of Largest Contributors.
18 Generated Radioactivity Ranking of Transuranic Activity Contributors.
19 Generated Radioactivity Ranking of Light Element Activity Contributors.

Figures:
1 Reported Number of Discharged LWR Fuel Assemblies from U. S. Reactors Each Year.
2 Reported Number of Defective LWR Fuel Assemblies (Breached and Leakers) from U. S. Reactors Each Year.
3 Examples of Pellet-Cladding Interaction (PCI).
4 Examples of Hydride Perforations Resulting in Release of Plenum Gases Including Fission Products.
5 Examples of Corrosion Deposits (Crud) on Exterior of Fuel Rods.
6 Examples of Spalled Crud and External Oxide on Zircaloy 2 Cladding
7 Examples of the Effect of Fission Product Iodine on Clad Cracking.
8 Examples of Fretting Damage.

Appendixes:
A Definitions applicable to failed fuel rods
B Sipping Procedures (A sampling method to detect leaking fuel elements)
C Decay Heat and Fission Gas Product Inventory for LWR Spent Fuel - Figure C-1: Decay Heat of LWR Fuel
D Burnup of Stored Fuel - Table D-1: Maximum Burnup of Spent Fuel
E Storage Duration of Spent Fuel - Table E-1: Maximum Residence time of Spent Fuel Assembles in Pool Storage

UNCERTAINTIES IN DATA

Not Applicable

DEFICIENCIES/LIMITATIONS IN DATABASE

The decreasing trend of defective assemblies (1976) needs validation by determining the ratio of defectives to inventory in 1977. The significance of incipient leakers on long-term storage needs more detailed evaluation. The amount of potential release through service- weakened cladding may require an additional load on the storage facility clean-up system.

APPLICABILITY OF DATA TO LICENSING
[Ranking: key data ( ), supporting data (X)

(a) Relationship to Waste Package Performance Issues Already Identified

This paper relates to licensing issues 2.3.6 on damage and failure mechanisms of fuel rod cladding and 2.3.6.1 on predicted rate of failure for each given mechanism of failure.

(b) New Licensing Issues

(c) General Comments

KEY WORDS

LWR spent fuel, fretting, pellet-cladding interaction, hydrogen attack on cladding, crud

GENERAL COMMENTS

In this report, spent light water reactor fuel discharged from reactors and stored in water basins has been inventoried through 1976. Defective fuel has been defined and categorized, and the trends of failed fuel have been evaluated for their impact on the operation of receiving facilities. Failure mechanisms, which release radioactivity have been identified. The sources and levels of activity have been estimated for typical LWR spent fuel assemblies. By estimating the conditions of commercial spent LWR fuel assemblies, the survey was originally assembled to provide a basis for the conceptual design of the receiving operations of LWR reprocessing plant. However, the same information is valuable for final nuclear waste disposal. Some copies of the tables are illegible and a few pages are missing in the reviewers copy of this document.

Draft Copy

NBS Review of Technical Reports on the
High Level Waste Package for Nuclear Waste Storage

DATA SOURCE

(a) Organization Producing Report

Los Alamos National Laboratory, Los Alamos, New Mexico.

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

A.E. Ogard and J.F. Kerrisk, "Groundwater Chemistry Along Flow Paths Between a Proposed Repository Site and the Accessible Environment," (LA-10188-MS), November 1984).

DATE REVIEWED: 10/24/86

TYPE OF DATA

1. Scope of the Report
Chemical analysis of groundwater sampled around the Yucca Mountain, Nevada, proposed repository site. The site is the Topopah Spring Member tuff in the unsaturated zone of Yucca Mountain.

2. Failure Mode or Phenomenon Studied
The speciation and solubility of nuclear waste elements in the groundwaters was calculated using the analysis of the groundwater chemistry along potential flow paths from the proposed repository.

MATERIALS/COMPONENTS

The groundwater in selected Yucca Mountain, Nevada, sites was sampled and the chemistry studied.

TEST CONDITIONS

1. State of the Material being Tested
The groundwater was obtained from wells drilled by the U.S. Geological Survey into the saturated zone around the proposed site.

2. Specimen Preparation
Samples of groundwater were obtained in three different ways. (1) Samples were taken aerobically and sometimes anaerobically during the USGS's pumping tests. Integral samples were obtained because all producing zones at all depths contributed to the groundwater sampled. (2) Individual permeable zones were isolated by inflatable packers and the water from between these packers was pumped and sampled. These tests provide the best information on the change in groundwater composition with depth because the isolation of individual permeable zones yields water from a particular depth rather than integral samples from all depths. Values of Eh measured from such wells also provide the best estimates of water Eh at depth because measurements

were made on water from an isolated zone and without exposing samples to air. (3) Individual samples were taken from selected depths in static holes by lowering an evacuated stainless steel bottle to a selected depth, opening the valve electrically to allow the bottle to fill, closing the valve, and raising the bottle to the surface. Such samples are designated as "thief" samples.

3. Environment of the Material being Tested
Deep wells were drilled and tapped at several Yucca Mountain sites, and also at Pahute Mesa and in the Amargosa Desert.

METHODS OF DATA COLLECTION/ANALYSIS

Composition of the groundwater was determined by analysis for dissolved cations and anions, by electrode measurements for Eh, pH, sulfide, and dissolved oxygen, by alkalinity titrations, and by analysis for detergents.

Cation concentrations (for Ca, Mg, Na, K, Li, Fe, Mn, Al, and Si) were determined using a Beckmann SpectraScan IIIB Multielement Emission Spectrometer with a DC Plasma Excitation Source. Groundwaters were normally filtered through a 0.05-micrometer Nuclepore membrane under anaerobic conditions at the well head, then acidified with ultrapure HNO and sent to the laboratory for analysis.

Anion concentrations were determined using a Dionex Model 16 Ion Chromatograph in the mobile laboratory at the well site. Samples of anaerobically filtered water, water taken directly from the well, and water exiting the mobile laboratory were all used as sample for anion analysis. Varying sampling procedures did not produce discernable differences in the anion content.

Alkalinity was determined by using a Metrohm E636 Titroprocessor to titrate unfiltered samples with HCl.

The detergent content of the water was determined spectrophotometrically with a Hach Model DR-EL/4 Portable Laboratory. Detergent was a good indicator or tracer of drilling fluids in the well.

Eh was measured with a Sensorex S500C-ORP electrode, pH with an Orion "Ross" Model 81-02 combination electrode, sulfide with a Beckman #39610 Sulfide/Silver Electrode, and oxygen with a Fellow Springs Instrument Model 54 ARC dissolved-oxygen meter and electrode.

Amount of Data

Four tables give the analyses of groundwaters from the pumped wells. Tables I and III are both titled "Elemental Concentrations in Groundwaters from the Vicinity of Yucca Mountain," and provide cation data; in I the concentrations are in mg/l and in II they are in mmols/l. Table II is titled "Anion Concentrations and Other Measurements for Groundwaters from the Vicinity of Yucca Mountain;" anion and detergent concentrations are in mg/l and Eh is given in mV vs. H^Y2^Y electrode. Table IV titled "Alkalinity and Anion Concentrations in Groundwater from the Vicinity of Yucca Mountain" gives anion content in mmols/l and alkalinity in meq/l. In the tables the wells are arranged in the order of location, from west to east--the direction of downward slope of the stratigraphy.

In situ organic content of the water from two wells were measured at Battelle Columbus. Total organic carbon contents were 0.15 mg/l in an integral sample from a producing well and 0.55 mg/l in a sample from a packed-off zone in a well.

Two tables give the analyses of the "thief" samples for two wells; some data for integral samples from the same wells are also included. Tables V and VI are both titled "Composition of Groundwaters from Yucca Mountain Wells "Thief" Samples". Table V contains data for cation content (mg/l), Table VI data for anion content (mg/l) as well as Eh and alkalinity (meq/l).

Two tables provide data for groundwater from two wells in Pahute Mesa and one well in the Amargosa Desert. Tables VII and VIII are both titled "Elemental Concentration in Groundwater from Pahute Mesa Wells and a Well in the Amargosa Desert." In Table VII the pH and cation and anion concentrations in mg/l are given. In Table VIII the alkalinity in meq/l and the cation and anion concentrations in mmols/l are given.

Table IX titled "Waste-Element Solubilities in Water from Three Yucca Mountain Wells" lists the solubility (m/l), the identity of the solid controlling solubility, and the primary aqueous species for the six waste elements in the three waters. The solubilities have been calculated with the EQ3/6 chemical equilibrium computer program and the current thermodynamic data base. For the calculations, the compositions of the waters was taken from Tables I and II. One of the waters is typical of water below the proposed repository site, one is a "thief" sample representing the carbonate aquifer underlying much of the area and the most concentrated groundwater possible along the flow path, and the third is typical of wells surrounding Yucca Mountain. The six waste elements are U, Pu, Am, Sr, Ra, Tc.

Table X, titled "Repository Loading after 1000 Years", lists the moles or equivalents of multivalent waste elements (Np, Pu, Tc, and U) in a 70,000-MTHM repository loading of spent fuel after 1000 years.

Two figures are ternary diagrams which compare element concentrations in the various well waters. Figure 3 is titled "Relative Na-K-Ca concentration in Yucca Mountain water" and Figure 4 is titled "Relative Na-K-Mg concentration in Yucca Mountain water."

Five figures give the pH of water from an integral sample taken from a producing well as a function of various added chemicals. Figure 5, titled "The pH of Well J-13 water and pure water as a function of added HCl," has a pH scale from 1.0 to 8.0, and an HCl Added scale from 0.0 to 10.0 mmoles. Figure 6, titled "The pH of Well J-13 water and pure water as a function of added NaOH," has a pH scale from 6.0 to 13.0, and an NaOH Added scale from 0.0 to 10.0 mmoles. Figure 7, titled "The pH of Well J-13 water as a function of pyrite oxidation," has a pH scale from 1.0 to 8.0, and a Quantity of Pyrite Oxidized scale from 0.0 to 2.0 mmoles. Figure 8 is titled "The pH of Well J-13 water as a function of pyrite and local mineral addition. Local minerals were Na-clinoptilolite (2 mols/mol pyrite added), K-clinoptilolite (2 mols/mol pyrite added), Ca-clinoptilolite (2 mols/mol pyrite added), and cristobalite (5 mols/mol pyrite added)." The pH scale is from 5.0 to 9.0 and the Quantity of Pyrite Added scale is from 0.0 to 2.0 mmoles. Figure 9 is titled "The pH of Well J-13 water as a function of NaOH and local mineral addition. Local minerals and addition rates are the same as those listed for Fig. 8." The pH scale is from 6.0 to 13.0 and the NaOH Added scale from 0.0 to 10.0 mmoles.

Five figures show additional relationships among the compositional variables of the wells tested. Figure 10 is titled "Relative fluoride content as a function of relative sodium content for waters from Yucca Mountain" (F/[F+Cl] from 0.0 to 0.6 and Na/[Na+Ca+K] from 0.5 to 1.0). Figure 11 is titled "Ratio of ion activity product to equilibrium constant for calcite as a function of the ratio for magnesite for waters from Yucca Mountain. The dolomite saturation line is also shown" (log^Y10^Y[IAP/K] for Calcite from -3.0 to 1.0 and log^Y10^Y[IAP/K] for Magnesite from -4.0 to 2.0). Figure 12 is titled "Ratio of ion activity product to equilibrium constant for calcite as a function of the ratio for fluorite for water from Yucca Mountain" (log^Y10^Y[IAP/K] for Calcite from -3.0 to 1.0). Figure 13 is titled "Total sulfate content as a function of total chloride content for water from Yucca Mountain" (Total Sulfate Content in mmoles/l from 0.0 to 1.5 and Total Chloride Content in mmole/l is from 0.0 to 2.0). Figure 14 is titled "Total sulfate content as a function of total chloride content for water from Yucca Mountain --expanded scale" (Total Sulfate Content in mmoles/l from 0.0 to 0.5 and Total Chloride Content in mmoles/l from 0.0 to 0.5).

Uncertainties in Data

None given.

Deficiencies/Limitations in Database

The integral samples obtained in the pumping tests are have the disadvantage of being composite samples, having been obtained from all producing zones. Also, the wells may not have been pumped long enough to clear the well of drilling fluids. (Detergent-free water is termed formation water.)

It has not been established whether or not the results obtained on the "thief" samples are representative of water that is in equilibrium with the particular zone sampled. The data from the "thief" samples cannot be interpreted at this time.

Applicability of Data to Licensing

Ranking: key data ( ), Supporting data (x)

(a) Relationship to Waste Package Performance Issues Already Identified

This report deals with issue 2.1.3 regarding the chemical characteristics (Eh, pH, chemical composition, etc.) and issues 2.3.2 and 2.3.2.3 concerning the solubility of the waste form and radionuclides.

(b) New Licensing Issues

None

Key Words

Attached.

General Comments

The report contains a large amount of data but much more data are needed to characterize the groundwater as a function of geographical area, depth, and time. The authors question whether the reducing groundwater is representative of the entire repository block, how the water mineral reactions affect oxidation/reduction buffering capacity, whether calculations and laboratory experiments accurately represent the actual repository processes of solubility, particulate filtration, etc. These and other related topics are proposed by the authors for future work. This report has a rather long list of references, a number of which seem directly related to the data in this report.

Related HLW Reports

[The following reports may be in the data center library already. If not, they should probably be obtained and a decision made as to whether any of them should be included in the data base. The Los Alamos reports are listed first, then U.S. Geological Survey reports.]

Reference	Report No.
9	LA-9328-MS
30	to be published
7	LA-9577-PR
8	LA-10032-PR
10	LA-9666-PR
12	LA-9484-PR

13	LA-9793-PR
14	LA-9846-PR
15	LA-10006-PR
11	LA-9331-PR
19	USGS-OFR-83-856
1	USGS-OFR-83-854
2	USGS-OFR-84-063
3	USGS-OFR-83-4171
4	USGS-OFR-83-856
5	USGS-OFR-83-855
6	USGS-OFR-83-853
20	USGS-OFR-83-542

also, from the Office of Nuclear Waste Isolation,

16	ONWI-448

Subject: Trip Report by R. E. Ricker on Visit to Battelle Columbus Laboratories (BCL) September 5, 1986

Purpose: To Obtain Background Information on the SRP by Attending Talks on Current NRC Office of Waste Management Sponsored Research at BCL

Four presentations on the status of NRC Office of Waste Management research programs on the long term performance of candidate materials for high-level waste packages at Battelle Columbus Laboratories were given at BCL on September 5, 1986:

(A) "Long-Term Performance of Materials Used for High-Level Waste Packaging, Project Overview" by D. Stahl, presentation by D. Stahl

This presentation was a basic overview of the entire NRC project at Batelle Columbus Laboratories (16 overheads).

(B) "Container Materials, Overpack Corrosion" by J. A. Beavers, N. G. Thompson and R. N. Parkins (consultant), presentation by John Beavers

This presentation reviewed the accomplishments of the first two years and the ongoing work in the third and fourth year of the overpack corrosion part of this program (71 Overheads).

(C) "Hydrogen Embrittlement of Containers for High-Level Waste-Containment" by H. J. Cialone, presentation by Henry Cialone

This presentation reviewed the results at Battelle on the effects of hydrogen on the properties of cast steels and Armco CP iron. Then, the plans to complete the work on the cast commercial-purity iron and to study the influence of welding on the sensitivity of cast steel were discussed (37 overheads)

(D) "Analysis of Container Corrosion" by A. J. Markworth, J. E. McCoy and D. D. Macdonald (consultant), presentation by Alan J. Markworth

This presentation briefly reviewed the work on general corrosion and then focused on the pit modeling work. Discussion on the relative influence of active vs. inert walls on the pitting model provoked numerous questions. (50 overheads in handout, 21 covered in presentation)

This visit was informative and the overall quality of effort at BCL is good. The overheads used in the presentations were handed out and copies (with my notes) are available (NBS-SRP Shelf list No. 72a-d) for anyone interested.

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ENCLOSURES

Our comments on this report were discussed by phone with Dr. Interrante, the NBS Program Manager on this project. A marked-up copy of the report was sent to him.

REMARKS

That completes this action.

E. A. Wick 2/6/87

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