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APPENDICES

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By B. John Garrick
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MINUTES OF THE 101ST MEETING OF THE ADVISORY COMMITTEE ON NUCLEAR WASTE
June 10–12, 1998
Rockville, Maryland

The U.S. Nuclear Regulatory Commission (NRC), Advisory Committee on Nuclear Waste (ACNW), held its 101st meeting on June 10–12, 1998, at Two White Flint North, Room T-2B3, 11545 Rockville Pike, Rockville, Maryland, 20852. The purpose of this meeting was to provide a forum for attendees to discuss and take appropriate action on the items listed in the agenda (Appendix II). The entire meeting was open to public attendance.

A transcript of selected portions of the meeting is available in the NRC's Public Document Room at the Gelman Building, 2120 L Street, NW, Washington, DC, 20555. Copies of the transcript are available for purchase from Ann Riley & Associates, Ltd., 1250 I Street, NW, Suite 300, Washington, DC 20005. Transcripts are also available for downloading from, or reviewing on, the Internet at http://www.nrc.gov/ACRSACNW.

ATTENDEES

ACNW members who attended this meeting included Dr. B. John Garrick, ACNW Chairman, Dr. Charles Fairhurst, Dr. Raymond G. Wymer, and Dr. George M. Hornberger. For a list of other attendees, see Appendix III.

June 10, 1998

1. CHAIRMAN'S REPORT (Open)

[Mr. Howard J. Larson was the Designated Federal Official for this portion of the meeting.]

Dr. B. John Garrick convened the meeting at 8:30 a.m. and explained the purpose of this session. He announced that several articles of interest had been included in the handout provided to the members, and noted that he would defer the reading of items of current interest to a later time in the meeting. Dr. Garrick gave a brief summary regarding both the natural and the engineered barrier system (EBS) as key elements of defense in a multiple-barrier, defense-in-depth approach for licensing a geological repository for high-level radioactive waste (HLW). He pointed out the importance of a demonstration by the Department of Energy (DOE) that the performance of the EBS and its component subsystems would significantly contribute to compliance with the NRC's HLW regulation. In particular, such a demonstration would be a fundamental feature of a license application (LA). He also stated that the topic of engineered

barriers is very important to the Commission since the NRC staff is approaching its review of the DOE's viability assessment (VA), and is also preparing to move from pre-licensing to licensing activities for the proposed Yucca Mountain repository.

II. MEETING WITH THE CHAIRMAN, U.S. NUCLEAR REGULATORY COMMISSION (OPEN)

[Mr. Howard J. Larson was the Designated Federal Official for this portion of the meeting.]

To begin the next portion of the meeting, Dr. Garrick introduced Dr. Shirley A. Jackson, Chairman of the U.S. Nuclear Regulatory Commission. In her opening remarks, Chairman Jackson welcomed the invited speakers and indicated her pleasure at being able to address the Committee on the most relevant topic, "Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository." She noted that Title 10, Part 60, of the Code of Federal Regulations (10 CFR Part 60) recognizes both the natural and the engineered barrier systems. Nevertheless, because of the DOE's emphasis, the NRC has in the past concentrated on the performance of the natural barrier rather than the engineered barriers. She stated that the Commission has approved the NRC staff's proposed strategy for preparing a new regulation, 10 CFR Part 63, which is specific to Yucca Mountain.

Chairman Jackson next addressed, and commented on several of the ACNW's stated interests, including the following examples:

- Risk-informed, performance-based regulation — The NRC continues to make progress as it moves toward this objective, with the intention being a more efficient and effective regulatory basis.

- Proposed 10 CFR Part 63 regulation, specific to Yucca Mountain — This regulation is a departure from prescriptive subsystem requirements. The looming potential uncertainty could be differences in 40 CFR Part 197, the Environmental Protection Agency's standard specific to Yucca Mountain, which could include a separate groundwater requirement.

- Application of the defense-in-depth and multiple-barrier concepts.

- Application of performance assessment (PA) to waste issues, recognizing that one cannot directly apply probabilistic risk assessment (PRA) methods.

Chairman Jackson discussed the NRC staff's pre-licensing responsibilities for Yucca Mountain (e.g., evaluation of the DOE VA, which requires maintenance of appropriate expertise, as well as development of related acceptance criteria). She touched on recent Congressional budget activities and her recent discussions with the Senate appropriations committee. She noted that each group in the agency must develop an operating plan and that a regulatory agency, such as the NRC, can only "walk the line" by being performance based.

After answering several questions from ACNW members, Chairman Jackson closed her discussions with the comment that the ACNW's "work is important, and will become more important to us in the future." She exhorted the Committee to provide its advice to the Commission in a timely and efficient manner.

III. NEAR-FIELD ENVIRONMENT AND PERFORMANCE OF ENGINEERED BARRIERS IN THE YUCCA MOUNTAIN REPOSITORY (Open)

[Dr. Andrew C. Campbell was the Designated Federal Official for this portion of the meeting.]

A. Introduction: Dr. Raymond G. Wymer

For this working group session, Dr. Raymond G. Wymer provided opening remarks including the purpose and format of the session. He stated that the working group brought together scientists and engineers from governmental, academic, and private organizations, including the DOE, the NRC, and the NRC's Center for Nuclear Waste Regulatory Analyses (CNWRA). He said that the working group would address information and modeling needs for calculating the release and transport of radionuclides from the near-field environment of the proposed HLW repository. The focus of the session, Dr. Wymer said, would be on conditions and processes that may occur inside the disposal drifts of the mined geological repository. He said that the working group would consist of three half-day sessions with plenary speakers and presentations by DOE and NRC representatives in three broad areas including: engineered barriers and environmental chemistry, waste package (WP) corrosion, and radionuclide chemistry in the near-field environment. In addition, Dr. Wymer said that there would be a panel discussion on the afternoon of the second day featuring the plenary speakers, and there would also be a public comment period.

B. Engineered Barriers and Environmental Chemistry

Plenary Presentation: Dr. Michael Apted (QuantiSci, Inc.)

Dr. Wymer introduced the first speaker, Dr. Michael Apted, QuantiSci, Inc., who gave a presentation on "Engineered Barriers and Environmental Chemistry." Specifically, Dr. Apted discussed the concepts of "robustness and confidence building; the multi-barrier concept for waste isolation; defense-in-depth (DID) in waste management; and how different nations approach the problem of design and performance assessment of the near field. He discussed the design strategy used for the Yucca Mountain EBS environment. Dr. Apted noted that the time frame of compliance, which is much larger in the rest of the world compared to the United States, determines how much reliance can be placed on different barriers in the EBS rather than different features of the geologic site. He cautioned against focusing on arbitrary subsystem performance requirements. In addition, he discussed the advantages and disadvantages of relying on the EBS instead of the natural barriers. Dr. Apted defined "robustness" in terms of effectiveness and reliability, he said that a "robust" approach

attempts to eliminate reliance on uncertain processes in favor of simple and easily demonstrable processes.

Dr. Apted discussed the primary function of containment in terms of: isolating the waste during the thermal pulse generated by radioactive decay; the mean time to failure of the WP relative to the half life of the isotopes; and the distribution, size, and geometry of WP failures. Dr. Apted discussed the use of different corrosion resistant materials (CRMs) in WPs. He discussed taking credit for fuel cladding in PAs and the need to develop a data set to justify such credit. He discussed different approaches in PA for controlled release of radionuclides from the EBS. Dr. Apted said that colloids in the near field can be eliminated as an issue if a barrier is used that prevents or limits the transport of colloids out of the near field. He described a "top-down" EBS strategy, which he contrasted with a "bottom up" strategy. In addition, Dr. Apted discussed changes in the DOE's approach since Total System Performance Assessment 1995 (TSPA-95), and discussed new information and additional enhancements for the EBS. He discussed perturbations of the near field (e.g., thermal, mechanical, and hydrochemical) and key issues that may need to be considered in a PA. He discussed monitoring and retrievability required by the current NRC regulations. Specifically, he said that the regulations impose limits on the use of backfill because of the difficulty and cost of emplacing it after the retrievability period.

In summarizing the issues he discussed, Dr. Apted noted that simply designing a thicker CRM layer with C-22 does not yield a robust design. He reiterated his view that "robustness" refers to effective and reliable EBS performance given simple, well-understood processes, rather than on adding more design options or thicker WP materials.

Discussion:

Dr. Joseph H. Payer, Case Western Reserve University, observed that "robustness" has been used in the [DOE HLW] program for corrosion-resistant WP designs, which is a different meaning than that defined by Dr. Apted.

Dr. Shoesmith, Whiteshell Laboratories, commented on Dr. Apted's statement that no other repository program is using CRM for the WP. Dr. Shoesmith noted that, other programs rely on the reducing environment to minimize container corrosion. By contrast, the Yucca Mountain environment will essentially be oxidizing instead of reducing, so there is a need for a WP material that is resistant to corrosion in this type of environment. He noted that hydrogen gas production may be a problem for sealed repositories with reducing environments.

Dr. Apted said that the unease he expressed was with regard to uncertainties of localized corrosion mechanisms.

C. Environmental Chemistry Issues

Plenary Presentation: Dr. William Murphy (Center for Nuclear Waste Regulatory Analyses)

Dr. Wymer next introduced Dr. William Murphy, Center for Nuclear Waste Regulatory Analyses (CNWRA), who spoke about "Environmental Chemistry Issues." Dr. Murphy said his presentation would focus on the key technical issue (KTI) concerning the evolution of near-field environment (ENFE), and he discussed the NRC's other nine KTIs. In particular, Dr. Murphy noted that, in the ENFE KTI, the NRC is developing acceptance criteria to resolve the subissues for the thermal-hydrological-chemical (THC) coupled process issues related to seepage, WP environment, release, transport, and criticality. Dr. Murphy discussed near-field rock properties and described the mineralogy of rock that is sealed inside a sill intrusion as a possible analog to the heating effects of the waste. He said that alteration resulting from the thermal pulse is likely to proceed in a manner similar to natural paragenesis. He further said that one can infer that the near-field evolution of formed minerals is likely to follow the site diagenetic sequence of volcanic glass alteration to zeolite to analcime to albite. He discussed the heterogeneity of flow fields at the site and the near-field effects on water chemistry. In addition, Dr. Murphy discussed other processes that will be affected as the heat pulse decays (thermal perturbation) and he said that the transformation of silica phases is an unresolved problem.

Dr. Murphy described the changes in carbon dioxide (CO_2) gas and water (H_2O) vapor during the heating and cooling phase of the repository performance. Dr. Murphy discussed the natural differences in water chemistry between matrix water, fracture water, perched water, and saturated zone water. The last three are all similar in composition and all quite different from matrix water, which is much higher in sulfate and chloride (SO_4^{2-} and Cl^-). Dr. Murphy described thermodynamic modeling of how water chemistry constituents will change with time as the repository heats up and cools down. To illustrate, he described a model calculation of changes in anions like bicarbonate, sulfate, and chloride (HCO_3^{2-}, SO_4^{2-}, and Cl^-) as boiling progressively removes more water from drips falling on hot WPs. The most concentrated solutions become sodium- and chloride-rich brines. He said that this has some implications for WP corrosion, which is strongly affected by the chloride concentration in the water contacting the metal.

Dr. Murphy described near-field effects on gas phase compositions. In particular, he noted that as boiling occurs, the water vapor purges nitrogen and oxygen (N_2 and O_2) from the air and CO_2 and H_2O vapor increase. He said that the gas compositions return to ambient conditions when boiling stops.

Dr. Murphy discussed the possible impacts of introducing large amounts of cementitious materials into the drift. This will cause alkaline conditions and high calcium

concentrations to prevail for some period of time. Other issues of concern are the stability of concrete and the possible chemical interactions with the host rock. Dr. Murphy discussed the near-field effects on the chemical environment for containment and release, but he noted that carbonation will mitigate some of these conditions. In addition, he discussed the near-field effects on radionuclide transport, including: sorption and precipitation or coprecipitation of radionuclides by other mineral phases.

Dr. Murphy discussed a number of topics related to metallic materials, as they affect the possible corrosion of the WP and the dissolution of the waste forms (e.g., the formation of ferrous-oxides). He said that the Yucca Mountain environment is thoroughly oxidizing, and it will not become reducing except in very localized situations. He discussed a variety of waste form topics, and he showed a picture of uranium ore from the Nopal 1 mineral deposit at Peña Blanca, Mexico, which he described as a natural analog for the Yucca Mountain repository. Dr. Murphy noted said that there are many similarities between the oxidized uranium ore and the reaction products found in DOE's spent fuel degradation experiments and other tests.

Dr. Murphy noted a number of miscellaneous concerns, such as the effects of microbially induced WP degradation, criticality, gas composition, and the use of different types of backfills and buffers. He described the status of information regarding the masses of chemical components in the natural system, which he said was good and getting better, as well as the engineered materials, which he said will need a common design rather than frequent changes in materials. In addition, Dr. Murphy discussed the status of information requirements for thermodynamic modeling data, mineral phase data, and kinetic data. He summarized the main issues from his presentation, specifically noting that some of the work involved state-of-the-art modeling.

Discussion

In answer to a question from Dr. Shoesmith about the calcium (Ca) content of the water, Dr. Murphy said that one can argue either for low or high Ca, but cement will be a high Ca source. Dr. Apted asked if taking credit for degradation products is either credible or reliable. Dr. Murphy noted that this is a realistic approach and, for Yucca Mountain, it may be important to make a case for secondary products taking up radionuclides that get released. Dr. David Sassani, management and operations contractor, from Las Vegas, Nevada, talked about newer modeling results that indicate higher CO_2. In response, Dr. Murphy discussed the depletion of carbonate ions from the aqueous phase. Dr. Shoesmith said that after 10,000-11,000 years, the models show ambient carbonate values.

D. Near-Field Environment Models

1. DOE/Management & Operations Contractor Presentation: Dr. Abe Van Luik (Department of Energy)

Dr. Abe Van Luik, DOE, talked about the "Near-field geochemicaleEnvironment abstraction for total system performance assessment viability assessment (TSPA-VA)." In particular, he said that the DOE intends to take credit for cladding in the TSPA-VA, but that they will decide later about taking such credit in the license application. He added that DOE changed the CRM to C-22 only 6 months ago, and they will have further changes to the design in the near future. Dr. Van Luik discussed the items on the presentation outline. In particular, he showed the relationship of the near-field geochemical environment work to other components of the TSPA-VA. He discussed the technical bases for the modeling, including site measurements, site experiments, site analogs, laboratory experiments, and data analysis and compilations. In addition, he discussed different areas of the analyses, including gas and water ingress to the drift, the in-drift gas model, and the in-drift water model.

Dr. Van Luik gave an overview of the base-case approach, including the thermohydrological evolution of the repository. He described how the model accounts for introduced materials in a simplified way. He discussed the incoming gas compositions and the model predictions of air in the repository during the time of the thermal perturbation. He noted that TSPA uses abstracted information from a two-dimensional (2-D) mountain scale model and a three-dimensional (3-D) drift scale model. He described the air composition at defined time periods of interest. He discussed incoming water compositions and described how the abstracted TSPA model is derived from a more complex process-level models. In addition, he described the chemical changes in the water including pH changes. Dr. Van Luik discussed changing gas compositions in the drift over time, and he discussed the potential formation of $CaCO_3$ in concrete (carbonation) at 10,000 years and 100,000 years. Dr. Van Luik said that the results of a mass balance calculation for iron oxidation and oxygen (O_2) consumption show that there is plenty of O_2 to have completely oxidizing conditions except during the boiling period.

Dr. Van Luik described the results of the different process-level models for water-solids chemical reactions. He described the model outputs to the TSPA-VA base case. He discussed the potential for colloids to carry Pu and said that this is not a minor issue. He discussed the sensitivity analyses that DOE is performing, as well as current and future planned activities. He described the interactions of the waste forms with water and the effects on water composition. Dr. Van Luik discussed the potential formation of salt deposits on the WP, indicating that as salts accumulated on the WP water can no longer evaporate because of the salt's hydroscopic properties. He discussed the importance of the nitrate content of the salt. There was a

question about sodium fluoride in the salt. Dr. Van Luik said that the salt is composed of sodium (Na), potassium (K), and sulfate (SO_4) in the solids. The rest of the ionic species exist in a liquid brine phase, which forms as the relative humidity increases, and water drips eventually wash the salts off the WP. Dr. Van Luik discussed models of microbial effects, as well as uncertainties in the models and which of these were covered or not covered in the current modeling work. He added that much work remains to be performed.

Discussion

Dr. Whipple noted that the reported colloid concentrations appeared to be in error. Dr. Van Luik said they will check on them.

Dr. Staehle, University of Minnesota, asked how do they define failure. Dr. Van Luik said that if containment for thousands of years is imperiled, the system has failed. Dr. Staehle asked about the design life and leakage rate goals, and Dr. Van Luik said that the design requirement is to have thousands of years of containment with 10,000 years as the goal.

Dr. Payer, Case Western Reserve University, asked about the chemistry of the water getting inside the WP and contacting the waste. Dr. Van Luik said that when sufficient flow is established to wet the inside of the WP, the water chemistry contacting the waste will be the same as in the drift.

2. NRC/CNWRA Presentation: Dr. Peter Lichtner (CNWRA)

Dr. Peter Lichtner, CNWRA, outlined his presentation on "thermal-hydrologic-chemical [THC] coupled near-field environment models." In particular, he discussed one- and two-way THC coupling and the near-field chemistry environment, including salinity, pH, oxygen content, mineral alteration, changes in permeability, and microbial influences. He distinguished process-level models and PA models and discussed examples of process-level models. Specifically, Dr. Lichtner contrasted different modeling approaches for the explicit fracture model (EFM), the equivalent continuum model (ECM), the dual continuum model (DCM), and the multiple interacting continuum models (MINC), and showed concentration profiles for different models in fractures and in the matrix. He discussed the different complicating factors in the model problem.

Dr. Lichtner described the "MULTIFLO" model calculations, including the general conceptual model and the chemical model, and he showed model results for some of the major chemical species (e.g., Cl and pH) and mineral phases. The pH changes were modeled only on the basis of CO_2 degassing from water during the thermal pulse and did not include how concrete may affect pH. Dr. Lichtner discussed mineral alteration and noted that no alteration of crystalline material occurred in the model, but there was some alteration of glass material. He said that these were

similar to metamorphic changes attributable to temperature. He added that the formation of secondary products from the alteration of crystalline silicates is very minor. Dr. Lichtner showed the results of different model calculations (DCM vs. ECM) for temperature, saturation, Cl, and different infiltration scenarios. He described the "dry out" calculations and how they are done. He said that there is a flow of Cl from fractures to the matrix when coupling is employed in the model. He provided his conclusions.

Discussion

In answer to a question, Dr. Lichtner stated that they can use a simple thermo-hydrologic (T-H) model to obtain salinity values.

Dr. Wymer commented that the speakers should focus on two questions for the next day's session:

(a) What are the most important results of these models?
(b) What are the doses to the critical groups?

Dr. Garrick asked the speakers to consider what these models do for uncertainty (increasing or decreasing). Dr. Payer asked about modeling drips over different time periods, and Dr. Lichtner responded that a drift scale model would be needed to look at saturations; he discussed some of the fluid flow work by Ronald Greene, CNWRA. Dr. Apted asked if the model can be used to determine which fractures will flow and over what time period. Dr. Lichtner replied that many simulations would be required to better understand this. Dr. Fairhurst asked if concrete has a large effect on pH and Dr. Lichtner said it was a transient effect that is not very important in the current calculations.

Dr. Fairhurst asked why there was such a focus on the thermal period when conditions return to ambient after few thousand years. Dr. Lichtner replied that the concern was with subsequent changes after the return to ambient conditions, such as WP corrosion. Dr. Fairhurst asked about the effects of concrete on water chemistry and whether it was significant to performance. Dr. Lichtner explained that any pH excursion to higher values was relatively short lived. There also was some discussion of the role of iron in generating colloids and the possible importance for repository performance.

Dr. Murphy and Dr. Lichtner discussed the results of different process models. Dr. Tae Ahn, Division of Waste Management, NMSS, raised a concern about comments regarding cladding credit and discussed some of the bases for the NRC's model of cladding protection. Dr. Apted noted that the DOE's Expert Elicitation Panel for Waste Form Degradation questioned the adequacy of the database. Dr. Shoesmith commented that zirconium metal (Zr) corrodes at an electrochemical potential that is near repository conditions and is also very sensitive to the presence of ferric ions

(Fe^{3+}). He added that they do not see a database that can support long-term performance projections for Zr alloy cladding.

E. Corrosion of Waste Packages

Plenary Presentation: Dr. Roger Staehle (University of Minnesota)

The first speaker in the afternoon was Dr. Roger Staehle, University of Minnesota, who gave a presentation on, "WP corrosion." Specifically, Dr. Staehle discussed 10 issues dealing with corrosion and problems with predicting and ensuring the performance of containers. He presented figures for stress and time to failure that demonstrate many orders of magnitude differences in observed failure rates. He presented nine "bases for a recommended approach" to provide a framework for dealing with corrosion, and he discussed a corrosion-based design approach (CBDA) for prediction. Specifically, Dr. Staehle said that CBDA includes defining the corrosion environments, materials, and mode of corrosion; identifying the superposition of corrosion modes and environments; determining what is meant by failure; providing a statistical definition of corrosion; determining what accelerated testing is to be done; and defining how feedback of information will help with prediction and can be used to correct design. He described various corrosion modes, including general corrosion, intergranular corrosion, pitting, and stress corrosion cracking (SCC), and he discussed corrosion at welds as an important failure mode.

Dr. Staehle described several steps in corrosion prediction, including providing environmental definitions; identifying environmental conditions, as well as the primary parameters affecting corrosion (and any additional environmental parameters); and defining the environmental boundaries (or "box") established by experiment. He explained that those defining environments provide an unassailable foundation for corrosion prediction. He further stated that one needs to look for pH and Eh (electrochemical potential) conditions where a metal has its minimum solubility to identify conditions where corrosion will be the lowest. He compared titanium with C-22 in terms of the pH/Eh range of "passivity." He noted that molybdenum and tungsten make the C-alloys more resistant to corrosion at lower pH. He described the bounds of the "environmental box" and gave examples of many different combinations of modes that can lead to failure of steam generator tubes. He said that the bounds of the "environmental box" are Eh, pH, and chemical species and concentration. In addition, he discussed the six principal corrosion environments that a metal could experience, and he described the different Eh, pH, and species concentrations for each.

Dr. Staehle discussed the development of an environmental box and its application in a corrosion problem. He said that the key to using this approach is to minimize the number of coordinates and to define the corners of the box. Dr. Staehle discussed how corrosion products exert enormous forces when they form, and stated that these forces could cause failure of the WPs. He discussed probabilistic features for

corrosion. He described the "Weibull distribution" and provided examples of how it could be used to model failures for pressurized water reactor tubing. He discussed issues for developing an accelerated testing program, including the acceleration factors for pH, temperature, and stress. In addition, he showed a hypothetical cumulative failure for WPs as the temperature regime cools over 100,000 years, and he discussed different approaches for minimizing corrosion.
Dr. Staehle concluded with the following recommendations:

- The environmental box approach has a number of advantages for corrosion predictions.
- Consider not using steel corrosion allowance material (CAM) for the WP exterior because of volume expansion of corrosion products.
- Consider using two CRMs (e.g., Ti and C-22) together for the WP.
- Develop protocols for accelerated testing.
- Consider avoiding transition from warm to cool conditions in the repository.
- Organize chemical environment to favor minimum solubility of container materials.
- Minimize residual stresses.
- Use a probabilistic framework for modeling long-term corrosion.
- Concentrate SCC experiments on conditions where it occurs and extrapolate to conditions inside the environmental box.

Discussion

In response to a question, Dr. Staehle said that there is a need to have clearly defined engineering objectives and a clear definition of failure for the Yucca Mountain project. Dr. Payer and Dr. Staehle discussed realistic and bounding testing conditions. Next, Dr. Hornberger and Dr. Staehle discussed the ranges for the axes of the environmental box and whether the parameter relationships inside the box need to be monotonic functions of the values at the corners of the box (the extremes). Dr. Shoesmith said that time, which is a crucial parameter, must be extrapolated from shorter to longer times and that there is a need to decouple different models. Dr. Staehle said that one can invoke certain bounding approaches.

F. Localized Corrosion Issues

Plenary Presentation: Dr. Joseph H. Payer (Case Western Reserve University)

Dr. Joseph H. Payer spoke on "Localized Corrosion: Relationships Among Waste Package Materials, Water Chemistry, and Performance." He observed that long-lived WPs are essential for long-term isolation of waste. He said that localized corrosion breaks down the passive film and is the greatest realistic threat to the WP. He added that a prudent engineering practice is to select materials that resist crevice corrosion. He noted that the steel CAM will not be long lived because of corrosion. In addition, he discussed immune, active, and passive corrosion scenarios with

respect to the CAM and the CRM. Dr. Payer identified the Eh and pH conditions under which corrosion occurs, described the pH and Eh conditions at Yucca Mountain and for different solutions. He described crevice corrosion processes and said that alloy C-22 and Ti are the most corrosion resistant materials for conditions at Yucca Mountain, but he asked, "Are they good enough? He observed that if C-22 remains passive for Yucca Mountain conditions, the WP lifetimes are on the order of 10,000 years (for a of 1 μm/yr corrosion rate) and 100,000 yrs (for a of 0.1 μm/yr corrosion rate).

Dr. Payer described how material selections could be made for Yucca Mountain on the basis of the temperature of crevice corrosion. Above a temperature of about 105°C there is no corrosion because the WP is dry; however, as the temperature drops and the relative humidity goes up, the WP surface becomes wetted. Although these are not large amounts of water, the conditions last for long times and corrosion can occur. Dr. Payer said that the main environmental issues are the chemical and physical properties of the water, including temperature, pH, redox state, ionic species, nitrate, silicate, and the presence of complexing species. He noted that the chemistry outside the drift is not important for dealing with WP attack; it is explained well enough at this point in time and the local water chemistry is innocuous. He described the "vulnerable temperature range" (of crevice corrosion) as an intensive property that is easy to measure. He noted that the CAM can easily fail in few tens to hundreds of years. He displayed figures showing alloy C-22's corrosion vulnerability time versus temperature. He defined the time periods of vulnerability for alloy C-22 in the DOE's TSPA-VA base case. Dr. Payer said that there is a need to establish the realistic extreme conditions for Yucca Mountain to constrain corrosion. The long-term temperature modulations within the EBS at the WP are the most important parameters for corrosion. He said that there is a need for a broader database for Yucca Mountain conditions and the CNWRA is doing some of the crucial work.

Dr. Payer said that the major backfill issue is the thermal effect. In his opinion, the long-term modulation of water chemistry is questionable. He discussed capillary breaks and drip shields to keep moisture off the WPs. Specifically, he said that capillary barrier emplacement, stability, settling, and movements are issues for the long-term performance of a capillary barrier. He discussed different drip shield issues. He said that the expansion of steel corrosion products was a major concern and a source of long-term uncertainty.

Discussion

In response to a question, Dr. Payer said that WP welds and the "shrink fit" manufacturing process are major concerns. He discussed stress issues and concerns with aspects of the design that will place strain on the WP. He added that cyclic behavior (wetting and drying) can lead to concentrated salts and that many corrosion conditions occur at the wet and dry extremes of a wetting and drying cycle. Dr. Horn-

berger and Dr. Payer discussed the lifetimes of steel for wet conditions (i.e., a steel coupon in wet sand or tuff).

G. Corrosion Models

1. DOE/Management & Operations Contractor Presentation: Dr. Joseph Farmer (Lawrence Livermore National Laboratory)

Dr. Joseph Farmer, Lawrence Livermore National Laboratory (LLNL), discussed the "Development of Corrosion Models to Support TSPA-VA." Specifically, Dr. Farmer discussed the necessary baseline properties and the selection of engineering materials for the CAM and CRM. He noted the advantages of C-22 over Ti and alloys 825 and 625. He discussed the basis for selecting alternative design options and materials, and he showed photographs of the manufacturing process for the WPs. He discussed the detailed technical approach used by DOE, including work at the Long-Term Test Facility, development of quantitative models, and confirmatory testing. Next, Dr. Farmer provided a detailed description of the general corrosion and coating spallation models, the crevice corrosion and pitting models, and the SCC and thermal embrittlement models. In particular, he said that the critical flaw size to initiate SCC in C-22 is 1.4 cm near the welds, which they believes to be unlikely.

Dr. Farmer said that the corrosion of A-516 steel in the CAM will occur relatively quickly under repository conditions. For substantiation, he presented Raman spectra and X-ray diffraction spectra of Fe-oxide corrosion products. He said that one of the Fe-oxide phases present (β-FeOOH, Akaganeite) has a tubular structure that could trap radionuclide ions, which could then be transported as Fe-colloids. He presented the results of humid air corrosion studies done with thermogravimetric analysis (TGA). Dr. Farmer discussed the different types of coatings that can be applied to the CAM (e.g., HVOF and Plasma sprays). He described two mathematical models of interfacial corrosion and spallation (the uniform expansion and blister models), and he described scenarios leading to crevice corrosion and the integrated corrosion models for the WP. In addition, he discussed crevice corrosion modeling that has been performed and he described a new fiber-optic sensor that they have developed for measuring the pH of water solutions in crevices.

Next, Dr. Farmer discussed the probabilistic pitting models for the CRM and described their application to alloy 825. He discussed the application of pit stifling criteria to C-22 and noted that in the experimental program C-22 does not pit. He stated that the alloy maintains a passive oxide film under a wide range of pH/Eh conditions, and he showed results for cyclic polarization studies of the 625 and C-22 alloys, which demonstrate why C-22 does not pit. He discussed the predictions of theoretical models and compared them with measured general corrosion rates, which he noted are in the range of about 0.01 to 1.0- micron per year (μm/yr). Dr. Farmer showed scanning electron microscopy (SEM) and atomic force microscopy (AFM) photographs of C-22 surfaces exposed to different corroding conditions. These

photographs showed the formation of a surface oxide on C-22, which protects it from localized corrosion. He discussed the SCC model, including the three contributions to stress and the criterion for critical flaw size, and he briefly discussed microbial growth impacts. In addition, Dr. Farmer described the abstractions for TSPA-VA from an expert elicitation panel, as well as the logic diagram for the abstracted WP degradation model used in TSPA-VA. He showed the distributions of general corrosion rates for the CRM under dripping and non-dripping conditions, and he discussed the cumulative failure of WPs with time for different conditions and locations.

Discussion

Dr. Staehle commented on the role of Cr-oxide in the corrosion resistance of C-22 and the pH/Eh conditions where it might be vulnerable to local corrosion. He recommended that testing be done in solutions representing those conditions. Dr. Shoesmith said that a "cliff edge oxide" (shown in one of the AFM photographs) forms a local area where corrosion can take place. Dr. Farmer said that he didn't know whether it is an oxide layer because AFM does not give composition of the material. There ensued a detailed discussion of how the samples were handled and what was the meaning of the different layers observed in portions of the AFM photographs. Dr. Shoesmith maintained that the presence of a thick deposit indicated reprecipitation of a corrosion product rather than a passive oxide film. Such a thick layer he said was created by some form of recrystalization, which indicated an active surface rather than a passive surface. Dr. Farmer discussed the nature of the different surface deposits seen under AFM, including a passive oxide film.

2. NRC/CNWRA Presentation: Dr. Narasi Sridhar (CNWRA)

Dr. Narasi Sridhar, CNWRA, presented material on "Modeling container corrosion—NRC's approach." He said that the primary functions of the containers were to mitigate uncertainties in overall performance and to minimize pre-closure radiation exposure. He described the topics relevant to container performance and noted that his talk would focus on external corrosion and oxidation rather than material stability, mechanical failure, internal corrosion, or disruptive events. He discussed failure processes in the WP design and identified specific failure modes that need to be considered in TSPA, including high-temperature embrittlement. He discussed the DOE's candidate design and material changes in the WP since 1981. Because of this, he said there was a need for flexibility in the NRC's PA methodology that could be applied to classes of materials, as well as a need for the ability to evaluate design changes through input parameters rather than code changes. He noted the NRC's limited resources to perform in-depth studies of alloys or specific designs, and he discussed the limitations of the "CAM" and "CRM" labels used to describe the inner and outer WP materials.

Dr. Sridhar said that he would focus the next portion of his talk on the CRM. He proceeded to describe different ways of predicting localized CRM corrosion, including analysis of weight loss data, the critical potential method, the critical pH and solution chemistry approach, and the critical temperature approach. He noted problems with the weight loss approach. He presented material to show that low pH is an *effect* of localized corrosion, not a *cause* of it, and he added that, therefore, the critical pH approach is not correct. He said that high Cl concentration is the cause [of localized corrosion] and so one of the axes of [Dr. Staehle's environmental] box should be chloride concentration.

Next, Dr. Sridhar discussed the critical potential approach, showing how the corrosion rate of a material is tied to the electrochemical potential of the material relative to the solution it is in. He discussed the validity of the repassivation potential approach for estimating localized corrosion conditions. He discussed the approach they used to determine the important environmental parameters. Specifically, he said that the only important ions were chloride (Cl^-), which promotes corrosion, and nitrate (NO_3), which inhibits corrosion. Therefore, the NRC/CNWRA approach includes variable Cl^- concentrations in the TPA model that are derived from the MULTIFLO process-level model. Dr. Sridhar discussed the repassivation potential versus temperature, and described the concept for applying this approach. Specifically, he compared the repassivation potential relative to the Cl^- concentration for the 825, 625, and C-22 alloys. He discussed critical localized corrosion temperature experiments for C-22 that are reported in the scientific literature. He discussed the negative effects of welding on the resistance to localized corrosion for C-22, and he noted that annealing can largely restore corrosion resistance. He discussed localized corrosion mechanisms and the current state of knowledge about them. In particular, he characterized the mechanical similarity between pitting and crevice corrosion. He said that repassivation is dictated by solution chemistry inside the pits, and he discussed the role of Cl^- concentration.

Dr. Sridhar discussed the "CAM," stating that modeling of carbon steel corrosion is complex because of different environmental factors. Localized corrosion, he stated, occurs under a limited set of circumstances and is likely to form broad and shallow features as shown in pipelines and archeological objects. He said that the steel corrosion product akaganeite has a high Cl content (1-13 %) because of its tubular structure, and this may lead to local areas of high Cl. Next, he stated that local corrosion in A516 steel occurs only under alkaline conditions, and repassivation is dependent on both temperature and pH. Dr. Sridhar described the implementation of container failure models in the TPA model, and he described some of the differences between the DOE and NRC approaches, adding that these are being resolved with time. For the CAM, he said that the NRC uses corrosion and repassivation potentials to estimate corrosion rates, while they use the extreme value growth rate for pits. He further explained that the DOE uses parametric expressions from field exposures, and the NRC uses a pit growth rate model from an expert elicitation. For the CRM, he said that the NRC uses corrosion and repassivation potentials to determine the

corrosion mode, while the DOE uses a constant pit growth rate once local corrosion is initiated. In addition, he said that the DOE uses parametric expressions from accelerated immersion testing. Finally, he discussed some of the uncertainties and future activities for the CAM and the CRM.

Discussion

During the question and answer session, the following issues were discussed:

(a) the 2-3 thousand-year pH increases in the repository resulting from cement-water interactions and its effects on WP outer barrier corrosion

(b) secondary uranium phases

(c) resistance to internal oxidation and oxidation along grain boundaries of Ti and Ni alloys.

H. Summary: Dr. Martin J. Steindler (ACNW Consultant)

Dr. Martin Steindler, ACNW Consultant, provided a summary of the day's discussion. He began by stating that he wanted to focus on the NRC's role and said that they have a real challenge in evaluating VA. He said that they should keep in mind Chairman Jackson's comment (in her opening remarks) regarding timeliness and efficiency. He noted that the EBS has become more important as other aspects of the repository (natural site) have become problematic. He noted that they had not heard what is and isn't important. To clarify, Dr. Steindler stressed that it is important to have a good understanding of the basic scientific or mechanistic phenomena that underlie the models, and to know their limitations. He noted the need to defend the model abstractions used in the PA model, and he added that a better understanding of uncertainty in the data is needed for PA. He discussed the importance of coupled processes. In addition, he said that the staff needs to ensure that there is a reasonable approach to conservatism and that unreasonable extrapolations under the umbrella of conservatism could preclude any repository from being licensed.

Discussion

In the ensuing discussion of the aforementioned issues, Dr. Farmer said that the lookup tables they use in TSPA model have mechanistic bases and they provide the probability distribution functions (PDFs) and basis for them in the results. He noted that they do look at what is and is not important and discontinue work on issues of less importance (e.g., thermal embrittlement of carbon steel). He praised the scientific work and expertise at DOE and CNWRA and added that the high-quality work by the NRC/CNWRA has served as a driver for the DOE program. Dr. Staehle commented that there was no shortage of talent, but there was, he said, a lack of the necessary engineering approach and focus.

Dr. Garrick noted that C-22 is a relatively recent addition, but that DOE has had a long-term program for evaluating various materials including C-22. He asked what other applications of C-22 exist and what else is known about this material. He raised the issues of designing, fabricating, assembling, and building high-integrity, long-lived systems, and asked what level of confidence exists that these systems will last thousands of years.

Dr. Staehle said that C-22 is a well-studied material, but many materials have failed as a result of welds and problems with fabrication processes. He said that the biggest problems are not in the bulk materials, but in the welds. Dr. Farmer provided some reports to Dr. Garrick and noted that the DOE has looked at a number of fabrication and design alternatives. Dr. Payer said that the importance of welds and weld corrosion is recognized, but much more work is needed. He said that the use of C-22 is probably overkill, but given the uncertainties, it is the right material. They now need to fully evaluate what else needs to be done in areas such as fabrication. Dr. Sridhar said that C-22 was invented in 1979, and the C-alloys were used by the Germans in the 1950s. He said that there is much corrosion data for C-22 under certain conditions, but that they need to specify and map out conditions under which C-22 does and does not corrode. He said that in an Appendix 7 meeting, the NRC emphasized a long-term testing approach to focus on understanding the mechanisms and measuring parameters that provide information about those mechanisms. He said that welds do decrease potential corrosion, but this does not necessarily mean that it affects performance.

Dr. Wymer said that there is a lot of complexity in the system, so there is a need to focus on what is important. Dr. Staehle said that there is a need to determine the bounding conditions. He said that too much reliance on "mechanisms" ends up with too many variables to deal with. There is a need, he said, to reconstruct the program to define what the bounding environmental conditions are; a need to aim questions at simplicities rather than at the complexities. Dr. Apted said that one can't solve all the problems with one given barrier and noted past reservations about time frames of these scales. He said that one needs to identify the needed functions and performance of a barrier for the problem at hand. Dr. Staehle said that redundant barriers are an important part of engineering and reactor safety. Nonetheless, he said there is a need to identify bounding conditions that allow one to set design objectives. Dr. Sridhar said that they have looked at other issues like backfill, which led to high temperatures, so they began to worry about detrimental effects. He said that evaluating important parameters, establishing needs, and identifying bounding conditions are being addressed. Dr. Garrick noted a need for simplified designs and systems. Dr. Shoesmith said that there is much effort being devoted to bounding conditions, although this is not outlined in the work described for the Committee. Dr. Hornberger observed that, even for something simple, complexity gets added in by attempting to address the questions. Dr. Steindler noted that although there is a desire for simplicity, a lot of complex questions and issues will be raised in the licensing process, and these will have to be addressed.

June 11, 1998

The second day continued the discussion of the near-field environment and performance of engineered barriers in the Yucca Mountain repository.

I. **Chemical Processes Affecting the Release of Radionuclides in the Near-Field Plenary Presentation: Dr. David Shoesmith (Whiteshell Laboratories)**

The first plenary speaker on June 11TH was Dr. David Shoesmith, Whiteshell Laboratories, Manitoba, Canada, whose presentation was entitled, "Chemistry Considerations for Release and Transport of Radionuclides from Spent Fuel." Dr. Shoesmith introduced his presentation with a description of the "Theory of Theories." He described the TSPA-VA code configuration and discussed the relevant inputs and outputs for release and transport. He defined failure for different components of the EBS, including the WP cladding, waste form degradation, and radionuclide source term. He presented the main issues to be discussed for fuel corrosion and radionuclide source terms. He stated that the formation of colloids and their possible impact on release was a source of uncertainty. He added that if some aspect of the performance is unpredictable (e.g., colloids), an engineering approach is needed to preclude possible negative effects. Next, Dr. Shoesmith described the release of radionuclides from spent fuel in terms of the inventories of isotopes in the gap between the cladding and the fuel, in the grain boundaries of the fuel, and in the fuel matrix. He presented the key radionuclides in the inventories, and he described the redox chemistry of fuel oxidation and dissolution. He described two scenarios for dissolution of radionuclides from the fuel after the cladding has failed. One scenario was for humid air vapor penetrating failed portions of the cladding, and the other scenario involved drips penetrating failed parts of the cladding. He discussed the influence of fuel corrosion products and chemical reactions on the dissolution rates of radionuclides.

Next, Dr. Shoesmith discussed the changes in fuel composition and chemical state resulting from the formation of fission products. In particular, he said that the presence of CO_3^{2-} ions, Ca^{2+} ions, and $Si(OH)_4$ ions in the water can strongly influence the dissolution rate. The presence of CO_3^{2-} ions in the water increases the dissolution rate because it forms a chemical complex with uranium and other actinides, whereas the presence of Ca^{2+} ions, and $Si(OH)_4$ ions in the water inhibit the dissolution rate. He discussed the effect of alpha, beta, and gamma radiolysis and the so-called burnup effect for estimating the release of radionuclides from the spent fuel. Specifically, he said that there does not appear to be an intrinsic burnup effect, and the observed increase in corrosion potential under a gamma radiation field may explain the very aggressive corrosion observed in spent fuel laboratory drip tests.

Next, Dr. Shoesmith discussed two modeling approaches for fuel corrosion. One model is built upon parametric fits to experimental data. The other model is founded on an intrinsic dissolution rate modified for temperature dependence, fuel surface area exposed to water, reaction rate dependence on oxygen and carbonate concentrations in the water, and the presence or absence of seepage drips. Dr. Shoesmith discussed the influence of corrosion product deposits on the fuel surface, which affects the exposed surface area, reduce oxygen transport to the fuel surface, limit alpha radiolysis effects, and trap radionuclides in insoluble secondary phases. He discussed the fate of released radionuclides, which can be unretarded (e.g., ^{129}I released and transported as a soluble phase), partially retarded (e.g., ^{99}Tc reduction by dissolved iron to an insoluble phase), retarded by solubility limits (e.g., ^{237}Np or ^{239}Pu taken up into phases of limited solubility), or characterized by enhanced mobility attributable to the formation of colloids (e.g., ^{239}Pu). He showed some TSPA results of DOE's to illustrate the influence of these different processes on dose.

Next, Dr. Shoesmith described different release assumptions and the supporting information bases in discussing the soluble radionuclides. He said that the available experimental data for Tc interactions with redox active materials is sparse. He said that the problem with the current PA analyses is the rapid waste form alteration rate (about 1000 years) that is used. He noted that transport through corrosion deposits on the fuel surface can significantly retard release. This occurs because the diffusion of oxygen to the unreacted surface is sufficiently slowed to produce anoxic conditions at the fuel surface. He discussed colloidal transport of radionuclides and some of the key unknowns that need to be addressed. Dr. Shoesmith discussed retention of radionuclides by coprecipitation with corrosion products. In addition, he described the wide range of Np solubility results for a variety of different studies, and noted some of the continuing information needs:

- continuing the drip tests
- conducting drip tests on fresh UO_2 with J-13 water spiked with Np
- bridging the gap between spent fuel studies and natural analog studies
- characterizing radionuclide-retaining alteration products
- continuing accurate measurements of thermodynamic parameters for chemical modeling calculations.

Dr. Shoesmith cautioned that carbonate ions can profoundly limit the formation of these corrosion deposits and enhance transport. In summary, he said that the key requirements are to develop a better understanding of seepage water chemistry and flow, corrosion products, alpha radiolysis, colloid formation, rapid corrosion and alteration rates, and cladding credit.

Discussion

Dr. Steindler asked about the role of complexing agents such as fluoride ions (F^-), and Dr. Shoesmith discussed the possible role of this ion. Dr. Staehle noted that F^- enhances Zr corrosion.

Dr. Whipple asked about the retention of radionuclides, and Dr. Shoesmith said that it will be important for Np and possibly Pu, if colloid formation is an issue. Dr. Shoesmith discussed the role of iron (Fe^{2+}) in reducing Tc to an insoluble phase, and noted that the oxidizing environment will tend to oxidize most of the iron to Fe^{3+}.

Dr. Payer asked about the change in water chemistry as it reacts with the corrosion deposits. Dr. Shoesmith said that he did not think it would become acidic as suggested by Payer. Dr. Staehle asked about the role of Tc to inhibit corrosion and the role of surface charges on colloid to limit their mobility. Dr. Shoesmith said there was probably not enough Tc present to act as an inhibitor, and more information is needed on colloid behavior.

J. **Chemical Issues and Considerations for the Use of Backfill in an Unsaturated Zone Repository**

Plenary Presentation: Dr. Joonhong Ahn (UC Berkeley)

The next plenary speaker was Dr. Joonhong Ahn (UC Berkeley), who spoke on "Chemical issues and considerations for the use of backfill in an unsaturated zone repository." Dr. Ahn discussed the work he has done on the use of backfill for the Japanese HLW disposal program. He said that the project may want to consider the use of backfill at Yucca Mountain, but there are uncertainties associated with its use. He proposed the possible use of bentonite as a backfill material and noted some benefits of its material properties (e.g., low hydraulic conductivity, swelling and self-sealing, chemical buffering, and colloid filtration). He discussed two-dimensional model representations of the water flow in the EBS and the disturbed region around the drifts as a function of the degree heterogeneity of rock fractures. He noted that with the use of bentonite, such moisture movement will primarily be driven by diffusion. He discussed bentonite swelling experiments to test its ability to expand into fractures. In addition, Dr. Ahn discussed the redox chemistry of bentonite and noted that the 1-2% pyrite content will lead to reducing conditions. Other mineral phases present will buffer the pH around 9. Considering the low water flow rates, the high pH and reducing environment may last for a long time. Dr. Ahn therefore discussed a mathematical model and assumed chemical reactions for controlling Np mobility in the EBS as developed for the Japanese HLW repository concept. If a reducing environment is maintained at pH 9, the mobility of Np is decreased because it exists as a reduced chemical species. Dr. Ahn discussed the sorption and diffusion

processes that may affect Np and Am mobility in bentonite-filled fractures. In addition, he discussed the possible formation of the clay mineral illite from smectite in bentonite, as well as the decreases in sorption coefficients and increases in pore water velocity associated with this transformation. Dr. Ahn concluded with a summary of the main points of his talk, and recommended that bentonite backfill be used for the Yucca Mountain repository because it would provide stable chemical and hydrologic conditions around the waste packages that would be decoupled from the natural system conditions. He recommended conducting analyses for partially saturated conditions, which are more relevant to Yucca Mountain, and developing an integrated model that incorporates all aspects of bentonite performance.

Discussion

Dr. Fairhurst asked about the Japanese participation in an international modeling program and some of the issues with respect to fracture flow. Dr. Ahn said that the Japanese developer (PNC) is participating.

K. Model Treatment of Chemistry Details

1. DOE/Management & Operations Contractor Presentation: William Halsey (Lawrence Livermore National Laboratory)

The next speaker was Dr. Bill Halsey from LLNL who spoke about "Waste Form Degradation and Radionuclide Mobilization." Dr. Halsey began with a discussion of the TSPA-VA code configuration and the particular details of the code for modeling waste form release of radionuclides. He discussed some of the assumptions used in the model, including the following:

- Waste forms are assumed to be exposed to drift environment after waste package and cladding failure.
- Waste form degradation is assumed to be represented by an "intrinsic dissolution rate," which congruently releases radionuclides.
- A few highly soluble radionuclides are assumed to be released at this rate.
- The concentrations of most radionuclides are assumed to be limited by equilibrium solubility.

Dr. Halsey said that aqueous concentration limits determined by secondary phases are being considered, but are not incorporated into the base case. He discussed some of the issues from the Waste Form Expert Elicitation, including processes and environments, reactive surface area of fuel, cladding credit, solubilities, secondary phases, rapid release fractions, glass waste form dissolution, and colloid formation. In addition, Dr. Halsey discussed specific cladding degradation and failure modes,

including juvenile failures, mechanical disruption, creep failure, stress corrosion cracking, oxidation and hydrogen embrittlement, and localized corrosion. He said that the key issue for long time frames is the potential for localized corrosion.

Next, Dr. Halsey discussed the intrinsic dissolution rate for spent fuel and other factors that determine the concentrations of radionuclides transported away from the waste forms. The intrinsic dissolution model considers a series of parameters such as temperature, burnup, pH, O_2, and CO_3^{2-}. The approach uses fitting constants for each parameter that are adjusted to fit the experimental data. This model is believed to provide an upper bound on the dissolution rate because the constants are fit to high flow rate experiments and the model does not consider uptake of radionuclides into secondary phases. The use of the high flow rate dissolution experiments leads to model predictions of complete fuel dissolution in less than 1000 years. In the area of radionuclide solubilities, Dr. Halsey discussed the overall approach and some of the key issues. He said that additional work since TSPA-95 has allowed them to reduce the Np solubility concentration range by a factor of 100. He said they are also developing information on radionuclide concentrations in water films on the surface of the spent fuel after dissolution. He said that these concentrations are controlled by the formation and dissolution of secondary phases rather than by the intrinsic dissolution of the spent fuel. The data being used to develop this information comes from the water vapor and slow flow rate dissolution experiments. These solution concentrations reflect interactions with non-ideal phases, such as solid solutions, that are not amenable to "chemical equilibrium" calculations. A number of key radionuclide concentrations in these water films are significantly below the current solubility ranges used in the TSPA-VA model. Dr. Halsey said that the concentration ranges are much less than those developed in a DOE expert elicitation. In addition, he discussed defense high-level waste (DHLW) glass dissolution and release of radionuclides. (Because a significant fraction of the Pu appears as a colloid in glass dissolution experiments, they are not using a solubility limit for Pu from DHLW glass.)

Dr. Halsey discussed uncertainties and sensitivities. Specifically, he said that the key uncertainties in the models include waste form surface area contributing to release, cladding performance, dissolution rates, rapid release fractions, elicited solubility values, retention of radionuclides in secondary phases, colloids, and diffusive transport. He discussed waste form sensitivity studies for evaluating cladding performance, secondary phases as controls of radionuclide release, and diffusive versus advective transport. In addition, he discussed some of the improvements to the Repository Integration Program model that enable them to do these sensitivity studies. Other possible sensitivity studies include evaluating spent fuel dissolution, effective surface area, and design alternatives. Finally, Dr. Halsey showed results of sensitivity studies for cladding, secondary phases, and diffusive transport, and he concluded with a summary of his main points.

Discussion

Participants discussed the importance of disruptive events on WP performance.

2. NRC/CNWRA Presentation: Bret Leslie (NRC)

The next speaker was Dr. Bret Leslie (NRC), who discussed the "NRC's Approach to Modeling Radionuclide Release from the Engineered Barrier System." Specifically, Dr. Leslie presented an overview of the NRC's approach and discussed how it is integrated, flexible, and iterative. The NRC's approach for calculating radionuclide release from the EBS includes congruent dissolution of spent fuel in either a "bath-tub" or a flow-through configuration, solubility constraints for certain radionuclides, and a transfer function to account for other EBS material interactions.

Dr. Leslie cautioned that the results are preliminary, and the use of a particular value or parameter does not constitute regulatory acceptance. Dr. Leslie explained that the TPA 3.2 code considers four alternative conceptual models, including fuel dissolution in water containing CO_3^{2-} ions, Ca^{2+} ions and $Si(OH)_4$ ions, a constant release rate model; and release from secondary U mineral phases (e.g., schoepite). He described the rationale for the last model, as well as some possible differences with the repository design. In addition, Dr. Leslie discussed the following assumptions and options in the model:

- There is no colloidal release.
- Chemistry is unchanging with time.
- The bathtub and flow-through approaches are predicted on variations of the same model.
- Radionuclides are released congruently with fuel dissolution.
- Solubility limits are applied after dissolution.
- An option is available for cladding credit.
- Conditions are assumed to be oxidizing.

Next, Dr. Leslie explained that radionuclides are released from the waste form to the interior of the WP, and can only be released from the package by flowing water (advection). Dr. Leslie discussed the different dissolution models in detail. Specifically, he said that the carbonate model is founded on the flow-through experiments of Gray and Wilson (1995). He described the parametric equation for the model, stated the assumptions, and discussed some near-field geochemical reactions that could affect the model variables. He discussed the calcium and silica dissolution model, stating that it is founded on the laboratory batch experiments of Wilson (1990). He described the temperature dependence of the model, stated the assumptions and discussed some near-field geochemical reactions that could affect the model variables. The third model he described was the constant release model, which can

be predicted on either empirical data or natural analog data. He discussed the constraints they are using from the Peña Blanca natural analog site and the application of this information to modeling EBS releases. In addition, he stated the assumptions and discussed some near-field geochemical reactions that could affect the model variables. The fourth model he discussed reflects releases from secondary mineral phases containing uranium (e.g., schoepite). This model is founded on short-term drip and vapor tests, natural analog studies, and thermodynamic studies. Releases are calculated as a function of temperature, pH, and total carbonate. Regarding this model, Dr. Leslie stated the assumptions and discussed some near-field geochemical reactions that could affect the model variables. He discussed the results for different conceptual models and compared the sensitivity of the final dose to these different models. He noted that the natural analog models give results that are several factors of ten less than the congruent dissolution models.

Dr. Leslie provided an overview of radionuclide solubilities. In particular, he stated two key assumptions that the solubility values are for an oxidizing environment, and radionuclide solubilities are controlled by pure mineral phases. He said that the solubility values are derived from a poorly documented "expert elicitation" by the DOE, and he discussed some auxiliary analyses being conducted by the NRC and CNWRA staff. In addition, he noted that the calculated dose is very sensitive to Np solubility, and he showed the Np solubility ranges used by the NRC and DOE, noting that the DOE range is a factor of ten lower than that used by the NRC. He said that the inconsistency in the approaches for using solubility values in different release models needs to be considered. He discussed other EBS interactions to evaluate different design options, including the transfer function approach used by the NRC. This approach is used to model mass transport in the near field though inverts or backfill. He said that the NRC's TPA code has recently been modified to allow the option of using this approach. He compared and discussed the different approaches used by the NRC and DOE for modeling releases from the EBS. Finally, he concluded by discussing the NRC's integrated and iterative approach, as well as the need to analyze alternative conceptual models for near-field chemistry. He discussed the limitations of the models, including the lack of data to support the release models, the short duration of lab tests, and the few experiments to evaluate EBS interactions and their importance to performance.

Discussion

Dr. Apted asked if the NRC is concerned about the large differences between the codes used by the DOE and NRC. Dr. Leslie said that their model provides intermediate outputs at different stages of the calculation in order to yield a better handle on comparisons with DOE results. Dr. Hornberger asked if one could derive a sensible bounding analysis out of the complexity discussed by Dr. Murphy for the natural system. Dr. Leslie said that at the process level, there is a lot of complexity and this will never be known in detail, but at the system level, there is less need for detailed data to support the model. He said that when information from lab tests, natural

analogs, and modeling are integrated together, there may be sufficient information at the system level. Dr. Shoesmith said that he thought the problem was separable into two parts. He said that sufficient information is currently known about fuel dissolution to model it with some confidence, but there is not enough information currently known about secondary phases to provide a good model. Dr. Halsey added that one should not compare the dose outputs of the DOE and NRC models because all of the differences, but comparing the sensitivity results of the two models makes sense.

L. **Dr. David Stahl and Mr. Jerry Cogar (DOE/Management & Operations Contractor - Framatome Cogema)**

The next speakers were Dr. David Stahl (DOE/M&O - Framatome Cogema in Rockville, MD, and Mr. Jerry Cogar (DOE/M&O - Framatome Cogema in Las Vegas, NV), who spoke about the DOE's engineering development program for WP material and fabrication. To begin this talk, Dr. Stahl discussed the history of the WP selection and testing program. He noted that testing was put off when the emphasis of the HLW program shifted to site characterization surface studies and was rejuvenated after 1992. He said that he and Thomas Doring were primarily responsible for the WP design of a thick outer container of CAM over a thinner, inner container of CRM, and he discussed the objective of this particular design. He said that the original basis for selecting alloy 825 for the inner waste package CRM was low cost and ease of use. He discussed some of the selection considerations for the CAM and CRM and concluded with the rationale for selecting C-22 for the CRM.

Dr. Stahl concluded his presentation by turning the floor over to Mr. Cogar, who described the engineering development program for fabrication and welding. In particular, Mr. Cogar described specific details of the fabrication process and the testing procedures that they developed and implemented for a prototype WP made with alloy 625 as the CRM. He provided information about the welding procedures and noted that a couple of prototype WPs will be manufactured with C-22 as the CRM and will be tested this year using remote processes rather than manual ones. Finally, Mr. Cogar described some of the modeling and detection efforts used to spot defects.

Discussion

In answer to a question about welds from Dr. Payer, Mr. Cogar described some of the testing that is being done or will be done at LLNL. Mr. Roger Sealey (Hanes, International) asked about stress relief for the entire WP after it is manufactured. In response, Mr. Cogar described the stress relief procedure that they have developed. Dr. Garrick asked what the WP design would look like if they had been asked to develop a million-year container. Mr. Cogar said that it would probably look very similar to the current design. Next, Dr. Wymer asked about the need for intimate contact of the inner and outer containers, and Mr. Cogar said that this had been specified to provide mechanical strength. He said that stress at the contact and other

issues have been raised by various boards and that they are looking at this, and has evaluated a number of design options to deal with it.

M. Panel Discussion of Key Issues and Concerns: Dr. Chris Whipple (ICF Kaiser); Dr. Michael Apted (QuantiSci); Dr. William Murphy (CNWRA); Dr. Roger Staehle (University of Minnesota); Dr. Joseph Payer (Case Western Reserve University); Dr. David Shoesmith (Whiteshell Laboratory); and Dr. Joonhong Ahn (University of California, Berkeley)

After lunch, the panel of plenary speakers presented their views, comments, and suggestions regarding the near-field environment and performance of engineered barriers in the Yucca Mountain repository.

The first panelist, Dr. Chris Whipple (ICF Kaiser), discussed what he considers to be the main information needs and issues. In particular, he discussed information needs for WP design, fuel alteration, and PA modeling. He said that the project seemed to seek a complete list of near-field chemistry problems rather than to set priorities. He discussed three WP issues, including the need to define the purpose of the CAM, the need to understand the impact of corrosion products, and the need for trade-off analyses of alternative designs (e.g., C-22 on the outside, backfill in the drifts). Other analytical issues include cladding credit versus secondary phases, cyclic wetting and drying of WPs, influence of cement on pH, and the effect of ventilation. According to Dr. Whipple, a key near-field issue is defining priorities. He added that the problem is too complex to do a first principles analysis without experimental validation. He discussed the concepts of robustness and simplicity, indicated that it may be possible to present a deterministic bounding analysis (safety case) for the non-PA audience for the 10,000 year case as was done for WIPP. Finally, Dr. Whipple discussed his perceptions of the DID issue, noting that for a repository, one does not have multiple independent barriers as in a nuclear power plant, and the effect of coupled processes on multiple barriers is a key issue.

The next panelist, Dr. Apted (QuantiSci), discussed the relative safety contributions in a multiple-barriers system. He discussed his concern that there is evidence of a "bottoms up approach" that lacks targets, functions, and specified goals. His specific concerns included the UO_2 dissolution rate, the containment time and functions, and the impact of initial conditions assumptions. He said that there does not appear to be any attempt to factor in past PA studies to guide and constrain the PA, safety, and design issues. Finally, he discussed PA in the face of uncertainty, noting that all PA parameters have uncertainty and variability. In particular, he said that one can improve PA/safety by better characterizing the stochastic variability; however, in his opinion, one cannot justify improved safety on the basis of uncertainty. Finally, he said that taking credit for the physical properties of a "failed" barrier is dubious, but taking credit for chemical properties is possible.

The next panelist, Dr. Murphy (CNWRA), discussed a number of near-field environment issues that he believes are important to performance. He noted that the system is complex, heterogeneous, and transient. He noted other issues including the evolving EBS design, the poor constraints for the data, and the fact that coupled process modeling is at the state of the art. Dr. Murphy discussed the NRC/CNWRA program in terms of its focus on performance, prioritizing issues to be resolved, sensitivity studies, and the need for simplification. He talked about bounds on the environmental conditions and noted that NRC/CNWRA studies are primarily devoted to defining these bounds. He added that the complexities need to be considered in justifying the bounds. Next, he discussed simplifications for the geological disposal system. He said many of the complexities arise because of transient conditions. He said that ambient conditions will exist for long times and that the natural system at Yucca Mountain is relatively simple. Finally, he discussed issues from natural analog studies. In particular, the NRC study site at Peña Blanca, showed that oxidation of UO_2 is rapid relative to the rate of leaching of oxidized U from the local environment. In addition, Dr. Murphy discussed how studies of the natural alteration process at the site could be used to validate the predictive models.

The next panelist, Dr. Staehle (University of Minnesota), who provided his perspective on the potential failure mode of dissolved ferric ion (Fe^{3+}) interacting with C-22. He discussed the C-22 corrosion implications and alternative failure modes. He described the chemistry of dissolved Fe^{3+} in solution, and he discussed the implications of using bentonite to affect the corrosion potential of iron containers. He discussed some of his concerns regarding welding, and noted that welds have always been a concern in heavy sections although the problems are surmountable. In addition, Dr. Staehle discussed the hydrogen entry problem for Zr metal (cladding), and described a process for evolving container design over the lifetime of the repository. He discussed some issues regarding 3-D models. Finally, he described his proposed engineering elements for designing WP containers, including the design life, failure, and bounding parameters; probabilistic definitions; accelerated testing; integrated computer models; fabrication development; iterative design modifications; site design; and emplacement procedures.

The next panelist, Dr. Joe Payer (Case Western Reserve University), discussed sensitivity and PA. In particular, he said that if a sensitivity analysis in a PA indicates that a feature is not important, it may be the case, or it may be that the model is wrong. One must carefully consider the PA results and sensitivity analyses to ensure that they make sense, rather than simply accepting the model results as necessarily representing reality. Another issue Dr. Payer raised was what he called the confounding of process functions and engineering component performance in a PA. For example, he said that an analysis of drip shields that simply "turns off" water drips on the package assumes that the shield will work and doesn't tell anything about the performance of the drip shield. He commented that any feature that prevents drips would show the same result.

Dr. Payer spoke about long-term waste package performance issues. In particular, he said that long-lived waste packages are essential for long-term isolation and that material selection and design predicted on resistance to crevice corrosion is prudent engineering. He said that modulations of environmental conditions in the EBS, such as water composition, are crucial to understanding performance. Significant issues, according to Dr. Payer, include chemical concentrations in water evaporating from hot waste packages, metal interactions with corrosion products and other nonmetallic materials, and corrosion in metal/metal crevices. He noted that he would like to see more emphasis on understanding integrated EBS performance in the NRC and DOE programs.

Dr. Payer defined and discussed the vulnerable temperature regime concept for waste package corrosion. He noted that each different alloy has a temperature above which it is susceptible to crevice corrosion. This sets the lower end of the vulnerable temperature region for that alloy. The upper end is set by the temperature at which a water film can form on the waste package surface. He showed different heating and cooling scenarios for the repository and described the time period of vulnerability for each scenario. In addition, he said that one can select a material with a high temperature of crevice corrosion or engineer the cooling history and placement of the waste packages to minimize the time period of vulnerability.

Dr. Hornberger asked if there would be any crevice corrosion if cool waste is emplaced. Dr. Payer said no, such an approach would remove crevice corrosion as an issue. Dr. Payer said that the research needs included developing realistic bounds for water chemistry and the modulations in the EBS, developing information on the critical temperature of crevice corrosion for proposed CRM alloys, and developing the temperature maximum for the formation of water films on the canisters. With respect to experimental data, Dr. Payer further stated the system is over-modeled and under-tested. With respect to WP design, he noted that there is insufficient engineering data and analysis to support the final design. He said that there is a need to develop information on realistic, extreme environments and to better understand crevice corrosion performance and SCC. In addition, he said more emphasis should be placed on fabrication and welding issues, and the focus of interest should be on very early time periods (e.g., 50, 100, 300, 1000 years).

The next panel speaker, Dr. David Shoesmith (Whiteshell Laboratory), discussed "top-down" versus "bottom-up" modeling and the need to develop a sufficient database to support modeling assumptions and processes. He described some key issues and the history of modeling spent fuel dissolution including some of the original concepts and first order calculations, which were subsequently shown to be incorrect. He discussed some of the design issues, and said that there could be an evolution in container design over the repository life. He said that the waste form is not decoupled from the barriers that protect it. It would be better, he said, if the PA did not have to specify details of pit failures and patch failures because of the large uncertainty of how and when these will occur. He said that fabrication and welding

issues don't fit into a PA analysis, but are important since problems would be reflected in early (juvenile) failures. In addition, Dr. Shoesmith said that just because a model shows something to be unimportant, doesn't mean it is. There is a need to develop more information on waste form performance and the role of secondary phases. Dr. Shoesmith said that cladding credit is an open issue. He noted that there will be Fe^{3+} and heat present to concentrate dissolved salts, and these factors can lead to localized failure. He said that the fuel corrosion issues include a need to better understand the role of secondary products and the advective and diffusive pathways for controlling releases. He said that retention of radionuclides in secondary phases is not amenable to thermodynamic calculations, and the stability of the secondary phase and the retention factors for radionuclides in the phase are key issues. He concluded with the statement that empirical analyses will be necessary to support such a model, but a scientific understanding of these analyses will also be necessary.

The final panelist, Dr. Joonhong Ahn (UC Berkeley), discussed simplified flowcharts for the engineering design of an airplane and a repository to illustrate areas of common methodologies areas where the analogy breaks down. He said that there is a need to develop fully integrated, realistic process models that accurately reflect all of the available information so that one can determine if the PA model bounds the problem.

Discussion

Dr. Steindler reiterated the need to develop focused experiments to support the models at both the PA and process levels. Dr. Stahl discussed the proposed WP design of C-22 over carbon steel, and said it would not provide defense in depth. He discussed the budget for his group and the need to prioritize in conjunction with the PA group. He discussed the CAM and its purpose and performance benefits with respect to radiolytic protection and structural integrity. He discussed the credit for cladding to limit the surface area of spent fuel exposed to water that the DOE will include in the TSPA-VA. In addition, Dr. Stahl discussed targets, goals, and functions with respect to the HLW regulation (10 CFR Part 60), and discussed high aspect ratio pitting of carbon steel and its possible impact on C-22 failure. He said that they will be evaluating corrosion at metal interfaces, and various aspects of cladding corrosion.

The next speaker, Mr. Engelbrecht von Tiesenhausen (Clark County, Nevada, Department of Comprehensive Planning, Nuclear Waste Division), discussed a number of issues of concern to Clark County. One issue he noted was that there would be 200,000 feet of welds in the repository waste packages that would not be annealed and stress relieved. He expressed concern for undetected weld defects, and pitting corrosion of welds. He expressed concern with regard to quality assurance (QA) issues that had been raised in corrective action reports on the DOE QA

program. He said that these problems may lead to juvenile failures of waste packages, and could be important in the PA. Dr. Staehle and Mr. von Tiesenhausen discussed possible benefits of electron beam welding to avoid residual stress that could not be relieved by heat annealing processes. Dr. Shoesmith said he thought that there is a low probability that a failed weld site would be a water ingress site and this type of scenario should be analyzed as a special case. Dr. Tea Ahn (NRC) asked for comments on several issues, including instant release and peak dose, differences between solubility limits and dissolution rates, the need for spent fuel dissolution studies, and the use of cladding credit to limit the exposure area of the spent fuel. He said that the NRC model considers three failure modes for cladding, including rock fall, hydrogen embrittlement, and localized corrosion. He noted that rock fall is the major concern. Dr. Apted discussed areas where he agreed with Dr. Ahn. Dr. Bret Leslie discussed some of the different programmatic areas of responsibility for the NRC and DOE in terms of design and modeling issues. He discussed the NRC's Issue Resolution Status Reports (IRSRs) and the development of acceptance criteria in the IRSRs that will be incorporated into a standard review plan. He noted that two programmatic issues of concern are to conduct and use information from expert elicitations and data collection in a QA program.

Dr. Wymer asked about the "800-pound gorilla" -- what is most important -- in EBS performance. Dr. Abe Van Luik (DOE) said that he believes the "1000 pound gorilla" is the issue of whether and how much water would drip on the waste packages. Dr. Wymer asked about the use of a Richards barrier and Dr. Van Luik said it was an alternative design issue. Dr. Staehle said strength and mechanical integrity were also important. Dr. Apted discussed the need to understand water entry to the drift and waste packages. Dr. Stahl discussed the analysis of the drift and liner degradation and rockfall. He noted that water pathways are being analyzed in TSPA-VA. Dr. Van Luik noted that the concrete liner could not limit water entry to the drift under the current design. Dr. Whipple discussed different areas of the analysis and said that rock fall is separately analyzed as part of the seismic analyses. Dr. Van Luik said developing more sophisticated analyses in this area. Dr. Shoesmith discussed the limited time of the temperature period of vulnerability and suggested that dripping could be dealt with and was more like a "15-pound baby baboon." Dr. Staehle discussed the need for the NRC to evaluate the C-22 corrosion data and other data and determine the quality. In response to a comment from about the DOE's discussion of data, Dr. Staehle said that the issue is the long-term performance of C-22 (e.g., possible changes in a rate law as it ages). Dr. Payer talked about the need to establish realistic extreme environments to set boundaries on dripping. Dr. Shoesmith noted that although one can rely on the slow corrosion rate of a passive film for 100 to 1000 years, it is another issue to claim that this continues for a million years. Dr. Steindler provided some comments on C-22 noting that although it looks better than some other materials, the time period of experience with it is also much shorter. He noted that the key issue will be regulatory acceptance of the data and analyses in a hearing. Dr. Stahl agreed, but noted that the corrosion data for the C alloys in general goes back 40 years. Dr. Staehle cited the experience with INCONEL 600,

which initially appeared to have high corrosion resistance, but was later was discovered to have crucial flaws with respect to cracking in certain environments.

Dr. Murphy discussed the presence of 3 million year old crystals of uranium oxide at the Nopal natural analog site. Dr. Shoesmith said that this kind of data is important, but long-term experiments are also needed. Dr. Stahl said that planning is to conduct some types of experiments on uranium oxide phases. Dr. Garrick discussed the engineered system and compared it to the natural system. He asked if the engineered system can provide as much protection as the natural system. Dr. Steindler and Dr. Garrick discussed what needs to be addressed to make a safety determination on the basis of the performance of the engineered system and the natural system. Dr. Steindler said that both must be considered. He commented that the issue is whether more money should continue to be spent on characterizing the natural system, or if a change in focus is needed to focus experiments to support the engineered system design and analysis.

Dr. Garrick noted that much of the focus in the past has been on the geologic system, and more emphasis is needed to address the engineered aspects of the repository. Dr. Payer said that he believes there is a need to focus on the near time periods of the first 100 to 1000 years, and exclusive focus on 100,000 to a million years was not credible in the eyes of the public. Dr. Shoesmith said that the observation of the shift in reliance on the geosphere to reliance on engineered barriers is correct. He noted that many of the HLW repository programs worldwide have made or are making such a shift in focus. Dr. Fairhurst discussed some of the issues of geologic disposal and the role of engineered barriers. He asked if it was possible for the repository to be designed to have a lower temperature. The answer was yes. He said it was incumbent on the engineers to show if the performance could be improved by the use of engineered barriers. A discussion ensued about the relative importance of water or temperature in determining corrosion potential. It was agreed that both were important. Dr. Payer said that the key issue is that corrosion processes are much less aggressive near room temperature than at higher temperature, but that the absence of water clearly means that little corrosion can take place. He added that transport of radionuclides does not occur without water. Dr. Payer noted that there was not a lot of discussion concerning backfill, but this may be an important design option that needs much more work. Finally, Dr. Fairhurst noted that much work is being done on backfill in the rest of the world. Thereupon, at 5:00 p.m. the Committee ended the working group session.

IV. MEETING WITH THE NUCLEAR ENERGY INSTITUTE (Open)

[Mr. Howard J. Larson was the Designated Federal Official for this portion of the meeting.]

The Committee heard a presentation and exchanged perspectives with two staff members of the Nuclear Energy Institute (NEI), including Ralph Beedle, Senior Vice President and Chief Nuclear Officer, and Lynette Hendricks, Director, Plant Support Department.

To begin the presentation, Mr. Beedle and Ms. Hendricks briefly discussed the NEI organization, (comprised of some 250 members, both foreign and domestic, representing all aspects of the nuclear fuel cycle-supported by an in-house staff of slightly less than 200 people. Mr. Beedle summarized his introductory remarks with the observation that he fully agrees with the agency's perspective on risk-informed, performance-based regulations, stating that it is the only way to deal with the issues facing the industry today.

Mr. Beedle presented a sample overview of some of the issues the NEI is actively pursuing, and discussed the following five issues, in which he believes the ACNW should become involved since they are of major significance to the NEI's constituency:

- Problems caused by dual regulation (NRC and EPA) of nuclear facilities — Mr. Beedle stated NEI's belief that the question concerning the "right number" is just as much an issue as which agency should be setting the number.

- Disposal of the Trojan Reactor Vessel — Mr. Beedle indicated that the proposed disposal plan seems to have many benefits (lower personnel exposure, an estimated $14 million in savings, avoidance of creating "orphan" waste and, following a long-standing successful U.S. Navy practice of major component disposal). Mr. Beedle expressed regret that there seems to be no simple way at this time to deal with the problem of greater-than-Class-C wastes.

- Low-level radioactive waste issues — The particular problem stated relates to ensuring access to disposal sites at a reasonable cost. Although not a crucial issue to nuclear power plant operations, it is crucial to the industry in other ways in that the attention paid to the issue by the NRC "sets the tone." The current and potential significance of the environmental justice issue was also noted.

- Clearance of materials — Clarification and guidance by the NRC in this area is needed insofar as the significance of detection of a "single atom off site."

- The need for dry cask storage for spent fuel — Mr. Beedle pointed out that by the year 2000, 25 plants will have lost the capability to off load a full core, and 8 years later, it is projected that there will be approximately 45 plants without such a capability. Dry casks, therefore, are a critical path issue for decommissioning nuclear power plants.

After indicating several ways in which he thought the NRC could help resolve some of these issues, Mr. Beedle closed his presentation by stating that the ACNW could "help the NRC fulfill its mission by promoting a better understanding of risk in the regulation of radioactive materials."

V. ELECTION OF OFFICERS (Open)

[Mr. Howard J. Larson was the Designated Federal Official for this portion of the meeting.]

The Committee re-elected Dr. B. John Garrick as Chairman and Dr. George M. Hornberger as Vice-Chairman. Their terms of office run from July 1, 1998, through June 30, 1999.

VI. EXECUTIVE SESSION (Open)

[Mr. Howard J. Larson was the Designated Federal Official for this part of the meeting.]

A. Future Meeting Agenda (Open)

Appendix IV summarizes the proposed items endorsed by the Committee for the 102ND ACNW meeting, July 20–22, 1998.

B. Future Committee Activities (Open)

The 103RD ACNW meeting has been rescheduled for August 27 and 28, 1998. The 104TH ACNW meeting is scheduled for October 19–22, 1998, in Las Vegas, Nevada.

The ACNW also plans to meet with the Reaktorsicherheit-Kommission (Reactor Safety Commission, Germany) during the week of September 14–18, 1998. In addition, the Committee plans to tour the Konrad, Morsleben, and Gorleben facilities during the visit to Germany.

APPENDIX I

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Nuclear Waste; Notice of Meeting

The Advisory Committee on Nuclear Waste (ACNW) will hold its 101st meeting on June 10–12, 1998, in Room T–2B3, 11545 Rockville Pike, Rockville, Maryland.

The entire meeting will be open to public attendance.

The schedule for this meeting is as follows:

On June 10 and 11, 1998, 8:30 A.M. until 6:00 P.M., the Committee will discuss the following:

A. *Near-Field Environment and Performance of Engineered Barriers.*—The Committee will conduct a two-day working group session entitled, "Near-Field Environment and the Performance of Engineered Barriers in the Yucca Mountain Repository." The participants will be scientists and engineers from a variety of governmental, academic, private, and other organizations who will focus on conditions and processes that may occur inside the disposal drifts of the proposed mined geological repository.

On June 12, 1998, 8:30 A.M. until 4:00 P.M., the Committee will discuss the following topics:

B. *Meeting with Industry Representative.*—The Committee will discuss with Mr. Ralph Beedle, Senior Vice President, Nuclear Energy Institute, the ACNW's December 23, 1997, letter to the NRC Chairman titled, "1998 Strategic Plan and Priority Issues for the Advisory Committee on Nuclear Waste."

C. *Meeting with NRC's Director, Division of Waste Management, Office of Nuclear Material Safety and Safeguards.*—The Committee will meet with the Director to discuss recent developments within the division such as developments at the Yucca Mountain project, rules and guidance under development, available resources, and other items of mutual interest.

D. *Election of ACNW Officers.*—The Committee will elect the Chairman and Vice Chairman for the ACNW for a 1-year term beginning July 1, 1998 through June 30, 1999.

E. *Prepare for Next Meeting with the Commission.*—The Committee will prepare for its next briefing with the Commission. The Committee is scheduled to discuss items of mutual interest with the Commission on July 21, 1998. (tentative)

F. *Preparation of ACNW Reports.*—The Committee will discuss planned reports, including: the staff's plans to review DOE's Viability Assessment, the total systems sensitivity analysis and other topics discussed during this and previous meetings as the need arises.

G. *Committee Activities/Future Agenda.*—The Committee will consider topics proposed for future consideration by the full Committee and Working Groups. The Committee will discuss ACNW-related activities of individual members.

H. *Miscellaneous.*—The Committee will discuss miscellaneous matters related to the conduct of Committee activities and organizational activities and complete discussion of matters and specific issues that were not completed during previous meetings, as time and availability of information permit.

Procedures for the conduct of and participation in ACNW meetings were published in the **Federal Register** on September 2, 1997 (62 FR 46382). In accordance with these procedures, oral or written statements may be presented by members of the public, electronic recordings will be permitted only during those portions of the meeting that are open to the public, and questions may be asked only by members of the Committee, its consultants, and staff. Persons desiring to make oral statements should notify the Acting Chief, Nuclear Waste Branch, Mr. Howard J. Larson, as far in advance as practicable so that appropriate arrangements can be made to schedule the necessary time during the meeting for such statements. Use of still, motion picture, and television cameras during this meeting will be limited to selected portions of the meeting as determined by the ACNW Chairman. Information regarding the time to be set aside for taking pictures may be obtained by contacting the Acting Chief, Nuclear Waste Branch, prior to the meeting. In view of the possibility that the schedule for ACNW meetings may be adjusted by the Chairman as necessary to facilitate the conduct of the meeting, persons planning to attend should notify Mr. Larson as to their particular needs.

Further information regarding topics to be discussed, whether the meeting has been canceled or rescheduled, the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by contacting Mr. Howard J. Larson, Acting Chief, Nuclear Waste Branch (telephone 301/415–6805), between 8:00 A.M. and 5:00 P.M. EDT.

ACNW meeting agenda, meeting transcripts, and letter reports are available for downloading or reviewing on the internet at http://www.nrc.gov/ACRSACNW.

Dated: May 6, 1998.

Andrew L. Bates,

Advisory Committee Management Officer.

[FR Doc. 98–12529 Filed 5–11–98; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

Meeting

AGENCIES: Nuclear Regulatory Commission and Environmental Protection Agency.

ACTION: Notice of public meeting of the Interagency Steering Committee on Radiation Standards

SUMMARY: The U.S. Nuclear Regulatory Commission (NRC) will host a meeting of the Interagency Steering Committee on Radiation Standards (ISCORS) in Rockville, Maryland. The purpose of ISCORS is to foster early resolution and coordination of regulatory issues associated with radiation standards.

Agencies represented on ISCORS include the U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Department of Defense, U.S. Department of Transportation, the Occupational Safety and Health Administration of the U.S. Department of Labor, the U.S. Department of Health and Human Services, and any successor agencies. The Office of Science and Technology Policy, the Office of Management and Budget, and a State representative are observers at meetings.

The objectives of ISCORS are to: (1) facilitate a consensus on allowable levels of radiation risk to the public and workers; (2) promote consistent and scientifically sound risk assessment and risk management approaches in setting and implementing standards for occupational and public protection from ionizing radiation; (3) promote completeness and coherence of Federal standards for radiation protection; and (4) identify interagency radiation protection issues and coordinate their resolution.

ISCORS meetings include presentations by the chairpersons of the subcommittees and discussion of current radiation protection issues. Committee meetings normally involve pre-decisional intra-governmental discussions and, as such, are normally not open for observation by members of the public or media. However, for the June 11 meeting, all interested members of the public are invited to attend the meeting.

APPENDIX II

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

Revised: June 5, 1998

SCHEDULE AND OUTLINE FOR DISCUSSION
101ST ACNW MEETING
JUNE 10-12, 1998

Wednesday, June 10, 1998, Conference Room 2B3, Two White Flint North, Rockville, Maryland

8:10
1) ~~8:00~~ - 8:05 A.M. **Introductions**: Dr. B. John Garrick (Open)
8:18 ~~8:05~~ - 8:40 A.M. Dr. Shirley Ann Jackson, Chairman USNRC
8:40 - 8:45 A.M. Dr. Raymond G. Wymer

8:45 - 5:30 P.M. **Working Group Presentations on the Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository**

2) **Engineered Barriers and Environmental Chemistry (Open)**
8:45 - 9:30 A.M. Plenary speaker: Dr. Michael Apted (QuantiSci)

3) **Environmental Chemistry Issues (Open)**
9:30 - 10:15 A.M. Plenary speaker: Dr. William Murphy (CNWRA)

10:15 - 10:30 A.M. BREAK

4) **Near-Field Environment Models (Open)**
10:30 - 11:15 A.M. - DOE presentation
Dr. Abe VanLuik (DOE)
11:15 - 12:00 P.M. - NRC/Center presentation
Dr. Peter Lichtner (CNWRA)

~~12:00~~ - 1:30 P.M. LUNCH
12:05

5) **Waste Package Corrosion (Open)**
1:30 - ~~2:15~~ P.M. Plenary speaker: Dr. Roger Staehle, (Univ. of Minnesota)
2:20

[= Transcribed portions.

6) 2:15 - 3:00 P.M. **Localized Corrosion Issues (Open)**
Plenary speaker: Dr. Joseph Payer (Case Western)

3:00 - 3:15 P.M. BREAK

7) **Corrosion Models (Open)**
3:15 - 4:00 P.M. - DOE presentation
Dr. Joseph C. Farmer (LLNL)
4:00 - ~~4:45~~ 4:55 P.M. - NRC/Center presentation
Dr. Narasi Sridhar (CNWRA)

8) **Summary and Discussion of Key Issues and Concerns for First Day's Sessions (Open)**
~~4:45~~ 4:55 - ~~5:30~~ 5:35 P.M.
Dr. Martin J. Steindler (ACNW Consultant)

~~5:30~~ 5:35 P.M. ADJOURN

Thursday, June 11, 1998, Conference Room 2B3, Two White Flint North, Rockville, Maryland

Continuation of Working Group Presentations on the Near-Field Environment

9) 8:00 - ~~8:15~~ 8:05 A.M. Introductions: Dr. Raymond G. Wymer (Open)

10) ~~8:15~~ 8:06 - ~~9:30~~ 9:08 A.M. **Chemistry Considerations for Release and Transport of Radionuclides from Spent Fuel (Open)**
Plenary speaker: Dr. David Shoesmith (AECL)

11) 9:08 - 10:00
~~9:30~~ - 10:~~15~~ A.M. **Chemical Issues and Considerations for the Use of Backfill in an unsaturated Zone Repository (Open)**
Plenary speaker: Dr. Joonhong Ahn (Univ. Calif, Berkeley)

~~10:15 - 10:30~~ A.M. BREAK

10:00 - 10:15

12) 10:15 11:07 **Model Treatment of Chemistry Details (Open)**
~~10:30~~ -~~11:15~~ A.M. - DOE presentation
Dr. William G. Halsey (LLNL)
~~11:15~~ - 12:00 NOON - NRC presentation
11:07 - 11:50 Dr. Brett Leslie (NRC)
11:50 - 12:10 WP Engineering Development & Fabrication (Stahl, YMP/a

~~12:00~~ **-1:30 P.M. LUNCH**
12:10

13) 4:05 **Panel Discussion of Key Issues and Concerns (Open)**
1:30 -~~3:00~~ P.M. (R. Wymer, J. Ahn, M. Apted, J. Payer, D. Shoesmith, R.
4:06 - 4:40 Staehle, M. Steindler, and C. Whipple)

~~3:00~~ **- 3:15 P.M. BREAK**
3:11 - 3:20

14) ~~4:00~~ P.M. **Public Comment Period (Open)** NONE
4:05
4:40 - 4:50 Break

15) ~~5:00~~ P.M. **ACNW Discussion (Open)**
4:50

5:30 P.M. ADJOURN

Friday, June 12, 1998, Conference Room 2B3, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland

16) 7:~~30~~ 36 - 7:~~40~~ 45 A.M. Opening Remarks by the ACNW Chairman (Open) (BJG/HJL)

17) 7:~~40~~ 45 - 8:40 A.M. Preparation of ACNW Reports (Open)
17.1) Viability Assessment (GMH/LGD)
17.2) Total System Sensitivity Analysis (BJG/ACC)
17.3) Engineered Barrier System (RGW/ACC)
17.4) ACNW Contribution to ACRS's Report to Commission on NRC Safety Research

18) 8:40 - 9:~~30~~ 40 A.M. Nuclear Energy Institute (NEI) (Open) (BJG/HJL)
Comments on the ACNW's Plan and Priority Issues for 1998
Ralph Beedle, Senior Vice President, NEI, will comment on the ACNW's 1998 Issues and will provide suggestions for future priority issues for Committee consideration

9:40-9:50 Break
9:50-10:15 Letter
10:15 11:15

19) ~~9:30~~ - ~~10:20~~ A.M. Committee Activities/Future Agenda (Open) (BJG/HJL)

19.1) Set agenda for 102nd ACNW Meeting, July 21-23, 1998

19.2) Review proposed ACNW Operating Plan

19.3) Review topics for out months

19.4) Review EDO response to recent Committee letters

19.5) Recent and planned attendance at outside meetings (including trip/visit reports)

9:40 - 9:50

10:20 - 10:30 A.M. BREAK

11:15 11:18

20) ~~10:30~~ - ~~10:45~~ A.M. Election of Officers (Open) (BJG/HJL)
The Committee will elect officers for the period July 1, 1998 through June 30, 1999

11:18 11:30

21) ~~10:45~~ - ~~12:00~~ P.M. Prepare for next meeting with Commission (Open) (BJG/HJL)
A discussion of proposed topics and the associated viewgraphs for the currently scheduled July 21 p.m. presentation to Commissioners

11:30 12:15

~~12:30~~ - ~~1:00~~ P.M. LUNCH

12:15 12:25

22) ~~1:00~~ - ~~3:00~~ P.M. Continue report preparation and Commission presentation items (Open) (BJG/HJL)

19) again 12:25 - 2:10 PM

~~3:00~~ P.M. ADJOURN

2:10

- Presentation time should not exceed 50 percent of the total time allocated for a specific item. The remaining 50 percent of the time is reserved for discussion.

- Number of copies of the presentation materials to be provided to the ACNW - 35.

APPENDIX III: MEETING ATTENDEES

101ST ACNW MEETING
JUNE 10–12, 1998

ACNW STAFF	1st Day	2nd Day	3rd Day
Dr. Andrew Campbell	X	X	X
Ms. Lynn Deering	X	—	X
Ms. Michele Kelton	X	X	—
Dr. John Larkins	X	X	X
Mr. Howard Larson	X	X	X
Dr. Gail Marcus			X
Ms. Roxanne Summers			X

ATTENDEES FROM THE NUCLEAR REGULATORY COMMISSION

June 10, 1998

B. Leslie	NMSS
M. Comar	NMSS
K. Chang	NMSS
R. Johnson	NMSS
B. Ibrahim	NMSS
K. Gruss	NMSS
K. Stablein	NMSS
J. Davis	NMSS
M. Bell	NMSS
P. Justus	NMSS
N. Coleman	NMSS
J. Firth	NMSS
J. Muscara	RES
P. Reed	RES
J. Davis	NRR
L. Hamdan	NMSS
D. Brooks	NMSS
T. Ahn	NMSS

ATTENDEES FROM THE NUCLEAR REGULATORY COMMISSION (CONT'D)

JUNE 11, 1998

B. Leslie	NMSS
K. Chang	NMSS
T. Ahn	NMSS
P. Reed	RES
J. Firth	NMSS
K. Gruss	NMSS
D. Brooks	NMSS
L. Hamdan	NMSS

JUNE 12, 1998

R. Johnson	NMSS
M. Comar	NMSS

ATTENDEES FROM OTHER AGENCIES AND GENERAL PUBLIC

JUNE 10, 1998

B. Barnard	NWTRB
E. Pearcy	CNWRA
W. Matyskeila	Gamma Engineering
R. Wallace	USGS
R. Ewing	Univ. of Michigan
A. Agrawal	CC Technologies
A. Van Luik	DOE
J. Russell	CNWRA
W. Murphy	CNWRA
N. Stellavato	Nye County
J. Ahn	Univ. of Calif. Berkeley
D. Shoesmith	Univ. Western Ontario
J. Payer	Case Western Research Univ.
C. Whipple	ICF Kaiser
E. Tiesenhausen	Clark County
B. Halsey	Lawrence Livermore National Lab.
R. Seeley	Haynes International Inc.

ATTENDEES FROM OTHER AGENCIES AND GENERAL PUBLIC (CONT'D)

JUNE 10, 1998 (Cont'd)

A. Foster	DOE - Office of General Counsel
P. Lichtner	CNWRA
E. Feldman	ANL
E. Morris	ANL
E. Roseboom	USGS (retired)
J. York	Booz-Allen & Hamilton
N. Sridnar	CNWRA
M. Resnik	DOE
C. Hanlon	DOE
D. Stahl	DOE
S. Wing Tam	Argonne National Lab.
T. Batchelor	Allegheny Teledyne
L. Fairobent	The Environmental Co.
T. Kiess	National Research Council
J. Farmer	Lawrence Livermore National Lab.
J. Bresee	DOE
H. Cleary	SC&A
K. Singh	PA Dept of Environmental Prot.
K. Czyscinski	EPA
J. George	SAIC
R. Sindelar	Westinghouse Savannah River
R. Beyer	Westinghouse
J. Bartlett	SC&A/EPA
A. Haghi	M&O/Duke

JUNE 11, 1998

J. Wiley	National Research Council
R. Sindelar	Westinghouse Savannah River
R. Wallace	USGS
B. Barnard	NWTRB
N. Stellavato	Nye County
E. Tiesenhausen	Clark County
R. Ewing	PAPR Panel/ Univ. of Mich.
E. Pearcy	CNWRA
L. Fairobent	The Environmental Co.
J. York	Booz-Allen & Hamilton

ATTENDEES FROM OTHER AGENCIES AND GENERAL PUBLIC (CONT'D)

JUNE 11, 1998 (Cont'd)

R. Beyer	Westinghouse
K. Czyscinski	EPA
J. Bresee	DOE
P. Lichtner	CNWRA
W. Murphy	CNWRA
J. Wiley	National Research Council
A. Agrawal	CC Technologies
K. Singh	PA Environmental Protection
B. Halsey	Lawrence Livermore Lab.
C. Hanlon	DOE
A. Van Luik	DOE
R. Rosen	Lawrence Livermore Lab.
J. George	SAIC
G. Roseboom	USGS (retired)
W. Matyskiela	Gamma Engineering
J. Bartlett	EPA
C. Whipple	ICF Kaiser
E. Morris	ANL
A. Haghi	M&O/Duke
D. Stahl	M&O/Framatome
R. Seeley	Haynes International
S. Wing Tam	Argonne National Lab.
E. Feldman	ANL
T. Kiess	National Research Council

JUNE 12, 1998

B. Barnard	NWTRB
E. Tiesenhausen	Clark County
R. Wallace	USGS
J. Bartlett	EPA
L. Hendricks	NEI
C. Hanlon	DOE
J. Russell	CNWRA
N. Stellavato	Nye Co.
A. Haghi	M&O/Duke

ATTENDEES LIST via VIDEO LINK, LAS VEGAS, NV

JUNE 10, 1998

D. Geiger	M&O/Duke
C. Stockman	M&O/SNL
S. Frishman	NV/NWPO
J. Treichel	NV/NWTF
D. Sassani	M&O/PAO
P. Hammond	M&O/Licensing
G. Gordon	M&O/WPO
H. Benton	M&O/Waste Package
J. Lee	M&O/PAO

JUNE 11, 1998

D. Geiger	M&O/Duke
S. Frishman	NV/NWPO
J. Treichel	NV/NWTF
C. Stockman	M&O/SNL
J. Cogar	M&O
M. Knapp	M&O/WPO
G. Gordon	M&O/WPO

APPENDIX IV: FUTURE AGENDA

The Committee agreed to consider the following during the 102nd ACNW Meeting, July 21–23, 1998:

- **Planning For and Meeting With the Nuclear Regulatory Commission** —The Committee will prepare for and meet with the Commission to discuss items of mutual interest. Topics will include the ACRS Plans and Priorities list and earlier Committee reports on the interim guidance in support of the final rule on radiological criteria for license termination; NRC waste-related research; and risk-informed, performance-based regulation. Observations will also be presented on the recent two-day working group discussions on the near-field environment and the performance of engineered barriers in the Yucca Mountain Repository. The Committee is currently scheduled to meet with the Commission on July 21, 1998, at 1:30 p.m.

- **Yucca Mountain Regulatory Framework** — The Committee will be briefed by the staff on the status and content of the site-specific regulatory framework to be used to judge the acceptability of DOE's license application for disposal of high-level waste at the proposed Yucca Mountain, Nevada, site. Topics might include a discussion of the proposed relevant 10 CFR Part 63, the Issue Resolution Status Report (IRSR) on Total System Performance Assessment (TSPA), and a description of important measures developed by the staff for application to the proposed repository as well as other waste disposal facilities.

- **Generic LLW Disposal Facility Criticality Issues** — The Committee will review recent staff papers on the potential for criticality and the need to continue research on post-disposal criticality at low-level radioactive waste disposal facilities.

- **Development of a Standard Review Plan (SRP) for Decommissioning** — The Committee will be briefed by the staff on its plans to develop an SRP for use by the NRC in reviewing and evaluating nuclear facility decommissioning plans.

- **Meeting With NRC's Director, Division of Waste Management, Office of Nuclear Material Safety and Safeguards** — The Committee will meet with the Director to discuss recent developments within the division, such as developments at the Yucca Mountain project, rules and guidance under development, available resources, and other items of mutual interest.

- **Preparation of ACNW Reports** — The Committee will discuss planned reports, including risk-informed, performance-based regulation; waste-related research; regulatory guides dealing with decommissioning; and other topics discussed during this and previous meetings.

APPENDIX V
101st ACNW Meeting
June 10–12, 1998

APPENDIX V
LIST OF DOCUMENTS PROVIDED TO THE COMMITTEE

[Note: Some documents listed below may have been provided or prepared for Committee use only. These documents must be reviewed prior to release to the public.]

MEETING HANDOUTS

AGENDA ITEM NO.	DOCUMENTS
2	**Engineered Barriers and Environmental Chemistry**
	1. Engineered Barriers and Environmental Chemistry, presented by Dr. Michael Apted, QuantiSci **[Viewgraphs]**
3	**Environmental Chemistry Issues**
	2. Environmental Chemistry Issues (Specific to the Near Field at Yucca Mountain), presented by William Murphy, CNWRA **[Viewgraphs]**
4	**Near-Field Environment Models**
	3. Near-Field Geochemical Environment Abstraction for TSPA-VA, presented by Abraham Van Luik, DOE **[Viewgraphs]**
	4. Thermal-Hydrologic-Chemical (THC) Coupled Near-Field Environment Models, presented by Peter Lichtner, CNWRA **[Viewgraphs]**
5	**Waste Package Corrosion**
	5. Waste Package Corrosion, presented by Roger Staehle, University of Minnesota **[Viewgraphs]**

MEETING HANDOUTS (CONT'D)

AGENDA ITEM NO.	DOCUMENTS
6	**Localized Corrosion Issues**
	6. Localized Corrosion: Relationships Among Waste Package Materials, Water Chemistry, and Performance, presented by Joseph Payer, Case Western **[Viewgraphs]**
7	**Corrosion Models**
	7. Development of corrosion Models to Support TSPA-VA, presented by Joseph Farmer, Lawrence Livermore National Laboratory **[Viewgraphs]**
	8. Modeling Container Corrosion —NRC Approach, presented by Narasi Stridhar, CNWRA **[Viewgraphs]**
10	**Chemistry Considerations for Release and Transport of Radionuclides from Spent Fuel**
	9. Chemistry Considerations for Release and Transport of Radionuclides From Spent Fuel, presented by David Shoesmith, Whiteshell Laboratories **[Viewgraphs]**
11	**Chemical Issues and Considerations for the Use of Backfill in an Unsaturated Zone Repository**
	10. Chemical Issues and Considerations for the Use of Backfill in an, Unsaturated Zone Repository, presented by Joonhong Ahn, University of California, Berkeley

APPENDIX V
101st ACNW Meeting
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MEETING HANDOUTS (CONT'D)

AGENDA ITEM NO.	DOCUMENTS
12	**Model Treatment of Chemistry Details**
	11. Waste Form Degradation and Radionuclide Mobilization, presented by Bill Halsey, Lawrence Livermore National Laboratory, **[Viewgraphs]**
	12. NRC's Approach to Modeling Radionuclide Release from the Engineered Barrier System, presented by Bret Leslie, DWM, NRC **[Viewgraphs]**
16	**Opening Remarks**
	13. 101st ACNW Meeting - Items of Interest
18	**Nuclear Energy Institute (NEI)**
	14. Briefing for ACNW, dated June 12. 1998, presented by Ralph E. Beedle, Senior Vice President & CEO, Nuclear Energy Institute **[Viewgraphs]**

APPENDIX V
101st ACNW Meeting
June 10–12, 1998

MEETING NOTEBOOK CONTENTS

TAB NUMBER	DOCUMENTS

Opening Remarks by ACNW Chairman

1. Introductory Statement by the ACNW Chairman, undated
2. Items of Current Interest, undated
3. Introductory Statement by the ACNW Chairman, Second Day, undated
4. Introductory Statement by the ACNW Chairman, Third Day, undated

ACNW Working Group on the Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository

1

5. Status Report
6. "Repository Safety Strategy: U.S. Department of Energy's Strategy to Protect PublicHealth and Safety after Closure of a Yucca Mountain Repository," Rev 1, January 1998, U.S. Department of Energy, OCRWM, Washington, DC.
7. "Waste Isolation Study," Executive Summary, September 1997, CRWMS M&O, TRW Environmental Safety Systems, Inc., BOOOOOOOO-01717-5705-00062 Rev00/DCN 1.
8. "Second Interim Report Total System Performance Assessment Peer Review Panel," December 1997.
9. Letter dated October 8, 1997, from B. John Garrick, ACNW, to Shirley Ann Jackson, Chairman, NRC, Subject: Staff Performance Assessment Capability in the NRC HLW Program.
10. Nuclear Regualtory Commission's Key Technical Issues Annual Report, Executive Summary, 1996.
11. Total System Sensitivity Analysis for Yucca Mountain, Draft Minutes Report, April 22, 1998.
12. Viewgraphs presented to the ACNW on April 22, 1998, System Level Sensitivity Results and Alternative Conceptual Models in TPA 3.1, R.B. Codell and M. R. Byrne.

MEETING NOTEBOOK CONTENTS (CONT'D)

TAB NUMBER	DOCUMENTS
	ACNW Working Group on the Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository (Cont'd)
2	13. Viewgraphs by Dr. Michael Apted, Engineered Barriers and Environmental Chemistry.
	14. Physics Today article by Charles McCombie, Nuclear Waste Management Worldwide," pp. 56-62, June 1997.
3	15. Viewgraphs presented by William Murphy at the Workshop on Alternative Models and Interpretations, "Geochemical Models for Gas-Water-Rock Interactions in a Proposed Repository at Yucca Mountain— Near-Field/Altered Zone Coupled Effects Expert Elicitation, December 3-4, 1997.
	16. NUREG/CR-6288, Chapter 4, "Geochemical Investigations related to theYucca Mountain Environment and Potential Nuclear Waste Repository," November 1994.
	17. Murphy, W.M. and E.C. Pearcy, "Source Term Constraints for the Proposed Repository at Yucca Mountain, Nevada, Derived from the Natural Analog at Pena Blanca Mexico," Matereal Research Society Symposium Proceedings, Vol. 257, pp. 521-527 (1992) .
4	18. Viewgraphs presented by David C. Sassani at the NRC/DOE Technical Exchange March 17-19, 1998, titled, "Near-Field Geochemical Environment Abstraction for TSPA-VA."
	19. Viewgraphs presented by Peter Lichtner at the NFEE Workshop, December 4 1997, titled, "Modeling Coupled Thermal-Hydrologic-Chemical (THC) Processes."
5/6	20. Final Report: Waste Package Degradation Expert Elicitation Project, August 1997.

MEETING NOTEBOOK CONTENTS (CONT'D)

TAB NUMBER	DOCUMENTS
	ACNW Working Group on the Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository (Cont'd)
7	
	21. Viewgraphs presented by Joseph C. Farmer at the NRC/DOE Technical Exchange March 17-19, 1998, titled "Development of Corrosion Models to Support TSPA-VA."
	22. Viewgraphs presented by Sitikanta Mohanty at the NRC/DOE Technical Exchange March 17-19, 1998, titled, "NRC's Approach to Waste Package Degradation Modeling."
10	
	23. Viewgraphs presented by David Shoesmith at the Waste Form Degradation and Radionuclide Mobilization Expert Elicitation Workshop, January 27-28, 1998, titled, "Intrinsic Wasteform Dissolution Modeling."
	24. Waste Form Degradation and Radionuclide Mobilization Expert Elicitation Workshop, Summary, January 27-28, 1998.
11	
	25. Nagasaki, S., J. Ahn, S. Tanaka, and A. Suzuki, "Sorption Behavior of Np(IV), Np(V), and Am(III) in the Disturbed Zone Between Engineered and Natural Barriers," J. Rational. Nucl. Chem., Letters, 214, 381-389 (1996).
	26. Ahn, J, S. Nagasaki, S. Tanaka, and A Suzuki, "Effects of Smectiteillitization on Transport of Actinides Through Engineered Barriers of HLW Repositories," Materials Research Society Symposium Proceedings, 353, 231-238 (1995).
	27. Ahn, J., S. Nakayama (1991) "Modeling for Migration of a Redox-Sensitive Radionuclide in Engineered Barriers," Nucl. Tech., 97, 323-35.
	28. A. Meike and W.E. Glassley,"Chemical Modeling of Backfill Composed of Quartz Sand, Lime and an Fe-Phase," Lawrence Livermore National Lab, UCRL-ID-124631, pp. 1-20 (1997).

MEETING NOTEBOOK CONTENTS (CONT'D)

TAB NUMBER	DOCUMENTS
	ACNW Working Group on the Near-Field Environment and Performance of Engineered Barriers in the Yucca Mountain Repository (Cont'd)
11 (cont'd)	
	29. Tsukamoto, M. and T Fujita, "Uncertainty Analysis of the Performance of Engineered Barrier System for Geological Disposal of HLW," Radioactive Waste Management and Environmental Remediation, Proceedings of Sixth International Conference, pp. 309-314 (1997).
	30. Bynum, R. V., C. Stockman, Y. Wang, A Peterson, J. Krumhansl, J. Nowak, M.S.Y. Chu, J. Cotton, and S. J. Patchett, "Implementation of Chemical Controls Through a Backfill System for the Waste Isolation Pilot Plant (WWPP)," Radioactive Waste Management and Environmental Remediation, Proceedings of Sixth International Conference, pp. 357-361 (1997).
	31. Viewgraphs presented by William Halsey at the NRC/DOE Technical Exchange March 17-19, 1998, titled, "Waste Form Degradation and Radionuclide Mobilization."
	32. Viewgraphs presented by Richard B. Codell at the NRC/DOE Technical Exchange March 17-19, 1998, titled, "Approach to Radionuclide Release from Engineered Barrier in the NRC Total System Performance Assessment, Phase 3."
18	**Meeting With Representatives From the Nuclear Energy Institute**
	33. Status Report
19	**Meeting With the Director, Division of Waste Management, NMSS**
	34. Status Report

MEETING NOTEBOOK CONTENTS (CONT'D)

TAB NUMBER	DOCUMENTS
20	**Committee Activities/Future Agenda**
35.	Set Agenda for the 102nd ACNW Meeting, July 21–23, 1998
36.	Set Agenda for Out Months Through December 1998
37.	Review Proposed ACNW Operating Plan • Memo dated May 22, 1998, from John T. Larkins, Executive Director, ACRS/ACNW, to James L. Blaha, Assistant for Operations, EDO Subject: Second Quarter Operating Plan Update w/Attachment
38.	EDO's List of Future Meeting Topics
39.	EDO Responses to ACNW Reports
40.	OCRWM/M&O Meeting List and ACNW 1998 Calendar
22	**Prepare for Next Meeting With Commission**
41.	List of Tentatively Scheduled Topics and Proposed Viewgraphs