CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Spring 2003 Nuclear Waste Technical Review Board Meeting
Project Numbers 20.06002.01.081 and 20.06002.01.091;
AI 06002.01.081.314

DATE/PLACE: May 13–14, 2002
Washington, DC

AUTHORS: Gustavo A. Cragnolino and Chandrika Manepally

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PERSONS PRESENT: The Nuclear Waste Technical Review Board Meeting was attended by approximately 100 people. T. Bloomer, T. Ahn, and R. Codell [U.S. Nuclear Regulatory Commission (NRC)], and other NRC staff that attended at different times, were also present.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of the trip was to make an invited presentation on the corrosion research conducted at the Center for Nuclear Waste Regulatory Analyses (CNWRA) and to attend presentations from the U.S. Department of Energy (DOE) and its contractors on the thermal aspects of the current repository design and operating mode which was the main subject of the meeting.

SUMMARY OF PERTINENT POINTS:

After introductory remarks by Michael Corradini, chairman of the Nuclear Waste Technical Review Board, Margaret Chu, the Director of the Office of Civilian Radioactive Waste Management, noted that the fiscal year 2004 requested budget of $590 M is based on completing technical products in preparation for the license application, including transportation. Chu emphasized the importance of plans to strengthen the DOE organization in terms of safety and quality considerations. In this context, the incorporation of M. Knapp to the DOE team was noted. She expressed that realignment of activities was done in fiscal year 2003 to accommodate a budget $100 M lower than that requested and budget cuts could be a possibility for fiscal year 2004 too. Chu briefly described the topics to be covered in the meeting, indicating explicitly that design of surface facilities, performance confirmation and transportation plans would not be discussed. An extensive period of questions and comments by Nuclear Waste Technical Review Board members followed Chu's presentation. P. Nelson (Nuclear Waste Technical Review Board) asked for clarification of the meaning to DOE of the safety case and Chu answered that rather than using safety case in the European sense she would prefer to present, possibly in a document, "an integrated story" when Nelson insisted that total system performance assessment does not tell "the whole story." There were questions regarding the portion of the budget allocated to the science and technology program advocated by Chu and she noted that it will be increased from $2 M in fiscal year 2003 to the range of $25 to $35 M in fiscal years 2004 and 2005. Following a question by D. Bullen (Nuclear Waste Technical Review Board) regarding quality assurance problems, Chu emphasized the importance of creating a

nuclear culture in which the information collected is reproducible, retrievable, transparent and traceable. In response to a question regarding the possible delay of the license application beyond December 2004, Chu insisted that DOE plans to meet that time commitment in order to have waste emplaced in 2010 but recognized that progress need to be monitored closely.

J. Arthur (DOE/Office of Repository Development) made a brief presentation providing a management assessment of progress toward the license application and the decision schedule for fiscal years 2003 to 2005. A long period of questions by Nuclear Waste Technical Review Board members followed, mostly related to the impact of budget cuts on the various activities leading to license application and the criteria used for the distribution of these cuts among the components of the program. This presentation was followed by that of W. Boyle (DOE/Office of Repository Development), in which the logic for evaluating the engineered barrier system performance was provided, as well as a brief introduction to the following presentations. The presentation briefly summarized the DOE technical basis for the evolution of the in-drift environment and its effect on metal corrosion during the postclosure period. This presentation and discussions that follow indicated that the DOE was leaning towards a "hot" (above boiling) operating mode with options of increasing the ventilation period to achieve "cooler" postclosure thermal conditions. A temperature evolution plot for the postclosure period summarized results of various modeling studies. The temperature evolution was divided into three regions. A dryout zone where the temperatures are above boiling, a low temperature zone where the temperatures are below the threshold temperatures for crevice corrosion of the outer container material, and a transition zone between these zones. Maximum uncertainty was associated with this transition zone due to increased risk of seepage water entering the drift and, as a result, the occurrence of accelerated aqueous corrosion in this period. Discrepancies between the information provided in a poster and in Boyle's presentation, as a complement to the plot mentioned above, was a source of discussion. The discussion revealed that the poster superseded the information provided in the Boyle's presentation.

G. Bodvarsson (Lawrence Berkeley National Laboratory) gave a detailed presentation of the processes occurring in the unsaturated zone that are related to the seepage of water into the waste emplacement drifts. The presentation summarized the DOE conceptual model of seepage and coupled processes (thermo-hydrological and thermo-hydrological-chemical). Ambient seepage evaluation testing indicated that capillary barrier effects resulted in a seepage threshold that is well above the percolation rates observed at Yucca Mountain. Results of the single heater test, large block test and drift-scale test in the middle non-lithophysal unit of the Topopah Spring were summarized. According to Bodvarsson, model temperatures matched well with the observed temperatures. The details of the drift-scale thermal seepage model used to evaluate thermal seepage under repository conditions were presented. The model results show the development of a dryout zone (~5–10 m) beyond the drift wall, that results in an effective vaporization barrier against seepage. This model was validated based on data obtained from the heater tests. An alternate conceptual model accounting for the small-scale processes in discrete fractures was also discussed. The coupling of the chemical processes with the thermo-hydrological model was implemented using TOUGHREACT. The thermo-hydrological-chemical seepage model was validated against ambient chemical data and thermal field and laboratory data. A sensitivity study indicated that chemical composition of the initial pore waters is extremely important bearing on the types of residual brines that could develop upon evaporation and boiling. Bodvarsson noted that the presence of dryout zones prevents concentrated brines (fracture water) entering the drifts. It was not clear whether effects of edge cooling and cold trap were included in the analyses presented. Studies at CNWRA indicate that these effects result in

lower temperatures and could lead to absence of dryout zones and higher values of relative humidity.

M. Peters (Los Alamos National Laboratory) discussed in great detail the DOE assessment of the in-drift chemical environment considering its expected evolution over the three temperature regimes described above. The presentation summarized the in-drift chemical environment modeling approach, thermal-chemical evolution of waters potentially coming into the drift and the deliquescence of evaporative salts and dust on the waste package. After providing a brief summary of the available measurements and data, Peters described the chemical divide approach to determine brine evolution from natural waters and the abstraction approach used to reduce the number of calculated potential water compositions to a limited number grouped in bins. The evaporative concentration process was simulated using EQ3/6 and Pitzer expressions for activity coefficients of high strength solutions to plot the molar concentrations of the different ionic species and the pH as a function of relative humidity. Particular attention was paid to describe the evolution of the nitrate to chloride molar concentration ratio and a plot showed that the ratio tends to decrease with increasing relative humidity until a constant value, which in some cases is as low as 0.1, was reached. Special attention was devoted to the discussion of salt deliquescence and the formation of dust leachates. Peters summarized conclusions regarding engineered materials and dismissed their importance in affecting the in-drift aqueous environments claiming that they will form insoluble oxides and hydroxides. An aspect of his presentation was related to gas phase migration in the drifts. On the basis of some observations and model results that evaluate heat and mass transfer in the drift, Peters showed (with the help of a movie) that due to the thermal environment and in-drift thermal convection processes, convection causes turbulence (significant mixing) and an environment "open" to the atmosphere can be expected at the waste package surface. Finally, Peters provided a more detailed explanation of the three temperature regimes to conclude that the in-drift chemical environment is expected to be benign during the three regimes. The presentation was followed by a period of questions covering issues related to microbial activity, the abundance of nitrate in the Yucca Mountain soil, rock degradation by thermal cycles, and an interpretation of the evolution of certain processes (i.e., evaporation and water condensation) as a function of relative humidity.

J. Farmer (Lawrence Livermore National Laboratory) gave a presentation on materials performance based on the discussion of the expected materials behavior in the three temperature regimes described above. Following an introductory discussion on materials selection and the approach to corrosion testing and modeling, Farmer presented data to demonstrate that deliquescent salts do not promote localized corrosion of Alloy 22, contrary to the case of Alloy 825. This was followed by the presentation of data on cyclic potentiodynamic polarization of Alloy 22 in $CaCl_2$ brines with and without nitrate to demonstrate the inhibiting role of nitrate against localized corrosion. Much of Farmer's presentation was devoted to the definition of critical potentials and the criteria for their selection and measurement for assessing localized corrosion in relation to the values of the corrosion potential. The final part of the presentation dealt with the effect of the evolving environment over the three temperature regimes on the corrosion of Alloy 22 and the performance of the waste package. Farmer concluded that the waste package is resistant to corrosion in the three temperature regimes through different mechanisms, including the transition region in which high temperatures combined with the formation of an aqueous environment on the waste package surface may lead to localized corrosion. In this case the inhibiting effect of nitrate removed the potential susceptibility to crevice corrosion. A round of questions followed, mainly to clarify the meaning and significance of some figures. D. Duquette (Nuclear Waste Technical Review Board) disputed the criteria for

the selection of corrosion potentials presented by Farmer, and R. Latanision (Nuclear Waste Technical Review Board) emphasized the lack of studies on welded and thermally aged materials.

W. Boyle (DOE/Office of Repository Development) summarized the technical program in a brief presentation (no handout was provided) in which he emphasized that only 0 to 1 percent of the waters could be considered potentially detrimental to the waste packages, even though he recognized the impact that many uncertainties related to the transitional temperature regime may have on the performance assessment. D. Duquette (Nuclear Waste Technical Review Board) questioned the implication of such statement because the percentage of waste packages that may be affected by such aggressive waters was not included in the analysis. During the question period, Boyle made the case for a hotter repository to avoid negative health effects for workers that would result from an extended cool-down period for the spent nuclear fuel.

The status of ongoing DOE testing was presented by M. Peters (Los Alamos National Laboratory) covering both the geological and engineering components of the program. R. Budnitz (Lawrence Livermore National Laboratory) presented the philosophy, objectives, approach and current work of the Office of Civilian Radioactive Waste Management Science and Technology Program, as well as the work planned for fiscal year 2004. Among other topics related to modeling of seepage, seismic effects, and analogs studies, projects on advanced protective coatings and advanced welding methods for waste packages were mentioned as activities that were started in fiscal year 2003. For fiscal year 2004 six main areas were identified including transportation, operations and system engineering. In an animated discussion that followed, P. Nelson (Nuclear Waste Technical Review Board) emphasized the importance of integrating performance confirmation activities in this program to boost the development of appropriate sensors and tools, whereas P. Craig (Nuclear Waste Technical Review Board) noted the urgent need to rethink and provide an appropriate focus and funding to the study of societal issues related to high-level waste disposal.

G. Cragnolino (CNWRA) made a presentation on corrosion research covering the most recent studies conducted at CNWRA. The presentation was well received and several members of the Nuclear Waste Technical Review Board expressed their appreciation to the presenter for the work at the CNWRA and the content of the presentation.

The final presentation was made by A. Rubin (Princeton University). Rubin summarized the main observations and conclusions included in the Final Report of the Nuclear Waste Technical Review Board Peer Review Panel on Igneous Consequences.

IMPRESSION/CONCLUSIONS:

Attendance of this Nuclear Waste Technical Review Board meeting was highly beneficial because the meeting provided an excellent opportunity to obtain an updated view of the DOE program and current status of the modeling effort and data acquisition in areas related to thermal effects on flow, in-drift chemical environment, and waste package performance. In this case, it was also useful as a means to provide additional information to the Nuclear Waste Technical Review Board and to the public on the scope and content of the NRC and CNWRA work on corrosion of container materials and related issues.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Future attendance at these types of meetings will be useful to keep track of the DOE program. It is also useful to acquire a general perspective of relevant issues and prevailing ideas in the area of high-level nuclear waste management, science, and technology. Above all, attendance is important to be acquainted with the views of the Nuclear Waste Technical Review Board members that represent an important segment of the academic and technical community.

REFERENCES:

The handouts of the various presentations are available upon request from the author. An agenda of the meeting is attached.

SIGNATURES:

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6/12/03
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Chandrika Manepally
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