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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: U.S. Department of Energy (DOE) Waste Package Materials Performance Peer Review: Interim Meeting
Project Number 20.01402.571, AI Number 01402.571.018

DATE/PLACE: September 25, 2001
Las Vegas, Nevada

AUTHOR: Gustavo A. Cragnolino

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PERSONS PRESENT: The meeting was attended by approximately 50 people. John Garrick, chairman of the Advisory Committee for Nuclear Waste was also present.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of the trip was to attend the presentation in a public meeting of the interim report prepared by the U.S. Department of Energy (DOE) Waste Package Materials Performance Peer Review Panel. This presentation was followed by technical presentations by Betchel SAIC Company, LLC (BSC) waste package project staff. The agenda of the meeting is enclosed.

SUMMARY OF PERTINENT POINTS:

After brief introductory remarks by Jean Younker (BSC), Joe Payer (Case Western Reserve University, CWRU), the peer review chairman, introduced the other members of the panel: John A. Beavers (CC Technologies Laboratory, CCTL), Thomas M. Devine (University of California at Berkeley, UC), Gerald S. Frankel (The Ohio Sate University, OSU), Russell H. Jones (Pacific Northwest National Laboratory, PNNL), Robert G. Kelly (University of Virginia, UV) and Ronald M. Latanision (Massachusetts Institute of Technology, MIT). He emphasized the broad range of expertise in corrosion science and engineering of the panel members, and noted that the panel is being assisted by 12–15 subject matters experts from the U.S. and abroad on specific issues (i.e., geochemistry, hydrology, physical metallurgy, welding, etc). Payer presented an overview of the interim report (available in www.ymp.gov), stating that the final report will be presented in a public meeting in February 2002, in Las Vegas, Nevada. The main preliminary finding is that the panel did not find a technical basis for concluding that the WP materials being considered are not suitable for long-term containment. However, he stressed that significant technical issues remain to be settled, that uncertainty about long-term performance can be substantially reduced through further experiments and analysis, and that a large amount of necessary work, although already planned, remains to be completed to support performance assessment.

Jones (PNNL) and Latanision (MIT) presented the panel findings regarding potential degradation modes and contributing factors. In the presentation they noted that corrosion is the most significant potential degradation mode of the engineered barriers but metallurgical process related to design and fabrication details as well as operating conditions can affect corrosion

resistance and mechanical properties. They emphasized the importance of evaluating the effects of impurity segregation (sulfur and phosphorus were mentioned), recognized by the DOE as a potential degradation mode, but not included in current studies.

Kelly (UV) discussed the panel consideration of the aqueous environments formed on metal surfaces as divided in three primary classes: (i) moist dust; (ii) scale and deposits, and (iii) crevice areas at metal-to-metal contact surfaces. The panel considered that full immersion of metal surfaces is a highly unlikely condition in the proposed repository. Kelly indicated that the panel found the approach used by the DOE project consistent with the current state of scientific understanding (i.e., the chemical divide concept to analyze the waters) but noted that a more extended and in-depth experimental and modeling work is needed for defining the chemical composition of the three primary classes of environments listed above as related to their effect on various corrosion processes. The recommendation of the panel is to conduct a comprehensive experimental and modeling program for these three environmental conditions with the help of a task group of technical experts in the relevant disciplines (i.e., geochemistry, hydrology, corrosionists, etc.). It appears that, at least until now, the panel did not pay special attention to the role of trace elements such as lead.

The long term passive behavior of corrosion resistant metals was discussed by Devine (UC). After reviewing the DOE work in this area, he indicated that the panel has identified three factors that affect the stability of passive films, as follows: (i) changes in the intrinsic nature of the film; (ii) changes in the environment, and (iii) changes in the alloy itself. Devine discussed several aspects related to these three factors in relation to the DOE project findings and current plans. The panel found the current characterization of the films incomplete, the evaluation of the effect of environment changes limited, particularly in relation to the lack of studies on the influence of salt deposits and dust, and the consideration of alloy changes confined only to the effect of phase transformations on passive behavior without including impurity segregation effects that may play an important role in the long-term.

Frankel (OSU) presented a critical assessment of the approach used by the DOE for evaluating the possibility of localized corrosion and questioned both the validity of the corrosion potential values used by the DOE in the model abstraction for the total system performance assessment, as well as the adoption as critical potentials of threshold potentials associated with current increases in cyclic potentiodynamic polarization obtained with noncreviced specimens. He noted that the criterium based on the corrosion potential and critical potential is valid if and only if the corrosion potential can be modeled and verified with long term experimental measurements and the critical potential is defined as the repassivation potential for crevice corrosion. He presented an additional set of recommendations including the use of more aggressive solutions, oxidizing species, and higher temperatures to define regimes of susceptibility to localized corrosion taking into consideration various metal surface conditions and the classes of aqueous environments to be formed on waste package surfaces previously discussed by Kelly.

Beavers (CCTL) presented the panel findings regarding stress corrosion cracking. He questioned the validity of the slip dissolution/film rupture model for the repository conditions (predominance of residual stresses over cyclic or sustained applied loads) indicating that this model does not contain a threshold stress or stress intensity factor and that the DOE approach of using a threshold stress instead of stress intensity (based on fracture mechanics) may not be conservative because cracks usually initiate (with the exception of exposure to very potent

environments) at preexisting defects. He noted the lack of the necessary parameters for the case of Alloy 22 and suggested the consideration of alternative SCC models. Concerns with fabrication and metallurgical changes as result of post-weld treatments were also raised and several recommendations were provided for further testing. Most of Beavers' presentation was confined to Alloy 22, because he noted as a personal opinion that Ti Grade 7 appears to be susceptible to stress corrosion cracking or hydride cracking in the presence of an applied load as that resulting from rock fall and his use as a drip shield material should be reevaluated.

The final presentation by Payer summarized several statements from various panel member presentations and the main conclusions reached by the panel for this interim report. The main concern of the panel is the possible lack of adequate resources to complete the necessary work for evaluating the long-term performance of waste package materials. An additional concern is the lack of involvement of corrosion experts from universities and industry due to several constraints. The panel recommended a closer integration between the design and fabrication engineers and the corrosion and materials experts working on performance assessment. Regarding the material selection for the waste package, the panel included as an additional recommendation the selection of a backup alloy for the eventual case that following further testing Alloy 22 does not performed as expected and also the addition to the program for comparison purposes of an alloy more susceptible to various degradation modes than Alloy 22.

Jean Younker (BSC) provided a brief overview of the content of the various presentations by the BSC contractors to follow indicating that topics not covered in previous interactions with the panel will be included as well as topics that warrant further attention. She addressed the concerns of the panel regarding level of effort and resources committed, admitting that the consideration by the Senate and the House of the FY 2002 budget places serious constraints on the engineered barriers testing and modeling waste program. It was mentioned that the budget for testing and modeling of waste package and engineered barriers represents only 11 percent of the total amount budgeted by the DOE for scientific and technical work and the plans for FY 02–05 show the engineered barriers program on a critical path for the license application.

Tammy Summers (LLNL) discussed the metallurgical issues related to potential degradation modes and the increased involvement of the staff in aspects related to waste package design and fabrication processes, including the planning of closer interactions between the Science and Analysis Waste Package and the Waste Package Design departments. It appears that the issue of sulfur segregation will be considered following the panel comments. An update was provided on current and planned activities.

Greg Gdowski (LLNL) gave the presentation on the environment on the waste package and drip shield surfaces including the influence of dust, mineral deposits and their effect on heat transfer, the deliquescence of salt mixtures, and the possible role of several redox couples. He presented a preliminary characterization of drift dust and the planned activities for evaluating the evaporative concentration of representative waters with the inclusion of minor constituents. A path forward summary was included at the end of his presentation..

Gerald Gordon (Framatome) presented the information on long-term behavior of corrosion resistant metals by reviewing summarily the approach and data from the Long-Term Corrosion Test Facility (LTCTF) at LLNL, data from some recent cyclic potentiodynamic polarization and potentiostatic tests, and studies of the passive film formed on Alloy 22 and Ti grade 7 using

surface analysis techniques such as XPS. A brief discussion of the modeling work based on the point defect model developed by Macdonald was presented, as well as a description of the planned experimental activities.

Raul Rebak (LLNL) presented the planned program for the evaluation of localized corrosion resistance of the waste package and drip shield materials. A broad range of additional studies was described, mostly for Alloy 22, that undoubtedly will require a better defined focus and adequate prioritization. Consideration of intergranular corrosion and dealloying was included and the use of the crevice corrosion repassivation potential was mentioned but specific range of environments and other conditions were only broadly described.

The final presentation was made by Gerald Gordon (Framatome) on waste package and drip shield stress corrosion cracking assessment and mitigation. New data on stress corrosion cracking of Alloy 22 and Ti Grade 7 was presented , covering a range of material conditions in the case of Alloy 22 (i.e., cold worked, thermal treated, and welded tensile specimens were used). Whereas crack growth of Alloy 22 was observed under cyclic loading conditions on compact tension specimens in aerated and saturated alkaline solutions based on J–13 water at 105 °C, no crack growth was detected under constant load with the exception of a 20 percent cold worked compact tension specimen. No stress corrosion cracking was observed in constant loaded smooth tensile specimens at stresses well above the yield strength in the same type of environments. On the contrary, compact tension specimens of Ti grade 7 exhibited crack growth under constant load conditions and smooth tensile specimen showed stress corrosion cracking at 75–95 percent of the yield strength. Approaches to stress mitigation to avoid stress corrosion cracking were discussed by Gordon in certain detail but what he emphasized the most was the sensitivity of the crack growth rate measurements and the validity of the stress corrosion cracking model used recognizing , however, the challenges confronted. As an example, a value of $n > 1$ suggested to explain certain results for Alloy 22 was clearly questioned due to the lack of physical meaning for such a high value in a so-called repassivation coefficient.

The members of the panel asked specific questions to the presenters ranging from experimental details to fundamental corrosion concepts but essentially they covered various aspects of the planned testing.

After the initial presentation by Joe Payer, Carl Di Bella (a member of the NWTRB staff) asked for the position of the panel on the DOE site recommendation regarding those issues related to waste package and engineered barriers. Payer replied the panel was only chartered to express opinions and recommendations regarding the performance evaluation of engineered barriers materials and design and any position regarding site recommendation is beyond this scope. John Garrick (ACNW) commented the importance of evaluating the significance of the water composition in contact with the waste package and the corrosive environment generated in terms of radionuclide releases. He stressed the need of use a probabilistic approach to bound the uncertainties in the definition of the possible environments taking into account their subsequent impact on repository performance. Maury Morgenstein (State of Nevada consultant) raised the issue of impurities and trace elements during the public comment period at the end of the meeting.

IMPRESSION/CONCLUSIONS:

Overall, it is considered that attendance was beneficial. The meeting provided an excellent opportunity to listen to the opinion of a qualified group of corrosion experts on the approach used for the DOE for assessing the performance of waste package and drip shield materials including the modeling and experimental work conducted up to date and that planned for the license application. It is apparent that the interaction we have had with the peer review panel through the presentation of our work in the July Meeting at Case Western Reserve University in Cleveland and distribution of the Container Life and Source Term Issue Resolution Status Report, reports and papers played a role in the panel evaluation of DOE work. It is expected that the panel can help DOE to focus and prioritize the extensive work needed to close pending Container Life and Source Term and Evolution of the Near-Field Environment technical issues according to the existing agreements.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

Send to DOE peer review panel members the most recent Container Life and Source Term reports on corrosion of waste package and drip shield materials.

RECOMMENDATIONS:

Future attendance at these type of meetings is useful to keep track of the panel influence on DOE engineered barriers program and the advances in the program.

REFERENCES:

The handouts of the various presentations are available upon request from the author.

SIGNATURES:

Gustavo Cragnolino
Staff Scientist

9/28/2001
Date

CONCURRENCE:

Vijay Jain, Manager
Corrosion Science & Process Engineering, Element

9/28/2001
Date

Budhi Sagar
Technical Director

9/28/2001
Date

GC:jg

Waste Package Materials Performance Peer Review: Interim Meeting
Tuesday, September 25, 2001
Suncoast Hotel and Casino
Las Vegas, NV

8:00 a.m.	**Welcome and Introductions**
8:15 a.m.	**Introduction and Overview of Preliminary Findings** Joe Payer, Case Western Reserve University & Peer Review Chairman
8:45 a.m.	**Public Comments/Questions from the Audience**
9:00 a.m.	**Potential Degradation Modes** Russ Jones, Battelle-Northwest Ron Latanision – Massachusetts Institute of Technology
9:25 a.m.	**Composition of Aqueous Environments** Rob Kelly, University of Virginia
9:55 a.m.	**Break**
10:15 a.m.	**Long-Term Behavior of Corrosion Resistant Metals** Tom Devine, Jr., University of California, Berkeley
10:40 a.m.	**Localized Corrosion** Gerry Frankel, The Ohio State University
11:10 a.m.	**Stress Corrosion Cracking** John Beavers, CC Technologies Laboratories, Inc.
11:35 a.m.	**Peer Panel Schedule and Plan** Joe Payer, Peer Review Chairman
11:40 a.m.	**Public Comments/Questions from the Audience**
12:00 p.m.	**Lunch**
1:15 p.m.	**DOE comments** Richard Spence, DOE/YMSCO
1:25 p.m.	**Overview** Jean Younker, Bechtel SAIC Company (BSC)
1:35 p.m.	**Potential Degradation Modes** Tammy Summers, LLNL
2:05 p.m.	**Composition of Aqueous Environments** Greg Gdowski, LLNL
2:35 p.m.	**Long-Term Behavior of Corrosion Resistant Metals** Gerald Gordon, BSC

3:05 p.m.	**Break**
3:25 p.m.	**Localized Corrosion** Raul Rebak, LLNL
3:55 p.m.	**Stress Corrosion Cracking** Gerald Gordon, BSC
4:25 p.m.	**Public Comments/Questions from the Audience**
4:45 p.m.	**Closing Remarks: Summary and Path Forward** Joe Payer, Peer Review Chairman