CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Staff Exchange of Yi-Ming Pan between Center for Nuclear Waste Regulatory Analyses (CNWRA) and the U. S. Nuclear Regulatory Commission (NRC)
Project Number 20.06002.01.081; AI Number 20.06002.01.081.327

DATE/PLACE: July 19–30, 2004, Rockville, MD

AUTHOR: Yi-Ming Pan

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AUTHOR:	Yi-Ming Pan
PERSONS PRESENT:	Yi-Ming Pan (CNWRA) and NRC staff

BACKGROUND AND PURPOSE OF TRIP:

I participated in a staff exchange from July 19–30, 2004 at the NRC Headquarters in Rockville, Maryland. The purpose of this staff exchange was to (i) assess the lead-assisted stress corrosion cracking of the Alloy 22 waste package outer barrier and provide justification to close this issue, (ii) conduct a risk analysis to evaluate the consequence of crack opening by stress corrosion cracking, considering residual stresses and mechanical loading, and (iii) discuss insights on fabrication processes and material stability of waste package containers and waste form dissolution. During the term of this staff exchange, I worked with the NRC staff in the Division of High level Waste Repository Safety and Office of Nuclear Regulatory Research.

SUMMARY OF PERTINENT POINTS:

The NRC and CNWRA staff have developed the failure assessment diagrams in evaluating the effect of fabrication processes on the governing mechanical failure criteria for Alloy 22 and Titanium Grade 7 and 24 alloys. During this staff exchange, I worked with A. Csontos, T. Ahn, and D. Codell to extend this methodology to assess the susceptibility of waste packages to stress corrosion cracking using the threshold stress intensity factor values, applied stress, and flaw size distribution documented in the DOE reports. In the DOE model abstraction for stress corrosion cracking, the threshold stress intensity factor values range between 2.65 and 28.50 $MPa{\cdot}m^{1/2}$ with a mean value of 11.38 $MPa{\cdot}m^{1/2}$ based on a crack blunting criterion. Using the mean threshold stress intensity factor, the failure assessment diagrams for Alloy 22 base metal and weld were developed. The results indicated that mechanical failure for Alloy 22 is governed by the linear-elastic fracture mechanics criterion. In addition, only a tensile stress of 104 MPa is needed for failure to occur. It should be noted that the current DOE waste package design precludes the occurrence of stress corrosion cracking by imposing compressive surface stresses through solution annealing and stress mitigation processes. The DOE residual stress analyses on the 21 pressured water reactor mockup waste package container outer shell, however, indicated that at selected locations a tensile residual stress of about 220 MPa is present on the outside surface. Thus, given a critical environment that Alloy 22 is susceptible to stress corrosion cracking, the residual stress would provide driving force for the occurrence of stress corrosion cracking. This collaborative work will continue to determine the flaw size distribution, the stress distribution by rock fall, and the total exposed surface area, as well as the consequence of the crack opening resulting from stress corrosion cracking or mechanical failure. This risk insights approach will be used to address various stress corrosion cracking issues.

Brief discussions with NRC staff on lead-assisted stress corrosion cracking and risk insights on fabrication processes and material stability of waste packages were initiated. Additional evaluation will be conducted in the future to address these two issues.

I visited the DOE Licensing Support Office at Rockville to review the documents requested through G. Hatchett for the examination of the DOE response to KTI agreements CLST 1.14 and 1.15 in Technical Basis Document No. 6. The additional information requested after the NRC's review of the DOE response is absent in the documents.

During my stay at NRC, I participated in several meetings to facilitate interaction with NRC staff. These included standup management meeting, section meeting, and Yucca Mountain team meeting. I also participated in CLST team meeting and provided initial assessment of Technical Basis Document No. 6, Appendix Q pertaining to KTI agreements CLST 2.04 and 2.05. In addition, I attended a discussion arranged by A. Csontos with T. Hsia and B. Jain of the Office of Nuclear Regulatory Research on corrosion and leaching rate measurements of metallic, concrete, and insulation materials in support of the debris accumulation issue for pressurized water reactor sump performance.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

The risk analysis for evaluating the consequence of crack opening by stress corrosion cracking on waste package performance will continue. This will provide justification for assessing the DOE response to KTI agreements CLST 1.14, 1.15, and 2.08.

RECOMMENDATIONS:

Participation in staff exchange at the NRC has reinforced the collegial interaction between NRC and CNWRA staff. This interaction is beneficial to the Yucca Mountain team in preparation for upcoming license activities. Future staff exchange opportunities for CNWRA staff are strongly recommended.

SIGNATURES:

Yi-Ming Pan
Senior Research Engineer

Date 8/11/2004

CONCURRENCE:

Vijay Jain, Manager
Corrosion Science and Process Engineering

Date 8/11/04

Budhi Sagar
Technical Director

Date 8/11/04

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