CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES
TRIP REPORT

SUBJECT: Cementitious Materials for Waste Treatment, Disposal, Remediation, and Decommissioning Workshop; LeachXS Training Seminar
AI 20.06004.01.007.701

DATE/PLACE: December 11–14, 2006, Savannah River Site, Aiken, South Carolina

AUTHORS: Roberto Pabalan and David Pickett, Center for Nuclear Waste Regulatory Analyses (CNWRA)

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PERSONS PRESENT:

About 100 attendees from the United States and other countries were present, including U.S. Nuclear Regulatory Commission (NRC) staff members David Esh and Cynthia Barr and CNWRA consultant Fred Glasser.

BACKGROUND AND PURPOSE OF MEETING/TRIP:

The December 12–14, 2006, workshop was sponsored by the U.S. Department of Energy (DOE), Savannah River National Laboratory, Vanderbilt University, and the Consortium for Risk Evaluation with Stakeholder Participation for the purpose of disseminating technical information relevant to the use of cementitious materials at various DOE facilities. The workshop brought together experts from the DOE complex, academia, and the international community to make technical presentations focusing on the physical and chemical performance of cementitious materials used as barriers to the release of toxic contaminants, especially radionuclides. The CNWRA staff attendance was supported under an NRC Division of Waste Management and Environmental Protection-sponsored project focused on strengthening the technical basis for staff reviews of DOE non-high-level waste determinations. The CNWRA consultant Professor F. Glasser (University of Aberdeen, Scotland) and NRC staff member D. Esh were invited speakers at the workshop. In addition, D. Pickett attended a December 11, 2006, training seminar on the computer code LeachXS, a tool for evaluating the use of leaching tests in modeling contaminant release and transport from a variety of wasteforms. Training was provided by staff from Vanderbilt University and the Energy Research Center of the Netherlands.

SUMMARY OF PERTINENT POINTS:

The workshop included a number of high-quality presentations that provided not only useful technical information, but also information on the DOE approach to the use of cementitious materials in waste disposal. The LeachXS training provided an introduction to the capabilities of the code.

SUMMARY OF ACTIVITIES:

The day-long LeachXS training session took place on December 11, 2006, consisting of a series of presentations on the theoretical basis and functionality of the code. Hands-on exercises were conducted, and a CD-ROM containing a trial version was provided to training participants. Developers of LeachXS plan to release a much-enhanced revision of the code in Spring 2007.

The workshop, held December 12–14, consisted of a series of oral sessions and a display of posters. Session titles were

- Welcome and Plenary Speaker (M. Gilbertson, DOE Environmental Management)
- Role of Cementitious Materials in Meeting Regulatory and Stakeholder Requirements for DOE LLW Disposal: Panel
- Chemical and Mineralogical Properties and Containment Transport Properties in Cementitious Materials
- Water and Gas Transport Through Cementitious Materials
- Degradation Mechanisms and Test Methods, Durability Criteria and Long-Term Degradation Evaluation
- Long-Term Performance Predictions and Risk Assessment; Integration of Cementitious Materials in PA Modeling
- Path Forward: Key Gaps in Knowledge and Practice, Opportunities for Alternative Approaches and Improvements

The conference agenda can be accessed from the website <http://srnl.doe.gov/grout_agenda.htm>. A brief summary of some of the more pertinent papers follows.

D. Esh spoke on the regulatory perspective on cementitious materials in radioactive waste disposal, with emphasis on non-high-level waste determinations. He discussed the need for understanding uncertainties in assessments for demonstrating compliance with performance objectives.

F. Glasser provided an overview of the state of knowledge about cementitious containment of nuclear waste. He stressed the need for better integration of physical and chemical processes in modeling degradation and contaminant release.

B. Mauss (DOE–Hanford, Office of River Protection) discussed the impact of disposing secondary wastes at Hanford's Integrated Disposal Facility, a near-surface Resource Conservation and Recovery Act-permitted disposal facility. Risk analysis indicated most of the environmental impact is from I-129, which is volatilized during the vitrification of the high-level wastes. Thus, methods are being evaluated that would improve the retention of I-129 from low temperature waste forms (e.g., grout).

J. Newman (Westinghouse Savannah River Company) discussed the attributes of grout that are important to Savannah River Site high-level waste tank closure. These attributes include durability (strength and resistance to degradation/cracking), retention of contaminants (low hydraulic conductivity, low Eh, high pH), flowability, low shrinkage, set time, and cost.

F. Sanchez (Vanderbilt University) discussed conceptual models and approaches to understanding long-term performance of cementitious waste forms. The primary factors considered to determine waste form performance are its physical integrity, contact with water, moisture saturation condition, extent and rate of oxidation, and constituent chemistry and mass transport. Chemical degradation and physical stress effects were stated to be coupled and integrated. Physical stresses arise from cyclic loading, flexural bending, drying shrinkage, seismic events, and settlement. Chemical degradation processes include oxidation, leaching, expansive reactions, carbonation, sulfate attack, and rebar corrosion. Examples of leaching and mass transport experiments were provided. An integrated approach to understanding waste form performance using laboratory testing and computer simulation (e.g., using the LeachXS code) was proposed.

W. Deutsch (Pacific Northwest National Laboratory) presented a study designed to provide an estimate of contaminant concentrations released from closed Hanford tanks for use in performance assessment calculations. Samples of Hanford tank residual waste were characterized using X-ray diffraction analyses and scanning electron microscopy/energy dispersive spectrometry, and leaching tests using solutions of different compositions [deionized, $Ca(OH)_2$-saturated, and $CaCO_3$-saturated water] were conducted. The data were used to develop release models.

B. Huet (Princeton University) presented his work aimed at building a thermodynamic database for cement hydrate phases that includes temperature dependence. The database includes most of the hydrates that might be present in a cement paste, such as calcium silicate hydrates, calcium aluminate trisulfate and monosulfate phases, and hydrogarnets. The database is consistent with the Lawrence Livermore National Laboratory EQ3 thermodynamic database and can be used to assess the chemistry of cement pastes during exposure to chemically aggressive environments.

J. Marchand (Materials Service Life, Quebec, Canada) presented the main features of STADIUM®, a multi-ionic reactive transport model that can be used for simulating the alterations to the microstructure of cementitious materials resulting from mass exchange with the environment.

L. De Windt (Ecole des Mines de Paris, France) discussed the application of the HYTEC code to simulate the dynamic leaching of monoliths of cement solidified/stabilized waste. HYTEC is a reactive transport code that can simultaneously simulate the chemical evolution of pore water, the mineralogical alteration fronts induced by the sequential dissolution of the cement hydration products, and the concomitant release of elements from the waste.

H. Van der Sloot (Environmental Risk Assessment, Netherlands) discussed the use of LeachXS to model chemical speciation and release from cement-stabilized wastes.

G. Scherrer (Princeton University) presented novel methods, including a beam-bending method, thermopermeametry, and dynamic pressurization, that he developed to permit rapid measurement of the permeability of saturated samples of cement pastes, mortar, and concrete.

G. Flach (Savannah River National Laboratory) described a study to assess the long-term durability of a concrete vault in a sulfate-bearing waste environment. The vault functions as a hydraulic barrier to advective and diffusive release of radionuclides and nitrate from the waste form (saltstone) to the environment. The assessment considered sulfate attack as the primary degradation mechanism for the vault. Sulfate penetration was assumed to occur via bleed water intrusion into interior surface cracks, capillary suction into dry concrete, and sulfate ion diffusion through concrete pores. A geochemical model (Geochemist's Workbench®) was used to track the formation of expansive mineral phases such as ettringite. The formation of significant ettringite was assumed to coincide with actual physical damage, in lieu of explicit fracture modeling.

IMPRESSIONS/CONCLUSIONS:

The workshop provided the CNWRA staff exposure to a broad range of information on the physical and chemical characteristics of cementitious materials (e.g., grout) and their performance in supporting structures or containing waste. This information is directly applicable to the current tasking concerned with independent literature reviews and analyses to support staff non-high-level waste determination reviews. It appears that DOE support of relevant research will continue at a high level. Attendance at the LeachXS training session will aid staff in evaluating the use of computer codes in assessing grout performance in DOE disposal facilities.

PROBLEMS ENCOUNTERED:

None.

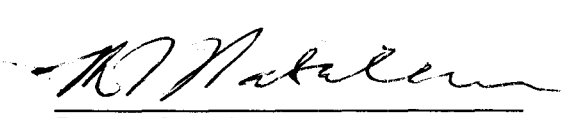
PENDING ACTIONS:

None.

RECOMMENDATIONS:

The CNWRA staff will use the abstracts and presentations from the meeting to aid in their current literature review efforts. Staff will also evaluate a trial version of LeachXS for possible use in later tasking.

SIGNATURES AND DATE:



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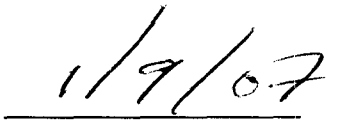

Date

David A. Pickett
Principal Scientist, Geochemistry

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