CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: The 103rd Annual Meeting & Exposition of the American Ceramic Society
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DATE/PLACE: April 22–25, 2001, Indianapolis, Indiana

AUTHOR: Y.-M. Pan, Center for Nuclear Waste Regulatory Analyses (CNWRA)

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PERSONS PRESENT:

The 103rd Annual Meeting & Exposition of the American Ceramic Society was held April 22–25, 2001 at the Indiana Convention Center in Indianapolis, Indiana. The conference attracted about 2,700 attendees and more than 1,300 technical papers were presented.

BACKGROUND AND PURPOSE OF TRIP:

The purpose of this trip was to attend Symposia B on the Impact of Ceramics in Energy Manipulation and the Environment and gather information on recent developments in nuclear waste science and technology that are relevant to the Nuclear Regulatory Commission (NRC) high-level waste (HLW) program. CNWRA staff also presented the paper *Dissolution Kinetics of High-Level Waste Glasses and Performance of Glass in a Repository Environment*, coauthored by Vijay Jain and Osvaldo Pensado.

Symposium B2 "Science and Technology in Addressing Environmental Issues in the Ceramic Industry" and Symposium B4 "Ceramic Science and Technology for the Nuclear Industry" were devoted to presentations and discussions on environmental issues and nuclear waste management. Five topic sessions were highlighted in Symposium B4: waste glass processing and melter systems, glass durability testing and modeling, glass formulation and testing, ceramic waste forms, and ceramic materials and alternative waste forms. Sixty six papers were presented in two symposiums. The proceedings will be published as Ceramic Transactions by the American Ceramic Society.

SUMMARY OF PERTINENT POINTS:

Since several parallel sessions were held, the summary provided in this report is based on the author's attendance at selected sessions and brief notes taken during presentations on topics relevant to vitrification and process technology, glass durability, glass formulation, and ceramic waste forms.

Vitrification and Process Technology

Ron Palmer from West Valley Nuclear Services, Inc. presented two papers entitled "West Valley Demonstration Project: Vitrification Campaign Summary," and "Chemical and Physical Characterization of the First WVDP HLW Feed Batch." The first paper reviewed the status of the vitrification campaign at the West Valley Demonstration Project (WVDP). As of April 23, 2001, the WVDP has produced 255 canisters

(compared to 246 in April 2000). The presenter pointed out that in a recent inspection in March 2001, coupling failure was observed in the Melter Feed Hold Tank agitator. This failure event caused a glass homogeneity problem and need for replacement. Other challenges present at the WVDP include the issues of melter reliability and waste tank clean out. The second paper reported results of a sample analysis of the first batch of HLW slurry transferred to the Concentrator Feed Make-Up Tank. The purpose of this work was to support the WVDP Waste Form Qualification Report. The waste sample was analyzed by Pacific Northwest National Laboratory (PNNL) to give cation, anion, and radionuclide concentrations and the physical properties of density, total solids, and suspended solids. The data from this analysis are consistent with the predicted inventory of the waste.

Sharon Marra from Westinghouse Savannah River Company (WSRC) updated the status and current development of the Defense Waste Processing Plant (DWPF). To date, 1000 canisters have been filled with glass from the first two macro batches. The second macro batch is almost complete, and the third macro batch is being prepared and will begin late this year. Current development activities at the DWPF include improving the glass production rate, increasing the operating window for production of acceptable melter feed, improving the melter inserts to maintain a stable glass pour stream, and evaluating the impact of a higher noble metals content in the third macro batch.

George Mellinger from PNNL presented a paper entitled "Waste Glass Processing Requirements of the Hanford Tank Waste Treatment and Immobilization Plant." This paper discussed the glass processing requirements specified in the Hanford Waste Treatment and Immobilization Project (WTP) and the technical baseline for the project, with emphasis on the waste glass processing aspects. The object of the WTP is to design, construct, and commission a waste treatment and immobilization facility to remediate Hanford tank waste. The initial capacity for vitrification of low-activity waste (LAW) in units of metric tons of glass (MTG) is 30 MTG/day and is 1.5 MTG/day for HLW. This capacity will be expanded to 60 MTG/day for LAW and 6.0 MTG/day for HLW. The LAW feed will produce 2,700 MTG (450 canisters) and 180 MTG (60 canisters) for HLW feed. In addition, several milestone due dates for specific activities were given in the presentation, including completion of acceptance testing (November 2007), start of radioactive commissioning (December 2007), completion of radioactive commissioning (January 2011), and completion of contract requirements (June 2011).

Glass Durability

CNWRA staff, Yi-Ming Pan, presented a paper entitled "Dissolution Kinetics of High-Level Waste Glasses and Performance of Glass in a Repository Environment." In this study, dissolution kinetics of two simulated HLW glasses were investigated in a simulated internal waste package environment containing steel corrosion products. Rate expressions for glass dissolution were developed taking account of the effects of corrosion products. These were compared with the model used in the Total System Performance Assessment by the Department of Energy (DOE). Enhanced glass dissolution was observed in the presence of corrosion products. Performance assessment analyses indicated that during the regulatory period the mean dose rate is comparable to the dose rate from the spent fuel dissolution. However, the magnitude of the dose rate is small in both cases. Dr. Bernard Grambow from Ecole de Mines de Nantes, France commented that even though the CMWRA rate expression provides a conservative upper bound to the dissolution rate in comparison with the DOE model, glass dissolution rate can be higher under certain environmental conditions. Jarrod Crum from PNNL presented a paper entitled "The Effect of Crystallization on Durability of INEEL Calcine-Based Glasses." This paper discussed the effect of thermal history on the resulting glass

microstructure and its ultimate impact on durability of INEEL-type HLW glasses. As the glass is poured into the canister, the radial temperature distribution is parabolic with about 400 °C difference in temperature between the centerline and the wall. A relatively slow rate of cooling along the centerline allows sufficient time for precipitation of fast nucleating and fast growing phases such as spinel, nepheline, and flouride F-based crystals. The effect of crystallization on glass durability has been evaluated for a series of glasses using the Product Consistency Test (PCT) method. The results indicated that within the compositional envelope tested, crystallization does not have a significant impact on durability. However, crystallization upon cooling is a primary concern that may limit waste loading in glass.

Hoa Gan from Catholic University of America presented a paper entitled "Leaching Behavior of HLW Glasses under TCLP Conditions." In this work, over 100 HLW glasses were formulated by statistical experimental design methods, using constraints suitable for Hanford HLW vitrification. Leaching properties of the glasses were determined using the Toxicity Characteristic Leaching Procedure (TCLP) (SW-846, Method 1311), developed by the Environmental Protection Agency. TCLP leachate concentrations were measured for the elements regulated by the Resource Conservation and Recovery Act, as well as other constituents. The normalized release rates of the elements were found to fall into three distinct categories: advanced elements (B, Ni, Ba, Co, Ag, and U), retarded elements (Si, Se, Sb, Pb, and Tl), and inert elements (Al, Fe, Zr, As, and Cr) having t^1, $t^{0.25}$, and t^0 kinetics, respectively. The models developed provide a good correlation to the large data set.

Glass Formulation

Carol Jantzen from WSRC presented an invited talk entitled "Systems Approach to Waste Glass Formulation: Future and Challenges." The presenter first reviewed the history of waste glass development in terms of the timeline of increasing melting temperature, and then discussed the successes of borosilicate glass formulations for the vitrification of radioactive wastes in the U.S. The use of a systematic approach has enabled the Savannah River Site to qualify complex 20 component glasses that are both durable and processable, while minimizing radionuclide volatility and corrosion of melter materials of construction. In this presentation, challenges for future glass formulation and qualification were addressed, including maximizing waste loading to maximize cost savings ($3000/canister for every 1 wt% waste), processing of corrosive or difficult waste melts (e.g., F, Cl, SO_4, and PO_4), controlling glass durability and phase separation in high alkali waste glasses, vitrifying refractory (ZrO_2 and Cr_2O_3) and metallic waste, and modeling long term glass durability from short term durability testing.

Ceramic Waste Forms

Alex Cozzi from WSRC presented a paper entitled "Furnace System Development for the Plutonium Immobilization Program." In the Plutonium Immobilization Program, a furnace system is being developed at the Clemson Environmental Technologies Laboratory (CETL) to meet the requirements for disposition of approximately 13 metric tons of excess weapons useable plutonium. The proposed immobilization form is a titanate based ceramic consisting primarily of a pyrochloride phase. The ceramic formulation is cold-pressed and then densified via a reactive sintering process. The designed product throughput of the furnace system is 200 acceptable pucks per day. A test program is ongoing to evaluate the design features, and nine furnace runs have been initiated to date. Additional information of the fabrication facility is available on the CETL World Wide Web at http://www.cetl.org/Home.htm. It should be noted that the Pu immobilization program has been indefinitely suspended by the DOE.

Lester Morss from Argonne National Laboratory (ANL) presented a paper entitled "Release of Plutonium from the EBR-II Ceramic Waste Form." The paper discussed corrosion behavior of a ceramic waste form (CWF) that has been developed to immobilize salt waste generated during electrometallurgical conditioning of spent sodium-bonded metallic fuel. The CWF is made of glass bonded sodalite. Two minor phases, halite (NaCl) and oxide [$(U,Pu)O_2$], are present primarily as colloid-sized particles in the glass, as characterized by electron microscopy. PCT tests were conducted to measure the release of matrix and radioactive elements from crushed CWF samples. Leaching solution analysis indicated that plutonium is released as small colloids similar to the particles in the uncorroded CWF.

Michele Lewis from ANL presented a paper entitled "Monitoring Consistency of Ceramic Waste Form." The PCT method was used to investigate consistency in the glass bonded sodalite CWF products. Ten CWF products with different glass/sodalite ratios and processing conditions were evaluated. The results of PCTs indicated that the test method is repeatable, and leaching of the CWF is sensitive to its composition and processing conditions. The relative standard deviations in PCTs were about 10 times lower for CWF than for Environmental Assessment glass. From this work it is suggested that the PCT method can be used for monitoring the consistency of the CWF for disposal in any federal HLW repository.

SUMMARY OF ACTIVITIES:

Vijay Jain of the CNWRA was one of the symposium organizers for both Symposiums B2 and B4 and was responsible for soliciting papers and session chairs.

CONCLUSIONS:

The meeting was very useful in keeping current with worldwide advancements in vitrification science and technology. The participation at the meeting was a good opportunity to present our work and generate discussion on nuclear waste processing technologies.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Continue participation in the Nuclear Waste Management Program at the American Ceramic Society.

SIGNATURES:

Yi-Ming Pan
Senior Research Engineer

5/7/01
Date

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