CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Attendance at the American Society of Testing and Materials (ASTM) C26.13 Repository Waste Subcommittee Meeting
Charge Number 20.06002.01.321; AI Number 06002.321.501

DATE/PLACE: January 24–28, 2005, Atlanta, Georgia

AUTHOR: V. Jain

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PERSONS PRESENT:

V. Jain from the Center for Nuclear Waste Regulatory Analyses (CNWRA), and Tae Ahn, Robert Einziger, Chris Brown, and Charles Interrante from the U. S. Nuclear Regulatory Commission (NRC). In addition, the participants included technical staff from national laboratories such as Argonne National Laboratory (ANL), Idaho National Laboratory (INL), Savannah River National Laboratory (SRNL), and Pacific Northwest National Laboratory (PNNL); Bechtel SAIC Company (BSC); and representatives from Commissariat à l'énergie Atomique (CEA), France and Studiecentrum Voor Kernenergie Centre D'Etude de L'Energie Nucleaire (SCK•CEN), Belgium.

BACKGROUND AND PURPOSE OF TRIP:

The ASTM C26 committee meeting was held January 24–28, 2004, at the Hyatt Regency Hotel in Atlanta, Georgia. ASTM C26 committee consists of several subcommittees such as C26.01 on Terminology, C26.02 on Fuels, C26.03 on Neutron Absorber Materials, C26.05 on Analytical Test Methods, C26.07 on Mixed Waste Materials, C26.08 on Quality Assurance, Statistical Applications, and Reference Materials, C26.09 on Nuclear Processing, C26.10 on Nondestructive Assay, C26.12 on Safeguards, C26.13 on Repository Waste, and C26.14 on Remote Systems. Author participated in the ASTM C26.13 subcommittee which is primarily involved in the development of standard methods, guides, and practices for activities related to disposal of high-level waste in geologic repository. The purpose of these biannual meetings is to define the need for standards, write standard methods, and issue standards for testing and materials. In addition to regular meeting, one and one-half days were devoted to a special seminar on Accelerated Testing of Materials in Spent Nuclear Fuel and High-Level Waste Storage Systems. In this seminar, twelve papers were presented. Copies of meeting agenda and seminar are attached.

I participated in discussions related to standards for testing of materials relevant to repository waste and the special seminar. The development of test methods such as Vapor Hydration Test for Measuring Waste Glass Dissolution, Single-pass Flow-through Test for Determining the Forward Reaction Rate for Glass and Spent Fuel Dissolution; Standard Guide for Drying of Spent Nuclear Fuels; and the Revision of the Standard Practice for Prediction of the Long-term Behavior of Materials, Including Waste Forms, Used in Engineered Barrier Systems for

Geological Disposal of High-level Radioactive Waste could be important to the NRC in its work related to the licensing of the potential repository at Yucca Mountain.

SUMMARY OF ACTIVITIES:

- ASTM C 1174-97—Standard Practice for Prediction of the Long-Term Behavior of Materials, Including Waste Forms, Used in Engineered Barrier Systems for Geological Disposal of High-Level Radioactive Waste was reissued after incorporating 10 CFR Part 63 requirements. The older version was based on 10 CFR Part 60 requirements. This standard is widely quoted by the U.S. Department of Energy (DOE) in the analysis and model reports.

- No new update was provided on Standard Test Method for Measuring the Dissolution Rate of Spent Nuclear Fuel in Dilute Aqueous Solutions Using a Single-pass Flow-through Technique. Lack of funding was cited as a potential cause for delay in completing the work.

- Thornton (BSC) discussed the status of the draft standard guide for the Characterization of Spent Nuclear Fuel in Support of Geologic Repository Disposal. This guide could provide criteria for accepting spent nuclear fuel at the Yucca Mountain site.

- Ebert (ANL) provided an update on the round robin studies to support the draft standard for Measurement of the Glass Dissolution Rate Using the Single-pass Flow-through Test Method. Round robin test results are being analyzed to support the release of standard.

- No update were presented on the draft standard test methods for Determining the Amount of Devitrification in a Nuclear Waste Glass and for Constructing Time-temperature-transformation Diagrams and for Determining the Liquidus Temperature (T_l) of Waste Glasses. Several action items were developed to move these standards to ballot.

- Ballot comments on the draft standard guide for the Drying Behavior of Spent Nuclear Fuel were discussed and dispositioned with required changes.

- Brown (NRC) led the discussion on the draft standard practice for Qualification and Acceptance of Boron Based Metallic Neutron Absorbers for Nuclear Criticality Control for Dry Storage and Transportation Packages.

A special seminar on Accelerated Testing of Materials in Spent Nuclear Fuel and High-Level Waste Storage Systems was organized to obtain feedback on the use and the applicability of accelerated tests used in the nuclear waste industry. In this seminar, twelve papers were presented.

Thronton (BSC) described the development and current use of the ASTM C 1174-97—Standard Practice for Prediction of the Long-Term Behavior of Materials, Including Waste Forms, Used in Engineered Barrier Systems for Geological Disposal of High-level Radioactive Waste in Support of Interim Storage and Geologic Repository Disposition of Nuclear Waste. He summarized a series of standards that ASTM C-26 has developed to support disposal programs.

Celina (SNL) gave a presentation titled "Science-Based Performance, Degradation, Lifetime Prediction and Condition Monitoring Studies of Polymers in Critical Applications." Celina highlighted difficulties in predicting the life expectancies of polymers. Temperature is widely used as a parameter to accelerate tests assuming a constant activation energy process. According to Celina, constant activation energy is valid only for a short temperature range. Changes in activation energy could result in under estimation of polymer life expectancy. Furthermore, self-repair could occur at higher temperatures during accelerated tests that could severely overestimate life expectancy at operating temperatures. Celina also pointed out that aging does not occur homogeneously in polymers and such processes should be taken into account in estimating failures.

Helie (CEA, France) gave on overview presentation on the carbon steel high-level waste container material in the frame work of French storage and disposal concepts. The French framework calls for 300 year of dry storage followed by geologic storage. The interim storage is divided into dry storage period of approximately 100 years and atmospheric corrosion period of approximately 200 years. The oxidation behavior during dry oxidation period follows a classical parabolic law of oxidation and atmospheric corrosion is modeled using a power law. The data is collected at higher temperatures to accelerate the corrosion process and extrapolated to lower temperatures. To check the validity of extrapolation, oxide layers were analyzed and data was compared with theoretical diffusion models. During 100 years of dry oxidation and 200 years of atmospheric corrosion, carbon steel is expected to corrode approximately 100 and 180 μm, respectively. Long-term corrosion behavior of carbon steel containers in being studied in clay solutions using electrochemical methods. Data collected from these experiments will be used in conjunction with theoretical corrosion models based on diffusion laws. Mizia (INL) presented results of a study to develop nickel-chromium-molybdenum-gadolinium based alloys as a neutron absorber material. He presented metallurgical details, corrosion and mechanical testing results for a range of compositions. At present, an ASTM Standard B392–04 "Low-Carbon Nickel-Chromium-Molybdenum-Gadolinium Alloy Plate, Sheet and Strip" has been approved and an ASME Code Case inquiry has been submitted to ASME Section III, Division III. Both electron beam and gas tungsten arc welding were successful in welding this alloy. However, extensive grinding was needed after every pass to remove oxide layer.

In the area of spent nuclear fuel five papers were scheduled for presentation. However, two papers were withdrawn. The paper by Shoesmith (University of Western Ontario, Canada) was focused on the development of the mixed potential model for determining corrosion rate of Canadian spent nuclear fuel. Corrosion of spent nuclear fuel inside a failed Canadian nuclear waste container is expected to be dominated by reducing environmental conditions and alpha radiation as a potential source of oxidants. He cited that key issues in development of the mixed potential model are fuel reactivity, influence of corrosion products, kinetics of hydrogen peroxide reduction or scavenging of hydrogen peroxide by corrosion products. Veyer (CEA, France) presented an overview of the French repository program, and highlighted integrated approach for determining long term performance of spent nuclear fuel. She stressed that extrapolation is needed through the use of predictive models to determine long-term performance. Therefore, in order to have a robust and reliable model, the predictive model should be mechanistic. According to Veyer, empirical models can not be justified for long term prediction because no validation is possible for such models. Abrefah (PNNL) presented a paper on estimating the reactivity of K-Basin metallic spent nuclear fuel during cold vacuum drying process.

There were five papers presented in the seminar that focused on the low-level waste glass waste forms. Jantzen (SRNL) presented a review of glass waste form development for the Defense Waste Processing Facility high-level waste glass. ASTM C–1174 was used as a guide during the process development to ensure that acceleration of one or more kinetic test protocol parameter does not result in the alteration of the dissolution mechanism. The dissolution model developed was verified using natural analogs. Ebert (ANL) presented dissolution data for high-level waste glass waste forms using a modified Vapor Hydration Test (VHT) to simulate waste forms exposed to humid air conditions. Results showed that modified VHT is more aggressive compared to the standard Product Consistency Test (PCT). PCT is routinely used for the development of high-level radioactive waste forms dissolution models. Van Iseghem (SCK•CEN, Belgium) in his presentation indicated that in Belgium glass dissolution studies are focused on the quality of glass production and for determination of lifetime of the glasses in geological repository environment. Prediction of lifetime requires accelerated testing. Most often temperature is used a parameter to accelerate dissolution behavior. He indicated that at higher temperatures glass dissolution is a dominant reaction mechanism while at ambient temperatures, ion-exchange is a dominant mechanism. Lifetime predictions made based on high temperature studies may not be reflective of actual behavior of high-level waste glass in actual repository conditions. McLoughlin (University of Sheffield, UK) provided an overview of the program on accelerated testing of glass waste forms. This program was recently started and is focused on the development of suitable glass compositions for the blended Magnox fuel. Eric Pierce (PNNL) presented results of pressurized unsaturated flow (PUF) test. PUF test has been developed to study formation of alteration phases on the waste form surface under unsaturated conditions.

IMPRESSIONS/CONCLUSIONS:

The meeting was useful in keeping current with the ongoing ASTM activities related to repository waste. The participation at the meeting was a good opportunity to provide technical and regulatory perspective to the development of international standards; and gather information and generate discussion on issues important to repository waste. However, it should be noted that the progress on several standards has been slow due to the lack of time and resources provided by the volunteer organizations to support ASTM standards and round robin testing.

PROBLEMS ENCOUNTERED:

None.

PENDING ACTIONS:

None.

RECOMMENDATIONS:

Staff should continue to participate at the ASTM C26 Committee meetings. Next meeting will be held in Reno, Nevada on June 11–15, 2005.

SIGNATURES:

Vijay Jain
Manager
Corrosion Science & Process Engineering

2/10/2005
Date

CONCURRENCE:

Budhi Sagar
Technical Director

2/10/2005
Date

Attachment
VJ:jg