ICET Test #1: Test Conditions and Observations
(NaOH and 100% Fibrous Insulation)

Test Conditions

The general conditions, approach, and requirements for the ICET program are contained within the test plan that governs this test series (Adams Accession # ML051100357). All tests are being conducted in an environment that represents expected containment pool conditions during recirculation. The initial chemical environment contains 2800 mg/L of boron, 100 mg/L of hydrochloric acid (HCl), and 0.7 mg/L of lithium hydroxide (LiOH). Tests are conducted for 30 days at a constant temperature of 60ºC (140ºF). The materials tested within this environment include representative amounts of submerged and unsubmerged aluminum, copper, concrete, zinc, carbon steel and insulation samples. Representative amounts of concrete dust and latent debris are also added to the test solution. Tests consist of an initial 4-hour spray phase to simulate containment spray interaction with the unsubmerged samples. Water is circulated through the bottom portion of the test chamber during the entire test to achieve representative flow rates over the submerged specimens.

The primary differences among the ICET tests are the buffering agent and the insulation materials. Test #1 incorporated a sodium hydroxide (NaOH) buffering agent and 100% fibrous insulation. An initial amount of NaOH was added to the aqueous chemical environment. The remaining NaOH was injected during the first 30 minutes of the 4-hour spray phase of the test. The amount of injected NaOH was determined so that the spray fluid pH did not exceed a value of 12 during the injection phase. The actual test solution pH was approximately 9.5 at the end of the NaOH injection into the spray. The pH of the test solution decreased slightly during the test, and was approximately 9.4 at the end of the test. This 30-day test was initiated on November 21, 2004, and was completed on December 21, 2004.

Important Test Observations

Several products were evaluated for the presence of chemical effects in these tests: the test solution, fibrous insulation samples, test chamber sediment, and sample coupons. Chemical by-products were found in the test solution, fibrous insulation samples, and sediment, all of which should be considered when addressing possible chemical effects implications as part of the generic letter (GL) 2004-02 evaluation. The test observations relevant to each product form are described as follows:

<u>Water Samples</u>

No chemical by-products were visible at the test temperature of 140ºF. However, microscopic evaluation revealed the presence of small amorphous particulates. At room temperature, precipitants became visible after the first 8 hours of testing. The amount of visible room temperature precipitation increased with time, and the precipitant formed more quickly at room temperature as testing progressed. More total suspended solids were also present as the temperature decreased from the test temperature to room temperature. Subsequent reheating of portions of solution led to some decrease in the total suspended solids. However, heating up to the test temperature of 140ºF did not re-dissolve all the solids that had formed at room temperature. Additionally, the precipitant analyzed was principally amorphous and the particle size was very small, on the order of 10 nm. Agglomeration or aggregation of these smaller particles led to the formation of larger structures.

Bulk kinematic viscosity and turbidity values obtained at room temperature began to increase starting within 8 to 10 days of testing and reached nearly steady values after approximately 20 days of testing. Test temperature measurements of kinematic viscosity and turbidity were nearly constant over the same time period. Strain-rate viscosity testing clearly demonstrated that the viscosity varies with strain rate for the room temperature samples after day 23 which is indicative of non-Newtonian behavior. No clear strain rate dependancy is apparent for the 140°F solution over the range of strain rates that were evaluated. Additional characterization indicated that the room temperature precipitant has an amorphous structure.

The most prevalent chemical additions to the initial chamber chemical composition (i.e, boron, LiOH, and HCl) include aluminum and sodium. The sodium concentration was greater than 2000 mg/L during the entire test, and remained relatively constant at 4500 mg/L after approximately 3 days of testing. The aluminum concentration was initially minimal, rose to 350 mg/L after approximately 20 days of testing, and then was nearly constant to the end of the test.

Fibrous Insulation Materials

Fibrous insulation materials were removed from the test chamber and analyzed after days 15 and 30 of the test. The day 15 sample exhibited evidence of chemical products on individual fibers, and a web-like material spanning multiple fibers. After 30 days, these substances were more prevalent and contiguous webbing appeared to span multiple fibers. These substances were only deposited on insulation at the surface of the insulation holder bags. The penetration depth spanned a few fiber diameters below the surface. Insulation within the remaining portion of the insulation holders bags was not subject to these deposits and these fibers appeared relatively clean post-test.

Sediment

There was a quantity of sediment found on the test chamber floor in addition to the latent debris and concrete dust quantities added just before the onset of testing. Much of this additional sediment appeared to be from fugitive insulation material that escaped from the insulation sample bag during testing. Generally, there were no visible chemical by-products in the sediment that were similar to the web-like material present in the fibrous insulation. While the sediment settled to the bottom of the testing chamber during the test, subsequent settling tests revealed that the sediment was easily suspended and required a substantial amount of time (hours to days) prior to settling in quiescent flow conditions.

Sample Coupons

No unexpected corrosion products have been identified on the surface of either the metallic or non-metallic specimens. The samples were weighed after drying and no cleaning was performed prior to weighing. Weight loss/gain measurements indicate that only the aluminum specimens experienced a significant weight change. The aluminum specimens lost approximately 25% of their pre-test mass. The carbon steel sample lost approximately 2% of its pre-test mass, while the concrete sample gained less than 3% more mass. The concrete weight gain may have resulted from retained water after several days of air drying. Other samples either gained or lost much less than 1% of their pre-test mass.

A more complete data report for ICET test #1, containing additional observations, is currently under NRC staff review and will be made publicly available once this review is complete.