ICET Test #3: Test Conditions and Observations (TSP and 80% Cal-Sil and 20% 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 60°C (140°F). 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 #3 incorporated a tri-sodium phosphate (TSP) buffering agent with 80% calcium silicate (Cal-Sil) insulation and 20% fibrous insulation. The TSP was injected into the recirculation line starting at 30 minutes after the initiation of sprays. The TSP injection was completed by the end of the 4-hour spray phase. The test solution pH was 7.3 after all TSP injection was completed. The pH increased to a value of 7.9 by the third day of testing. After day 3, the average pH values increased slightly to a value of approximately 8.0 by the end of the test. This 30-day test was initiated on April 5, 2005, and was completed on May 5, 2005.

Important Test Observations

The following general visual observations were made during the test. Twenty minutes after initiating the TSP injection into the test chamber, a white flocculent material was observed in the test chamber. This material appeared to be neutrally buoyant and was entrained in the test chamber flow. Approximately two and a half hours later, the white flocculent material was still visible but the size of the material was much smaller than before and appeared to be very fine and dense. After one day of testing, a white deposit was observed on the submerged stainless-steel insulation mesh and on the submerged galvanized steel coupons. When the test was completed and the test solution was drained, a white shiny substance with the texture of face cream mixed with small granular particles was present in the top layer of sediment, on the insulation sample bags, and on other surfaces within the test chamber.

It is important to note that on day 8 of testing, the inline flow meter stopped working. It was removed from service. Inspection revealed that scale and precipitation deposits accumulated on the flow meter turbine such that the turbine could not rotate. After the turbine was cleaned, it was reinstalled and operated during the remainder of the test without failure.

Several products are being evaluated for the presence of chemical effects in these tests: the test solution, fibrous insulation samples, test chamber sediment, and sample coupons. There is currently evidence of chemical by-products in the fibrous insulation samples and sediment that 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:

Water Samples

No chemical by-products were visible at the test temperature of 140°F or upon cooling to room temperature in the daily water samples. Additionally, no precipitates or by-products have become visible as the samples have set at room temperature since the end of the test. The turbidity was initially very high due to the addition of Cal-Sil debris prior to initiating the test. However, turbidity decreased steadily for approximately 5 hours to a value of 54 NTU at the beginning of the test (initiation of spray phrase). Within approximately 30 minutes from when the TSP injection began, the turbidity had increased significantly (> 200 NTU). By the end of the 4-hour spray phase, the turbidity decreased to 79 NTU. The turbidity continued to decrease and by the end of the first day, the turbidity fell below 4 NTU and remained largely constant over the remainder of the test. These turbidity trends are consistent with the earlier stated visual observations of activity within the test chamber.

The total suspended solids (TSS) values generally exhibit similar trends. During the middle of the TSP injection, while the white flocculent particles were visible within the solution, the TSS concentration was 268 mg/L. At the end of the 4-hour spray cycle, the concentration had decreased to 73 mg/L. After the first 24 hours of the test, the TSS concentration had dropped to 13.9 mg/L and remained roughly constant during the remainder of the test. There were, however, several days where high values (> 20 NTU) were recorded. These largely singular higher values are unexplained, but they may result from sediment which is agitated during the course of the test and entrained in the chamber flow. Kinematic viscosity measurements at 140°F and room temperature were constant during the entire test.

The most prevalent chemical additions to the initial chamber chemical composition (i.e, boron, LiOH, and HCl) included silica, sodium, and calcium. The silica concentration increased quickly to a value of approximately 100 mg/L after the first day of testing, and then remained relatively constant throughout the next 20 days. Starting at day 20, the silica concentration appeared to slowly decrease, but it remained greater than 82 mg/L by the end of the test. The initial sodium concentration (after TSP injection) averaged approximately 1000 mg/L during the bulk of the test. However, between days 10 and 15 of the test, the sodium concentration steadily rose to a value greater than 1500 mg/L. After day 15, the sodium values decreased sharply to 1000 mg/L by day 16. The calcium concentration started near 0 mg/L after the completion of the spray phase. It then rose monotonically throughout the test until reaching a value of approximately 110 mg/L at the end of the test.

Fibrous Insulation Materials

Fibrous insulation materials are being evaluated that were extracted from the tank during the beginning, middle, and end of the test. The white shiny substance found upon opening the test chamber was coating the insulation sample bags and at least some of the insulation sample material.

Sediment

There was a large quantity (approximately 9" deep in some places) of sediment found on the test chamber floor after the test. As expected, much of this sediment appears to be from the small Cal-Sil particles introduced during the beginning of the test. This apparent Cal-Sil material is prevalent within the bottom portion of the sediment layer. The white shiny substance found upon opening the test chamber makes up the topmost layer of the sediment.

Sample Coupons

There was a copper layer evident on the aluminum samples. This copper layer may have resulted from heavy metal corrosion of aluminum by copper ions. Otherwise, no unexpected sample corrosion products have been found to date.

A more complete data report for ICET test #3, containing additional observations, is currently being prepared and will be made publicly available once it has been completed.