November 6, 2006

MEMORANDUM TO: Michael L. Scott, Chief
Safety Issues Resolution Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

FROM: Allen L. Hiser, Jr., Chief ***/RA/***
Steam Generator Tube Integrity and
Chemical Engineering Branch
Division of Component Integrity
Office of Nuclear Reactor Regulation

SUBJECT: STAFF OBSERVATIONS OF TESTING FOR GENERIC SAFETY ISSUE 191 DURING AUGUST 17 AND AUGUST 18 TRIP TO THE ALION HYDRAULICS LABORATORY

On August 17 and 18, 2006, NRC staff traveled to the Alion Science and Technology Hydraulics Laboratory in Warrenville, Illinois, to observe testing associated with the resolution of Generic Safety Issue 191 (GSI-191). The objective of the trip was to observe chemical effects tests being conducted for the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3. The participating Nuclear Regulatory Commission (NRC) staff members were Paul Klein and Matthew Yoder of the Steam Generator Tube Integrity and Chemical Engineering Branch in the Division of Component Integrity. The staff interacted with personnel from SONGS along with vendor personnel from Alion Science and Technology.

Members of the NRC staff have previously visited the Alion Hydraulics Laboratory on February 24, 2006, and on April 28, 2006, to observe testing. Summaries of staff observations from these visits are available in ADAMS (Accession ML060750467, ML061720514).

The enclosure summarizes the staff's visit on August 17-18, 2006.

Enclosure:
Trip Report

CONTACT: Paul A. Klein, DCI/CSGB
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Observations of Testing at Alion Science and Technology Hydraulics Laborotory
August 17 and 18, 2006
Paul Klein and Matthew Yoder
NRR/DCI/CSGB

Overview

The Alion Hydraulics Laboratory has the capability to perform tests in several facilities including: (1) a large tank for performing integral head loss testing of modular strainer arrays or strainer prototypes, (2) a small-scale vertical head loss test loop, (3) a small-scale multi-function test loop with temperature control capability, and (4) a small-scale transport flume. The chemical effects tests for San Onofre Nuclear Generating Station (SONGS) were performed in the small scale multi-function test loop. This vertical test loop contains a horizontal 5.5-inch diameter flat plate within a clear plastic test section to facilitate bed formation. The test loop has a 16-gallon capacity, is constructed with materials intended to be compatible with representative sump environments, and is capable of operating at a maximum 160°F temperature. The Hydraulics Laboratory also has the chemicals and equipment needed for generating precipitates using the methodology outlined in WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191."

The technical approach employed by Alion to evaluate SONGS chemical effects consists of several test steps. The plant-specific amount of chemical precipitate is determined with the chemical model spreadsheet contained in WCAP-16530-NP. These precipitates are prepared in the Alion Hydraulics Laboratory using the directions provided in WCAP-16530-NP, with the exception that reverse osmosis water was used to generate the precipitate instead of potable water. Once the chemical precipitates generated in the reverse osmosis water, they can be transferred to the test loop which is filled with potable water. Prior to this visit by the NRC staff Alion performed bench top tests to compare precipitate generated using the WCAP procedures with commercially-manufactured particulate (e.g., sodium aluminum silicate).
The commercially-manufactured particulate had a different visual appearance than the precipitate generated according to the WCAP, and Alion personnel concluded it was not representative of the WCAP precipitate. After precipitates were mixed for more than the minimum mixing time specified in the WCAP, the solutions were diluted to a specific concentration and settling rates were measured in standard centrifuge tubes and verified to be consistent with the settling rates defined in the WCAP.

Once the chemical precipitates are generated, the scaled amount of non-chemical debris (e.g. fibers and particulate) from a postulated loss of coolant accident (LOCA) break location is introduced into the vertical test loop and a stable baseline head loss is established across the debris bed. After the baseline head loss is established and documented, incremental percentages of chemical precipitate are introduced to the test loop and the head loss associated with these precipitates is determined. These results would then be used to determine a "bump-up" factor due to chemical effects which would be applied in an appropriate manner to other tests (e.g., large scale tank tests with multiple strainer sections) with the same test conditions.

ENCLOSURE

NRC staff observed SONGS chemical effects tests from two LOCA scenarios that generate limiting (non-chemical) debris loads with different types of insulation.

The non-chemical debris for Test 1 is based on a postulated break in the reactor coolant system hot leg that generates a maximum debris load including mineral wool, NUKON latent fiber, dirt/dust, and coatings debris. The non-chemical debris for Test 2 is based on a postulated break at the reactor vessel that generates high particulate loading including Microtherm insulation, NUKON latent fiber, dirt/dust, and coatings debris. All coating debris is treated as particulate. The debris types and quantities were obtained from the SONGS debris generation and transport calculations.

Chemical precipitate loading is obtained from the SONGS chemical generation report that applies the WCAP-16530-NP chemical model. All plant specific loadings are scaled from the plant screen area to the vertical test loop screen area (0.165 ft^2). The flow rate in the test loop was set to achieve the 0.008 ft/sec plant screen approach velocity. The test loop fluid was potable water.

Test Results

On August 17th, the staff observed SONGS Chemical Effects Test 1. The ratio of total particulate mass-to-total fiber mass was approximately 2 for Test 1. After all non-chemical debris had been added to the vertical head loss loop, pressure drop stabilized after 2 hours and the bed thickness at that time was approximately 0.5 inch. The stable pressure drop was approximately 7.4 feet of water. Based on the heat input from the pump and the ambient conditions in the lab, the temperature of the fluid in the test loop during testing was approximately 85°F. Test loop fluid pH was approximately 7.3. Once the baseline pressure drop in the vertical head loss loop was stable, an aliquot equal to 1% of the total chemical product load for the SONGS hot leg break was introduced into the top of the loop. Within minutes, the pressure drop started to rapidly increase. When the test was stopped approximately 10 minutes after the introduction of the chemical precipitate, a gas pocket was visible under the debris bed. The bed had compressed to a 1/4 inch thickness and the pressure drop had increased to 13 feet of water when the pump was turned off to terminate the test.

The staff observed the start of Chemical Effects Test 2 on August 18th. The non-chemical debris load for this test was based on a postulated break at the reactor vessel that produced high particulate loading. The ratio of total particulate mass-to-total fiber mass was 34 for Test 2. All of the Microtherm insulation was added as particulate.

After all debris had been added to the loop, the baseline pressure drop (without chemical precipitates) remained low, approximately 0.02 feet of water. Due to the limited fiber in Test 2, the bed did not effectively filter the particulate and only the outermost portion of the debris bed was visible due to the high turbidity of the test fluid. After approximately 2 hours, the pressure drop across the screen section remained stable at 0.02 feet of water, and an aliquot equal to 1% of the total chemical product load for the SONGS break at the reactor vessel was introduced into the top of the loop. After approximately one-half hour, the pressure drop remained at 0.02 feet and a second aliquot equal to an additional 4% of the total chemical product load was added. Within minutes, the pressure drop started to slowly increase. The NRC staff departed for the airport approximately one hour after the 4% chemical product

addition. At that time, the pressure drop was 0.48 feet and increasing. Information that was later provided to the NRC staff by SONGS representatives indicated that approximately 3.5 hours after the 4% SONGS chemical product addition, the pressure drop was 1.7 feet and increasing at an approximate rate of 1 foot every 90 minutes. Since the lab personnel were not available to continue the test through the night, an additional 15% of chemical product (or a cumulative total 20% of chemical product) was added to the loop. Pressure drop exceeded 14 feet of water five minutes later and the test was terminated.

Observations

During the visit, the NRC staff provided several observations about the chemical effects tests to representatives from the licensee and from Alion Science and Technology. A summary of the NRC staff's observations is provided below.

- Alion personnel indicated that reverse osmosis water was used to generate the chemical precipitates since the use of potable water resulted in the precipitation of other unintended chemical products. Although the precipitates were generated in reverse osmosis water, head loss testing was performed at ambient temperature in a non-representative test environment (i.e., potable water). The effect of the potable water on the precipitate behavior is unknown. Testing should be performed to validate that this approach does not alter the precipitates in a non-conservative manner relative to head loss.

- Testing at Los Alamos National Laboratory has shown temperature and the presence of boron can influence aluminum hydroxide precipitates. In the SONGS test, the precipitate was made outside the test loop following the WCAP-16530-NP guidance.

- The staff is currently reviewing WCAP-16530-NP and has questioned whether the chemical precipitates generated according the WCAP directions are representative of the amorphous precipitates observed in previous Integrated Chemical Effects Tests.

- The staff noted that vendor implementation of the WCAP guidance for chemical precipitate generation may vary from other facilities since the WCAP does not provide detailed guidance in certain areas. For example, once generated, the shelf life for chemical precipitate is not provided and the effects of long term solution aging are uncertain. The chemical precipitates were made just prior to the SONGS tests. In addition, different test facilities may use different laboratory equipment to verify the precipitate settling rates meet the WCAP criteria.

- The staff discussed the basis for the chemical effects test termination criteria. The planned SONGS chemical effects test termination criteria was based on obtaining a stable pressure drop (less than 1% increase in 10 minutes) after all chemical precipitate had been added to the test loop. This criteria was not invoked for the SONGS tests observed by the staff since the tests were stopped before all chemical precipitate were added. The staff indicated that chemical effects test durations need to be sufficiently long so that tests are not prematurely terminated before time dependent chemical processes may occur. Although not applicable to these two tests, this is especially important when precipitates are not generated prior to testing but may form within the test loop after the injection of chemicals.

Summary

In summary, the staff observed chemical effects testing conducted for SONGS at the Alion Hydraulics Laboratory. Simulated plant debris in the two tests observed by the staff were representative of a break location that produced a fiber bed and a break location that resulted in a high particulate, low fiber bed. Introduction of a fraction of the total chemical precipitates predicted by the WCAP-16530-NP chemical model produced high pressure drop and resulted in test termination. These tests confirmed that chemical precipitates can produce high pressure drop across a pre-existing debris bed. Results from Test 2 (low fiber) were interesting since the baseline pressure drop across the debris bed was low without chemical precipitate. The NRC staff will continue to engage various licensees and vendors as chemical effects testing progresses. The staff expects these tests will provide a better understanding of plant specific chemical effects.