September 24, 2009

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

FROM: Mirela Gavrilas, Acting 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 JULY 22 TO JULY 24, 2009 TRIP TO THE ALION HYDRAULICS LABORATORY

On July 22 to July 24, 2009, a Nuclear Regulatory Commission (NRC) staff member and an NRC contractor 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 testing being performed for the Vogtle Nuclear Plant in the Alion High Temperature Vertical Loop. The participating NRC staff member was Paul A. Klein with the Division of Component Integrity under the Office of Nuclear Reactor Regulation, supported by Robert Litman from Environmental Management Support. During the visit, the staff interacted with Jimmy Cash from Vogtle and personnel from Alion Science and Technology including Jeff Poska, Luke Bockewitz, Jim Furman, Rob Choromokas, and John-Hee Park.

The enclosure summarizes comments and observations from the NRC staff visit in July 2009. Members of the NRC staff have previously visited the Alion Hydraulics Laboratory in 2006, 2007, and 2009. Summaries of staff observations from these visits are available in the Agencywide Documents Access and Management System (ADAMS) (Accession Nos.; ML060750467, ML061720514, ML071230203, and ML090500230). In addition, NRC staff comments from observation of Alion tests in Slovakia are available in Appendix II of ADAMS Accession ML082050433.

Enclosure:
Trip Report

CONTACT: Paul A. Klein, NRR/DCI
(301) 415-4030

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<u>DISTRIBUTION</u>:

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Observations of Testing at Alion Science and Technology Hydraulics Laboratory
July 22 to July 24, 2009
NRR/DCI/CSGB

Overview

The Nuclear Regulatory Commission (NRC) staff visited the Alion Hydraulics Laboratory in Warrenville, IL during July 22 to July 24, 2009 to observe chemical effects testing for Vogtle. Alion has the capability to perform multiple tests in the Warrenville facility including: (1) large tank tests for performing integral head loss testing of modular strainer arrays or strainer prototypes, (2) small-scale vertical head loss tests with temperature control capability to about 140^{o}F, (3) a small-scale transport flume, and (4) a high temperature vertical loop (HTVL) capable of operating up to approximately 200^{o}F. The staff was specifically interested in observing tests in the recently fabricated HTVL facility. Prior to the visit, the staff had the benefit of reviewing an Alion document: "Vogtle High Temperature Vertical Loop Test Plan."

Figure 1 provides an overall view of the HTVL piping loop arrangement. The test loop contains a pump, stainless steel piping, a heat exchange tank, various instrument ports, a top flange connection and a clear glass test section that holds a horizontal, 3/32-inch diameter hole perforated plate test section. Heating is controlled through the use of a gas burner coil located at the heat exchange tank and by heat trace on the stainless piping. Cooling is achieved by ice addition to the heat exchange tank. Addition of particulate, fiber, trisodium phosphate (to adjust pH) and boric acid are made through the flanged top connection above the filter housing. During testing, chemicals are added through a port located downstream of the heat exchange tank to allow for mixing of chemicals prior to reaching the debris bed. For the Vogtle tests, the target volumetric flow rate was 13 gpm, which resulted in a one volume turn-over time of approximately 1.2 minutes.

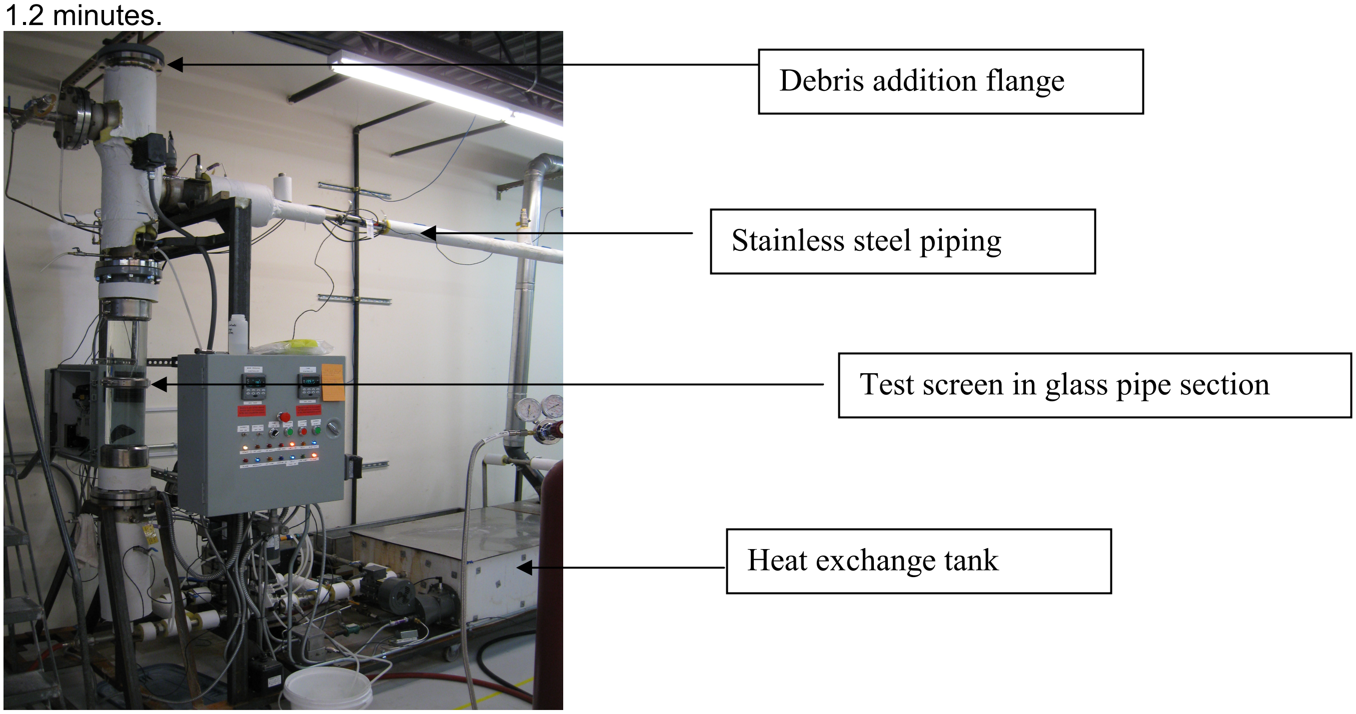

Figure 1. High Temperature Vertical Loop

ENCLOSURE

The overall technical approach to evaluate chemical effects for Vogtle involved a larger scale tank test with pre-mixed WCAP-16530 precipitates to determine the head loss associated with plant-specific debris, including the full chemical precipitate load. The plant-specific amount of chemical precipitate added to the tank test was calculated using the WCAP-16530-NP base model spreadsheet. The objective of the Vogtle HTVL tests was to demonstrate that aluminum based precipitates would not affect head loss above a certain temperature in a simulated plant-specific post-LOCA environment. Demonstrating that aluminum precipitates will not form at the highest post-LOCA pool temperatures provides a basis for crediting delayed precipitation of aluminum based precipitates that results in additional net positive suction head (NPSH) margin that can be applied towards increases in head loss due to precipitates.

Alion performed a total of 3 tests for Vogtle in the HTVL. An initial baseline head loss test was performed with 80 grams of silicon carbide particulate and 16 grams of fiberglass to determine the pressure drop associated with the non-chemical debris bed. At the end of the baseline head loss test, a small amount of WCAP-16530 sodium aluminum silicate precipitate was added to the loop to demonstrate that the baseline debris bed is sensitive (i.e., a significant pressure drop is measured) to chemical precipitate. Following the baseline head loss test, two chemical effects tests were performed using the same baseline particulate/fiber debris mixture but with the addition of sodium aluminate and sodium silicate after a stable baseline pressure drop was reached at the elevated temperature. Chemicals are injected downstream of the heat exchange tank so that there is approximately 0.5 minutes of mixing time before the material comes into contact with the filter bed, and the potential precipitants come up to the loop temperature so that premature precipitation due to low temperature does not occur. The chemical addition rate was 40 mL/min over the course of about 0.5 hours for the test that ended on July 22, 2009. Addition of particulate, fiber, trisodium phosphate and boric acid are made through the flanged top above the filter housing. The debris bed is established at the starting test temperature of approximately 200^{o}F and the temperature is decreased over time following the projected Vogtle post- LOCA temperature profile until the final temperature reduction from approximately 125 ^{o}F to 70 ^{o}F. Pressure drop across the debris bed is recorded and analyzed to evaluate potential chemical effects during the test. Two chemical effect tests are performed to assess test repeatability.

<u>Test Results</u>

When the NRC staff arrived at the Alion Lab on July 22, Vogtle's baseline HTVL test had been completed and the first chemical effects test was in the later stages of system cool down. At the end of the baseline test, WCAP-16530 sodium aluminum silicate precipitate was added to the test loop to measure the sensitivity of the HTVL to chemical precipitate. An amount equivalent to 1 ppm Al forming precipitate caused the pressure drop across the debris bed to increase by more than 2 feet over a 30 minute time period. These results are reasonably consistent with previous tests conducted at Argonne National Laboratory and demonstrate that baseline debris bed had a measurable head loss response to precipitates.

The Alion staff noted that when the sodium silicate and aluminum nitrate were added to the first chemical effects test that there were no signs of cloudiness to the naked eye. The staff observed the final temperature reductions from approximately 130 ^{0}F to 90 ^{0}F which took approximately 1 hour and 30 minutes, followed by further cooling to 70 ^{0}F. Flow sweeps were performed after a four hour temperature hold at 70 ^{0}F. There was a marked increase in the ΔP across the filter during cooling but it was not immediately clear how much of that increase could be attributed to viscosity differences at the lower temperature.

In subsequent viewings of the glass portion of the loop surrounding the fiber mat and with the aid of a bright LED light, the NRC staff observed either small particles or gas bubbles flowing in the loop, and going *through* the debris bed. These were not visible without the aid of the bright light. There was no change in the ΔP during the greater than one hour that this was observed by the staff and there was no sign of particulate build up on top of the debris bed during this time. These particulates or gas bubbles could also be seen on the downstream side of the debris bed following the fluid flow. To the naked eye it was hard to discern the size and source of these particles/gas bubbles. The staff, however, made similar observations in Vogtle's second chemical effect test, after the loop has been heated to 200 ^{0}F and degassed, but before addition of boric acid, TSP, or any debris.

Following initial observations of the test loop, the staff discussed the overall chemical effects strategy with the representative from Vogtle. The plant objective for the HTVL test was to demonstrate that the aluminum based precipitates would not impact head loss above 140 ^{0}F since earlier tank tests showed that sufficient NPSH margin exists to accommodate the pressure drop from 100% of the WCAP-16530 precipitate load at that temperature. The post-LOCA plant pH is calculated to be in the range of 7.6 to 8.1. The post-LOCA aluminum concentration in the pool was calculated to be between 4 and 5 ppm using an 8.1 pH input to the WCAP-16530 model. Since the high end pH range for the first chemical test was 7.8 and aluminum solubility decreases as a function of pH, the staff noted that the test pH may not be conservative if the post-LOCA pool pH could be lower. Therefore, the Vogtle representative decided to run the second chemical effect test with a maximum pH of 7.6 so that aluminum solubility in the test loop could not be greater than in a post-LOCA pool. HTVL fluid pH was measured with grab samples and the data indicated the pH was controlled within a range of approximately 0.25 pH units during the tests.

The NRC staff observed the completion of Vogtle's chemical effects Test 1 on July 22. Total pressure drop across the debris bed was approximately 4 feet of water when the test was ended. The staff observed the system drain down and removal of the debris bed following the test. Figure 2 shows the post-test debris bed for the first chemical effects test following removal from the glass section. The overall bed was fairly uniform with some clumps of fiber present on the top of the bed. Based on a cross section appearance, the bed had a particulate-rich darker bottom third section and a more yellowish fiber (less particulate) upper two-third layer.

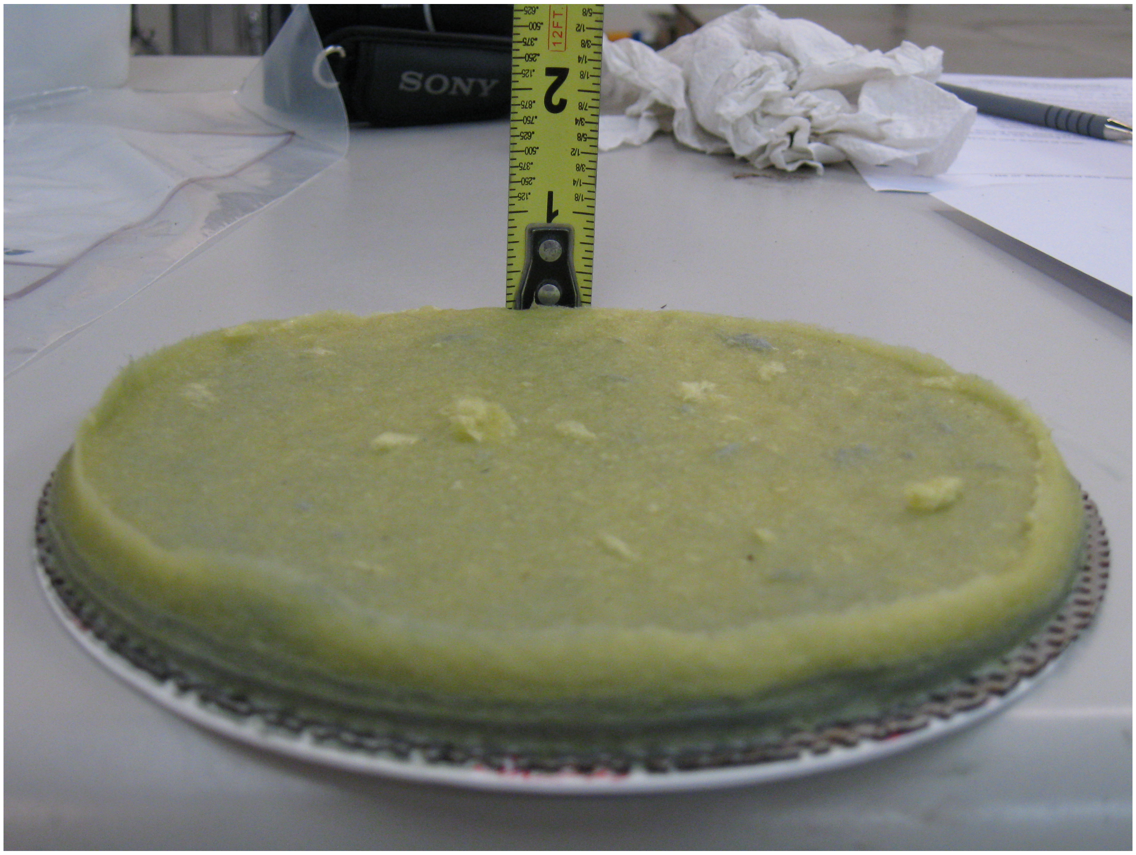

Figure 2. Vogtle Chemical Effect Test 1 Post-Test Bed Appearance

After drain down from the first chemical effects test, Alion personnel performed a series of fill and flush steps to prepare the HTVL for the second chemical effects test. A conductivity criterion was used to evaluate system cleanliness. During the second night, the staff observed the start of Vogtle's second chemical effects test. The loop was filled with water from a reverse osmosis system and heated until a system temperature of 200 ^{0}F is reached. Degassing was performed with a vacuum of about 7" of mercury while the system recirculation rate was at full flow. This degassing process was repeated four times over the course of about two hours until no visible gas bubbles remained under the test screen. The vacuum pump was turned off and the system was vented to atmosphere. The baseline ΔP across the clean screen was approximately 0.10 psid, similar to earlier clean screen values. Boric acid and sufficient TSP to adjust the system pH to the target value were added to the loop over about a 40 minute period.

The staff observed the fiber debris preparation and the addition of the fiber/particulate debris to the test loop for the second chemical effects test. The Nukon fiber was boiled in water for approximately 15 minutes. The fiber was strained and the water discarded. The staff noted that this water may contain leached materials that could influence the formation of precipitates and this may be a non-conservatism in the test process. The fiber was re-equilibrated in loop water, and at that time the fibers were shredded using an electric beater for about 10 minutes. The shredded material was examined by placing a sample in a clear glass dish and visually examining the dish on a light box. Figure 3 shows an example of the fiber distribution following these preparation steps. Although some clumps were visible, the fiber preparation appeared to effectively reduce the presence of clumped material. The slurry of fibers is put on a hot plate at 200 ^{0}F and the silicon carbide particulate is added. The mixture is stirred at temperature for about 10 minutes, and added to the system via the top flange on the loop. The fiber/particulate slurry was added in batches while stirring and the HTVL water was occasionally added to the beaker to keep the fiber slurry diluted during the addition process. The entire evolution, from the soaking of the fiberglass to the addition to the system took approximately one hour and fifteen minutes.

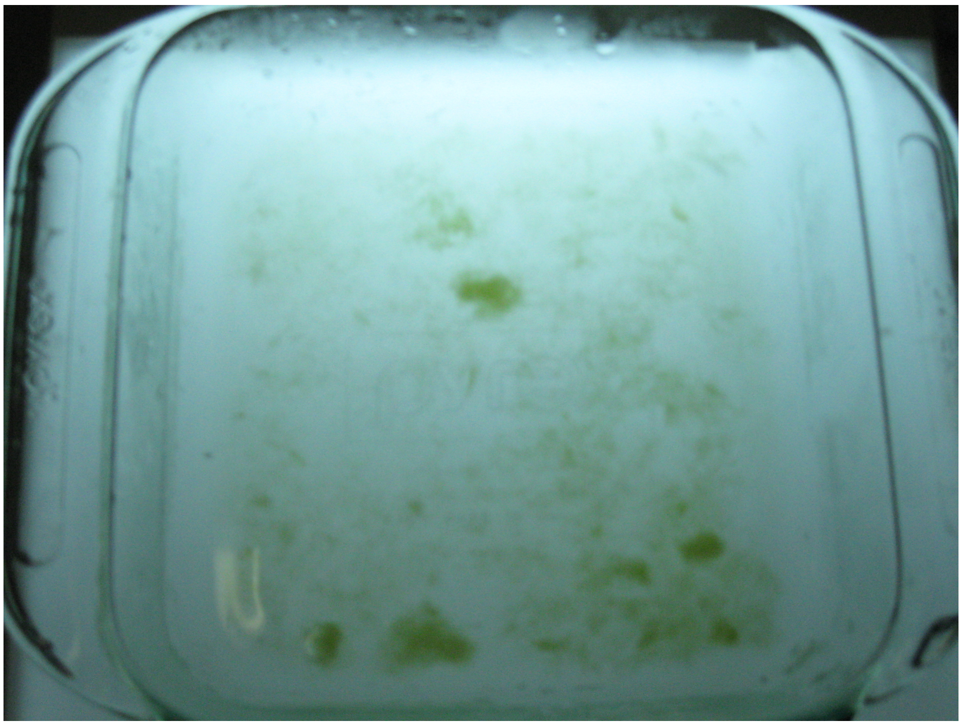

Figure 3. Fiber slurry appearance after debris preparation

Following debris addition, the stable baseline head loss criteria was reached after 12 hours. Table 1 provides a comparison between Vogtle's baseline head loss test and baseline (before chemicals) of the two chemical effect tests. The reported values show a reasonably consistent baseline pressure drop from the 5:1 particulate-to-fiber debris bed in these tests.

Table 1. Comparison of baseline pressure drop for Vogtle tests

Test ID	Debris	Bed Stabilization	Pressure Drop Before Chemicals	Pressure Drop At 70^{o}F*
Baseline	5:1, particulate-to-fiber	10 hours	1.76 psid	5.2 psid
Chemical #1	5:1, particulate-to-fiber	6 hours	1.56 psid	4.0 psid
Chemical #2	5:1, particulate-to-fiber	12 hours	1.34 psid	Not available

* Values are after 4 hours at 70^{o}F and before performing flow sweeps. The baseline test value reported is also before WCAP precipitate was added.

During the visit, the licensee showed the staff some preliminary data from the baseline test and first chemical effects test. The normalized data that factored in water viscosity changes as a function of temperature) showed a clear response to the WCAP chemical precipitate in the baseline test and what appeared to be a head loss response at the end of the first chemical effects test.

During the third day of the visit, the staff observed chemical addition to the second chemical effects test. Sodium silicate and sodium aluminate solutions were gradually added using a peristaltic pump. The staff performed independent calculations to verify that the quantity of chemicals added to the test loop would result in the targeted concentrations of aluminum and silicon. The staff also observed 200 ml of .1N nitric acid being added to the second chemical effects test to reduce the HTVL pH. At the time the staff departed from the Alion facility on the third day, the pressure drop across the debris bed had increased to greater than three feet of water.

The licensee indicated measurement of dissolved aluminum and other elements using an inductively coupled plasma (ICP) technique is planned to complement the information gained from head loss measurements. The staff had a number of questions related to the ICP analysis. Since the licensee indicated that Alion is planning to develop an in-house ICP capability, the NRC staff suggested to the licensee that a follow-up phone call to discuss details about how the ICP measurements will be performed would be prudent.

<u>Post-Test Phone Call</u>

The NRC staff participated in a phone call with the licensee and Alion Science and Technology on September 14, 2009 to discuss the Vogtle HTVL head loss data and Alion's plans to perform ICP measurement of samples taken during the Vogtle test. The NRC staff received a draft copy of the licensee's HTVL head loss data prior to the call. During the phone call, Alion personnel described how their ICP measurements would be performed. The NRC staff stated that our interpretation of the Vogtle HTVL data indicates a possible chemical effect as the test fluid temperature was decreased from 128^{o}F to 70^{o}F. The overall Vogtle chemical effects evaluation approach described to the staff during our visit to Warrenville and during phone call, however, seemed technically sound since the Vogtle chemical effects evaluation assumes precipitation of the entire 30-day chemical precipitate amount predicted by WCAP-16530 at 140 ^{o}F. The staff will review the Vogtle chemical effects data in more detail as part of a plant-specific review to Generic Letter 2004-02 responses.

<u>Observations</u>

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.

- The overall Vogtle chemical effects evaluation approach described to the staff during the visit seemed technically sound to the staff. The staff will review the Vogtle chemical effects data in more detail as part of a plant-specific review to Generic Letter 2004-02 responses.
- Although a conductivity criterion is used to evaluate system cleanliness, no internal

inspections were performed after the system was drained and flushed. The purpose of internal inspection would be to ensure that there are no internal dead spots where material is hiding out. If contamination from a preceding test occurred, it could alter the baseline debris bed composition and complicate interpretation of test results.

- Discarding the water after boiling the fiber results in discarding the chemical species that may have leached from the fiber during the boiling process. An Alion representative indicated they plan to run a test that includes using the boiled water to evaluate whether adding this solution to the HTVL test has any effects.

Summary

The NRC staff observed the end of HTVL chemical effects test one and the beginning of HTVL chemical effects test two conducted for Vogtle at the Alion Hydraulics Laboratory. The staff did not identify any major deficiencies during our test observations. Given the plant specific nature of chemical effect evaluations, the staff will need to review chemical effects evaluations that use the HTVL test protocol on a case-by-case basis to understand each licensee assumptions and overall strategy for addressing chemical effects. The staff will review plant-specific information from licensees using this approach during our review of licensee Generic Letter 2004-02 supplements.