April 30, 2008

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

FROM: Stephen J. Smith, Reactor Systems Engineer ***/RA/***
Safety Issues Resolution Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

SUBJECT: STAFF OBSERVATIONS OF TESTING FOR GENERIC SAFETY ISSUE 191 DURING FEBRUARY 12 AND FEBRUARY 13 TRIP TO THE ALDEN TEST FACILITY FOR PCI STRAINER TESTS

On February 12 and 13, 2008, NRC staff traveled to the Alden Research Laboratory in Holden, Massachusetts 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 South Texas Project (STP) strainer modification. The participating Nuclear Regulatory Commission (NRC) staff member was Steve Smith of the Safety Issues Resolution Branch in the Division of Safety Systems. The staff interacted with personnel from the STP licensee along with vendor personnel from the Alden Research Laboratory (Alden), Areva NP Inc. (Areva), and Performance Contracting Inc. (PCI).

The enclosure summarizes the staff's visit on February 12-13, 2008.

Members of the NRC staff have previously visited the Alden Research Laboratory on March 17 to 18, 2005, on January 18 to 19, 2006, on March 8, 2006, and January 16 to 18, 2008, to observe testing. Summaries of staff observations from the first three visits are available in ADAMS (Accession ML052060337, ML060750340, ML061280580). The trip report for the fourth trip has not been placed in ADAMS yet.

Enclosure:
Trip Report

CONTACTS: Steve Smith, DSS/SSIB
301-415-3190

April 30, 2008

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

FROM: Stephen J. Smith, Reactor Systems Engineer ***/RA/***
Safety Issues Resolution Branch
Division of Safety Systems
Office of Nuclear Reactor Regulation

SUBJECT: STAFF OBSERVATIONS OF TESTING FOR GENERIC SAFETY ISSUE 191 DURING FEBRUARY 12 AND FEBRUARY 13 TRIP TO THE ALDEN TEST FACILITY FOR PCI STRAINER TESTS

On February 12 and 13, 2008, NRC staff traveled to the Alden Research Laboratory in Holden, Massachusetts 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 South Texas Project (STP) strainer modification. The participating Nuclear Regulatory Commission (NRC) staff member was Steve Smith of the Safety Issues Resolution Branch in the Division of Safety Systems. The staff interacted with personnel from the STP licensee along with vendor personnel from the Alden Research Laboratory (Alden), Areva NP Inc. (Areva), and Performance Contracting Inc. (PCI).

The enclosure summarizes the staff's visit on February 12-13, 2008.

Members of the NRC staff have previously visited the Alden Research Laboratory on March 17 to 18, 2005, on January 18 to 19, 2006, on March 8, 2006, and on January 16 to 18, 2008, to observe testing. Summaries of staff observations from the first three visits are available in ADAMS (Accession ML052060337, ML060750340, ML061280580). The trip report for the fourth trip has not been placed in ADAMS yet.

Enclosure:
Trip Report

CONTACTS: Steve Smith, DSS/SSIB
301-415-3190

<u>DISTRIBUTION</u>: PUBLIC

DCI r/f	SSIB r/f	RArchitzel	MLScott	JLehning	SSmith
WRuland	PKlein	JGolla	MYoder	MEvans	AHiser
RTorres					

ADAMS Accession Number: ML080920398 NRR-106

OFFICE	NRR/DSS/SSIB	NRR/DSS/SSIB	NRR/DSS/SSIB: BC	NRR/DCI/CSGB: BC
NAME	SSmith	RArchitzel	MScott w/Minor Changes as marked	AHiser
DATE	03/31/08	04/07/08	04/30/08	04/30/08

OFFICIAL RECORD COPY

Observations of Testing at Alden Research Laboratory
February 12 and 13, 2008

Overview of Facility

This trip was a follow up to the staff observations of testing for Wolf Creek and Callaway that occurred from January 16 to 18, 2008. The staff considered that the follow up was necessary because of practices observed during the Wolf Creek/Callaway test. The major concerns identified during the earlier observations were the small amount of fibrous debris identified as fine debris in the plant-specific evaluation, and the debris preparation and introduction techniques used during the testing. The debris preparation and introduction appeared to result in a lack of finely prepared debris being added to the test flume. It is also possible that the debris was prepared properly, but agglomerated during the introduction process. The concern was based on the visual observation of large clumps of debris being added to the test flume. The licensees' transport analysis had concluded that fibrous fines and small fibrous pieces would be expected to transport to the plant strainer. Adding clumped debris would be expected to lead to lower head losses than would fine debris. The addition of this debris was captured on video and reviewed by the staff prior to determining that a follow up trip should be undertaken.

On February 12th and 13th, the staff observed a chemical effects head loss test for South Texas Project (STP) at Alden Labs. The Alden Laboratory has the capability to perform tests in two facilities. These are (1) a large tank flume for performing integral head loss testing of modular strainer arrays or strainer prototypes including near-field settling, and (2) a small-scale horizontal test loop. The staff observed two head loss tests for STP that were performed in the large test flume. The large test loop is comprised of a large tank, a pump, piping, immersion heaters, and a flume level control arrangement. There is also the ability to heat the tank water with an external loop. The test loop contains valves necessary to isolate or throttle flow and drain the flume. The pump is driven by a variable-speed motor to assist in controlling flow rate. Also installed are instrumentation for reading flow, pressure differential, temperature, and turbidity. Some of the instrumentation is connected to a desktop computer for trending and data collection. Grab samples were taken to determine the pH of the water throughout the test. The large test loop also has sample probes for taking samples to determine the amount of debris that bypasses the strainer.

The flume is about 45 ft long and 10 ft wide. Within the walls of the flume, plywood walls are built to vary the flow velocity of the water to simulate the flow velocity of water in the plant as it approaches the strainer. The velocity is changed by narrowing or widening the channel formed by the plywood walls. The entire flume is flooded, but only the water within the plywood channel is circulated. The water outside of the plywood walls is solely to prevent the walls from collapsing due to the force of the water inside the walls. Details of the test procedure and technical data were requested by the staff, but were not provided for review. The test flume has a large capacity, but for the STP test, the plywood walls were relatively close together so the test volume was somewhat reduced from the maximum possible. For the test observed on this trip, the external heating loop was used to bring the temperature up to the desired temperature of about 120^{o}F prior to the test start. The heating loop was isolated during the test, but the immersion heaters were used in an attempt to maintain the desired test temperature. Alden Labs 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."

Test Setup and Filter Details

The test tank contained a single Performance Contracting Inc. (PCI) strainer module connected to an outlet plenum. The outlet plenum was connected to the suction header for the test loop pump. The strainer array was contained within the plywood walls that provide the channel representing the flow stream to the strainer. (See Photo 1.) The arrangement was intended to model flow to an average strainer module (with some conservatism) from the several modules that make up each STP sump strainer. STP has three redundant strainers with two required for operability. The strainers are located on the floor level in the bottom of containment.

The testing at Alden Labs is designed to take credit for near-field settlement of debris. The channel provides a flow stream evaluated as prototypical (with some conservatism). The evaluation of the flow stream was based on comparisons of computational fluid dynamics (CFD) analyses for the plant sump pool and the test flume. The majority of the debris is placed in the flow stream about 40 feet upstream of the strainer and allowed to transport to the strainer. A small amount of latent debris (about 25 percent) was added along the length of the channel. The flow velocity approaching the strainer at STP is quite high. In this case the flume velocity was about 0.5 ft/sec.

The strainer module was relatively typical of the PCI design which includes flow control to distribute flow more evenly among modules and within each module. The module was the same design as the modules installed at STP. Dimensions for the plant strainers were not provided to the staff. The screen area of the test strainer was provided after the test was completed. The area of the test module was 91.44 sq. ft.

The licensee had completed transport tests on February 11, 2008, the day prior to the arrival of NRC staff. Based on the results of the transport test, some material was excluded from the tests performed on the ensuing days.

Test Performance (Fiber Only)

The intention of the staff was to observe the full load test being conducted for STP. Due to scheduling issues the staff arrived in time to witness a fiber-only test on February 12, 2008. After the fiber-only test was completed, the licensee decided to add the particulate and chemical debris to gain information regarding the head loss response under the condition where the fiber bed is deposited on the strainer before the other debris arrives.

The test flow rate was set at about 353 gpm. The test temperature was about 120 ^{o}F. The fibrous debris was added with fines first, then small, then large pieces. The staff noted that the amount of fine fibrous debris was typical of the amount of fine debris used by most plants, in this case about 40 percent. This was in contrast to the very small amount of fine fibrous debris added during the test observed by the staff in January (about 5 percent). The fibrous debris was prepared by shredding. The fine debris was also heated as part of the preparation process. The fiber was segregated into fine, small, and large batches. The fine debris was placed in buckets, mixed with a drill-driven stirrer, then poured into the flume. As the debris was being poured into the flume it was agitated by hand. It was apparent that the fine fibrous debris had been prepared and introduced to much better represent fine fibrous debris than had been observed for the Callaway and Wolf Creek testing. The small and large fibrous debris were then added with the small pieces being added first. For the STP test, the fine fibrous debris used in the test was about 20 lbs. This included 11 lbs. of Thermal Wrap fines and nine lbs. of Nukon fines.

After all of the fibrous debris was added the head loss was about 0.35 ft and increasing slowly. There was about one-half inch of fibrous debris floating on the surface of the water. The floating debris was skimmed back to allow observation of the strainer. The strainer appeared to be completely covered by a fibrous debris bed. Most of the gaps between strainer disks were full or bridged. There appeared to be open caverns below some of the bridged gaps. The bed was fluffy. (See Photo 2.) There was about three inches of fiber on the floor covering the first half of the channel. About one and one-half hours after all the fiber had been added, the head loss was about 0.42 ft. The particulate debris was then added to the channel followed by the chemical precipitates.

The debris added to the testing consisted of Nukon and Thermal Wrap fibers, Micro-Therm insulation, walnut shell flour (coatings surrogate), tin powder (coatings surrogate), a dirt/dust mixture (latent dirt), and calcium silicate insulation (Cal-Sil) (representing Marinite board). All of the particulate debris was mixed with water in buckets or trash cans and poured into the flume. The particulate debris was added heterogeneously with one component added at time. All of the particulate debris was well mixed with the water and appeared to be relatively well suspended. After the particulate debris was added head loss was about 1.07 ft. This was about four hours into the test.

The chemical precipitates were added after the particulate debris. There were about 700 gallons of water with chemical precipitates in suspension added to a 1000-gallon flume. The test facility had a water management system to maintain the proper water level during debris additions. The water management system used an overflow standpipe that allowed excess water to be discharged through filters and sent to waste. The filters captured debris. The debris was washed from the filters back into the flume to prevent the loss of debris from the test.

The first chemical precipitates added were aluminum oxyhydroxide followed by calcium phosphate. The aluminum oxyhydroxide addition rate was increased part way through the addition. The increase in chemical addition rate resulted in an increase in the head loss rate of change. At the conclusion of the chemical additions head loss was about 1.9 ft. At this time the test was stopped.

As the debris was added to the flume, the fluid temperature decreased because the water added with the debris was relatively cold. The immersion heaters could not maintain the initial temperature.

The flume was then drained. There was about 12 inches of debris in the bottom of the flume which reduced toward the debris addition point. The debris bed on the strainer was a transitioning bed. Some of the gaps appeared to be filled with debris and some were partially filled. On the edges of the strainer the debris appeared to be a thin bed. Some of the gaps were packed with debris. The debris bed appeared to be relatively dense. (See Photos 3 and 4.) Test personnel felt that the strainer was probably not completely covered with debris. However, the staff observed essentially complete coverage of the portions of the bed that were viewable.

The STP chemical precipitate generation was conducted in accordance with WCAP-16530-NP. The plant-specific amount of chemical precipitate was determined with the chemical model spreadsheet contained in the WCAP. These precipitates were prepared in the Alden Lab using the directions provided in the WCAP. At the appropriate point in the test procedure, the chemical precipitates were transferred to the test loop, which was filled with potable water. It is estimated that approximately 700 gallons of precipitate suspension was generated for use during the test.

The precipitate settlement for this test was not within the WCAP specifications. For testing that credits near-field settlement, the one-hour settling criterion is that approximately nine ml remains cloudy in a 10-ml graduated tube. The one-hour settlement was about 7.5 ml for the aluminum oxyhydroxide. PCI inquired as to how best to move forward if a test were in progress and the WCAP settlement could not be attained. PCI was inclined to add additional precipitate to compensate for the difference in settlement. The staff observing the test contacted NRC Division of Component Integrity (DCI) staff to discuss the issue. PCI decided to introduce the precipitate closer to the strainer. The NRC staff indicated that the test evaluation should provide justification for the deviation and the compensatory measure. The staff will evaluate this justification during its review of the licensee's GL 2004-02 supplemental response. The following day the chemist determined that some of the chemical (aluminum nitrate) being used to create the precipitate had absorbed some moisture. The chemist mixed a new batch of chemical precipitate using care to avoid using the moist chemical. The settling property of the new batch was determined to be 8.9 ml.

<u>Test Performance (Full Load)</u>

The full load test is run to determine the head losses associated with the full debris load for STP. If the test ends with more than a thin bed, then a thin-bed test would be run to determine the head losses associated with reduced fibrous loading.

The test temperature was about 120 ^{o}F. Twenty-five percent of the latent fiber and dirt was added to the loop with the pump turned off. The pump was then started and the test flow rate was set at about 350 gpm. The full load of particulate debris was then added to the loop. The particulate debris was the same as was added during the fiber-only test described above. The flow was maintained with no further debris additions for five flume volume turnovers. After the five turnovers, the head loss was about 0.06 ft.

The fine fiber was added next. The staff noted that the first bucket added was not as well broken into fines as had been the case for the prior fiber-only test. The test personnel diluted future buckets to ensure prototypically fine fibrous debris was being added as fiber fines. Head loss increased sharply to 15.1 ft, and then abruptly leveled off. The differential pressure transmitter had exceeded its calibrated range. The test personnel changed to a different transmitter and found head loss across the bed to be about 28 ft. The test personnel decided that the flow rate had to be reduced because the pump was at its net positive suction head (NPSH) limit although no unusual noises were noted coming from the pump. The flow was reduced to about 120 gpm, and head loss decreased to about 11 ft.

The flume was slowly drained until the pump started sucking air (the strainer submergence at this point was about one inch or less). The pump was secured and the flume was drained completely to allow observation of the debris bed on the strainer. The debris bed appeared to be a chocolate coating over the strainer. It appeared to be a thin bed. In addition, some debris had settled onto the strainer during drain down. It is likely that the entire bed was a homogeneous brown coating before debris fell onto it during drain down. The bed felt like a very dense sponge that was relatively strong under compression, but easily broke apart in tension. Fibers were evident in the brown particulate. (See Photos 5 to 9.)

It should be noted that the high head loss was obtained with the addition of only the fine fibrous debris in addition to the particulate. The small and large fibrous debris had not been added, and the chemical debris had not been added. It is doubtful that the addition of the other fibrous debris would have contributed to additional head loss, but the chemical debris may have resulted in additional losses.

Test Results

The test results and physical observations are summarized as follows:

The clean strainer head loss was measured to be about 0.05 ft for the test strainer.

The flume velocity flow rate was noted to be quite high for STP. The average flume velocity was about 0.5 ft per second.

The head loss associated with the full debris load with fibers added first (debris added in the following order: fibrous fines, small fibers, large fibers, particulates, chemicals) was less than 2 ft. This test resulted in a transitioning bed with some gaps mostly filled with debris, some gaps partially filled, and a thin-bed on the edges of the strainer.

The head loss with a small amount of latent particulate and fiber added first, particulate debris added second, and fine fibrous debris added next resulted in a very large head loss of 28 ft. The debris bed appeared to be a thin bed.

A reduction of flow from about 350 gpm to 120 gpm resulted in a reduction of head loss to about 11 ft, indicating that no boreholes or channeling were present in the debris bed.

A reduction of strainer submergence down to about one inch did not result in any vortex formation. At less than one inch submergence, some air was pulled into the strainer. This was the 120 gpm flow rate.

Follow-Up Information Exchange with the Licensee and PCI

After the test, the staff discussed the results with the licensee and vendor personnel. The staff noted improvements in the debris preparation and introduction for the fine fibrous debris, particularly on the first day of observed testing. Because of the relatively high velocities in the STP flume, the debris preparation and introduction were found to be adequate. For plants with lower flume velocities, additional dilution and agitation of the fine fibrous debris may be necessary to achieve conservative transport and debris bed formation.

The staff noted that the computer used for data logging and observation during the test was performing a “percent change in 30-minute average head loss” calculation. The staff was concerned that this could be used for the termination criteria because it was apparent by observation that the calculation was not the change in 30 minutes, but a change over a much shorter time period. It was determined that the calculation was actually the change in the 30-minute average occurring over the last 10 seconds. The staff noted that this should not be used as the termination criteria and that it would be more appropriate to take two 30-minute average data points 30 minutes apart to obtain a percent change in the last 30 minutes. A shorter time period could also be calculated similarly.

PCI planned on using an exponential extrapolation methodology. This methodology was not well understood by the staff, and more information is required on the issue so that the staff can evaluate the methodology.

The staff noted that the debris bed created during the fiber-only test that had additional debris added following the fiber test (2/12/08) was thicker than a thin bed. The staff understood that this test was run for information only, without the typical debris introduction sequence. However, the staff noted that future tests showing similar loadings should be followed up with a separate thin-bed test.

The staff noted that the fibrous size distribution used for the STP tests was more typical of what the industry had been using, when contrasted with the very small amount of fibrous fines used for the Wolf Creek test during the previous staff visit.

The staff commented that for the near-field style test being used by PCI for the strainer testing, it was likely that more debris (in addition to latent debris) would be closer than the debris introduction area used during testing. This amount of debris at various locations would be a plant-specific determination, but it is likely that all plants would have some debris closer to the strainer than the introduction point. The staff felt that with the relatively high flume velocities in the STP test flume that the introduction of debris closer than the introduction zone was not necessary to ensure transport to the strainer.

It was noted that the staff was still awaiting information on the clean strainer head loss and fluid pH information from previous tests.

The staff noted that performing a flow sweep was a good practice. The flow reduction at the end of the test run on February 13, 2008 showed that there was little or no channeling or bore holes present.

Because of the high head losses experienced during the test run on February 13, 2008, PCI and Areva discussed the possibility of performing a test consisting of introducing the debris into an empty flume, filling the flume with water, then starting the recirculation pump. The staff did not make specific comments on this test method other than it was felt that it would be difficult to technically justify running a test in this manner.

The following information is based on e-mail and telephone correspondence:
On February 14, 2008, PCI and Areva ran a test for STP that added the debris to the flume, filled the flume with water, and then started the recirculation pump. The test resulted in a head loss of about 8.5 ft. The test temperature was about 50 ^{o}F, so the allowable head loss was relatively high at about 25 ft. According to PCI, the debris bed appeared to be a thin bed and was about one-fourth inch thick. The head loss was about 5.5 ft prior to adding the chemical precipitates. A flow sweep at the end of the test showed a linear relationship between flow and head loss indicating no bore holes were present.

A similar test was run on February 14, 2008 with fines reduced by about 35 percent. This test resulted in a lower head loss than the previous test. PCI intends to use the results of the February 14, 2008 test as the design basis for the strainer.

Several days later, the staff conducted a call with the STP licensee and PCI to discuss the procedure used for the qualification tests for the strainer. The following is a summary of the issues that were presented by the staff as potential non-conservatisms or non-prototypicalities for the test that placed debris in the flume, filled the flume, and then started the recirculation pump.

1) The high debris concentrations in the test flume may have resulted in excessive interactions between pieces of debris. These interactions could result in excessive agglomeration of debris or other non-prototypical debris behavior.

2) STP added 10 percent of the fine fibrous debris after the start of the test recirculation pump to account for the phenomena of long-term debris erosion and for debris washing down into the containment pool after the switchover to containment sump recirculation. The basis for the amount of debris being used for this purpose was not technically justified. The staff also noted that there are other potential phenomena that could add suspended fiber to the pool during pool fill up or recirculation and other potential sources of eroded debris.

3) The staff believes that several mechanisms that would add turbulence to a post-LOCA pool were not modeled adequately in the PCI test flume. For example, at STP, flow from inside the shield wall would enter the outer annulus through 30-inch openings that are 20 feet away from the strainers. As it passed through the openings, the flow would be at a relatively high velocity resulting in turbulence that would tend to suspend debris in the pool. In addition, filling the pool in the test took about one hour in contrast to about 20 minutes in the plant. The test flume did not model break or spray flows into the pool. All of these would add turbulence to the post-LOCA pool. Therefore, as compared to the test conditions, more of the finer debris may remain in suspension in the plant than was modeled in the test.

4) Debris transport calculations generally over-predict the transport of small and large pieces of debris relative to the transport of fines, based on the expectation that maximizing the quantity of debris reaching the strainer is conservative. For a head loss test that credits debris agglomeration, however, maximizing the quantity of debris sizes that would be expected to settle in the test flume would likely be non-conservative, since non-transportable debris tends to agglomerate with transportable debris and prevent it from reaching the strainers. Based upon the configuration of the STP containment (e.g., presence of 30-inch openings that are 18 inches off the floor through which flow passes to reach the strainer, and the presence of floor gratings between the break and pool), it is not clear that much of the small pieces and larger pieces of debris would realistically be able to approach the strainers. Thus, to ensure conservative or prototypical debris bed formation, the debris added to the flume should be carefully considered or additional tests run to determine the limiting case.

5) The sequencing of the debris addition to the test tank was discussed during the phone call. The licensee stated that discretely sequencing in different sizes and types of debris was not prototypical of the plant condition. Although the staff agreed that adding in the finest, most-transportable debris first is conservative and that some degree of debris interactions would occur in the plant, the staff stated that understanding the degree to which these interactions would occur to within a reasonable accuracy would be very challenging due to the chaotic nature of blowdown, washdown, and pool fill-up, and the sparse analysis and experimental results regarding these effects and their time scales in the existing knowledge base. Given the large uncertainties involved, the staff does not believe that a prototypical debris arrival sequence can be technically justified without incorporating conservatism to address these uncertainties.

The licensee and vendor stated throughout the call that the test that was run on February 14, 2008, was more prototypical of actual plant conditions than the tests run on the previous two days, and resulted in a prototypical head loss for STP. The licensee plans to use the results of this test for qualification of the strainer. The staff would be concerned with using the results of a test run in this manner to qualify a strainer unless the items above are satisfactorily addressed.

Observations

The staff considered the results of the two observed tests to be of significant interest. Three points illustrated by the tests are important in a generic sense. These are:

1) Two tests run with similar debris, but with the debris added in different sequences, resulted in major differences in head loss. The test run with fibrous debris added first (allowing the fiber bed to build) followed by particulate, then chemical debris, resulted in a head loss of less than two ft. The test run with the particulate added first followed by fibrous debris (only the fine fiber, with no chemical debris added before the head loss reached the limit of the test setup) resulted in a head loss of 28 ft.

2) A test run with fine fibrous debris and the full particulate load (particulate added to the test first) resulted in an extremely high head loss due to the formation of a thin bed. The staff had been concerned that this could be an issue if vendors performed tests with prototypically fine fiber, but had not witnessed a similar strainer module test result in such a high head loss the past. The staff believes in general that vendors may be testing with a generic fibrous debris mixture which may not be prototypical of the fibrous debris that could arrive at the sump strainers during a LOCA and may not result in prototypical or conservative head loss results.

3) The test that resulted in the very high head loss allowed near-field settling and did not use agitation to force debris onto the strainer. This test may have been more prototypical than tests that use agitation because larger debris is not forced onto the strainer. Finer debris generally results in higher head losses. Note that there were other aspects of this test that may have resulted in an overly conservative head loss. However, the use of prototypically fine fiber transporting to the strainer without forced agitation is likely to result in higher head losses than would a test with larger fiber forced onto the strainer.

Summary

In summary, the staff observed chemical effects testing conducted for STP by PCI and Areva at the Alden Research Laboratory. Simulated plant debris in the test observed by the staff were representative of a break location that produced a limiting fiber bed and particulate loading expected following a LOCA. The attempt to complete a full-load test with the predicted debris load resulted in a significantly high head loss. The testing confirmed that fine fibrous debris combined with particulate debris can produce a thin bed resulting in a high pressure drop across a sump strainer. The staff will continue to engage various licensees and vendors as sump strainer testing progresses. The staff expects these tests will provide a better understanding of plant-specific chemical effects.

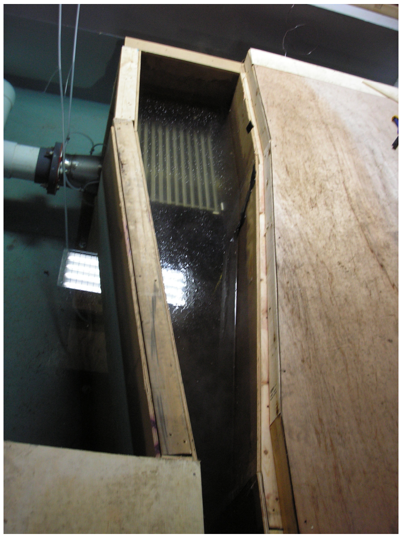

Photo 1

Photo 2

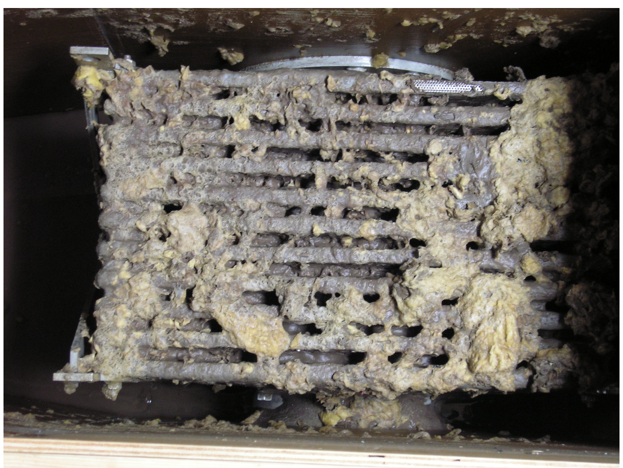

Photo 3

Photo 4

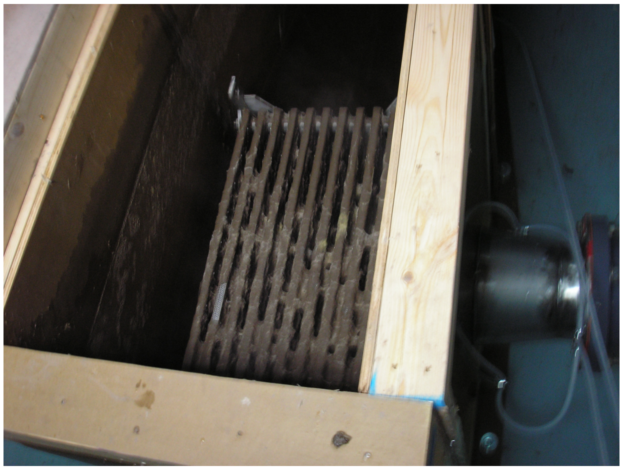

Photo 5

Photo 6

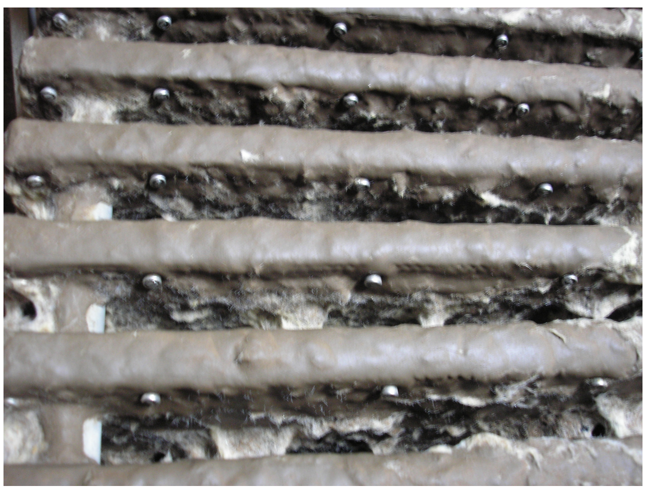

Photo 7

Photo 8

Photo 9