July 16, 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

Matthew G. Yoder, Chemical Engineer /RA/
Steam Generator Integrity and Chemical Engineering Branch
Division of Component Integrity
Office of Nuclear Reactor Regulation

SUBJECT: FOREIGN TRAVEL TRIP REPORT— NRC STAFF VISIT TO WINTERTHUR, SWITZERLAND, TO OBSERVE SUMP STRAINER TESTING PERFORMED BY CONTROL COMPONENTS, INCORPORATED – DETAILED TECHNICAL DESCRIPTION

Two Nuclear Regulatory Commission (NRC) staff members traveled to Winterthur, Switzerland, on April 20–25, 2008, to observe containment sump strainer testing performed by Control Components, Incorporated (CCI), and to discuss technical issues associated with sump strainer testing and qualification associated with Generic Safety Issue (GSI) 191. During the trip, the staff observed testing for two nuclear plants that demonstrated CCI's current testing capabilities and practices. Testing observed included integrated chemical effects head loss tests for Salem Generating Station and Palo Verde Nuclear Generating Station. In addition to witnessing the tests, the staff conducted detailed discussions with CCI representatives on technical issues associated with chemical affects, and current and previous head loss testing and analysis performed for U.S. PWRs. The participating staff members were Matthew Yoder and Stephen Smith.

The enclosure summarizes the staff's visit on April 20-25, 2008. Members of the staff previously visited the CCI test facility on September 17-22, 2006 (ML070170235).

Enclosure:
As stated

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Trip Report

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Observations of Testing at Control Components Incorporated
April 20 through 25, 2008

Trip Overview/Description of Facility

Control Components Incorporated (CCI) is one of five vendors supplying strainers to US pressurized water reactors (PWRs) in response to Generic Safety Issue (GSI) 191. The staff has been visiting the various vendors and test facilities involved in this issue to provide assurance that strainer testing is being conducted prototypically or conservatively.

This trip was made for the following reasons:

1) Support the staff's GSI-191 audit for Salem. During the Salem audit, the staff had raised questions regarding the test methods used at CCI for the Salem strainer tests.

2) Observe the execution of CCI's integrated chemical effects testing procedures to determine whether these procedures are prototypical or conservative with respect to head losses that could occur in an actual PWR sump. Since a number of pressurized-water reactor licensees have performed or will perform similar testing at the CCI facilities, this further supports the staff's review of these plants' supplemental responses to Generic Letter 2004-02.

3) Provide an opportunity for the staff to discuss the CCI chemical injection method. The staff has raised questions about the chemical effects methodology used by CCI for testing of several plants. Recent CCI tests use a method that the staff has found to be generally acceptable as documented herein, but previous tests were conducted using a CCI-specific procedure with which the staff has had concerns.

The CCI facility in Winterthur, Switzerland consists of a large office complex and a separate test facility. The staff concentrated its time at the test facility because direct observation of the testing practices and results was considered to be the best method for judging the testing practices.

The test facility contains two test setups termed multifunctional test loops by CCI. CCI's current test practice is to use the multifunctional test loop to model a portion of the subject plant's strainer. Each loop is made up of a test flume that can be adjusted in length, a pump, interconnecting piping, and instrumentation required to monitor various parameters during the test. A photograph of the test loop is shown in Figure 1. Figure 1 represents the typical test setup and the one that was used for the Palo Verde testing observed by the staff, except that for Palo Verde, the bottom row of pockets was blocked off to more closely represent the plant installation. Figure 2 depicts the loop as it was modified for the Salem testing.

The multifunctional test loop is a closed recirculation loop attached to an open-top Plexiglass channel. The water recirculation in the loop is realized by means of a centrifugal pump measured with a flow meter that has a capacity of up to 200 m^3/h. In general, the tests are performed with water in the loop between 10 and 30°C based on the potable water initial temperature and ambient temperatures. The flow rate is adjustable by adjusting the frequency of the pump motor, thus controlling pump rotational speed. Additionally the flow rate can be pre-adjusted by means of a valve in downstream of the pump. The water flow rate is measured using a magnetic inductive flow meter. The head loss across the strainer is measured by

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means of a differential pressure transducer. The temperature of the water is measured using a Type K thermocouple. All instrumentation is certified by a qualified laboratory according to accepted standards with Swiss Calibration Service Certificates.

A CCI strainer segment with a geometry representing the subject plant is placed in the Plexiglas channel before the loop is filled with water. The pockets match the dimensions of the subject plant pockets. In general, the pockets for CCI strainers installed in US PWRs are similar except that some are deeper than others. The height of the bottom-row test pockets above the floor is adjusted to correspond to the subject plant. The side plates are made of solid steel, while the bottom and top plates are either solid or perforated as in the actual installation.

Testing usually begins with the module at a minimum submergence of about 1 cm. After adding the prepared debris the water level increases. The water is then adjusted as necessary to ensure no more than a submergence level matching that of the minimum strainer submergence in the plant. When adjusting water level, the water is let down through a fine filter, and any debris captured by the filter is returned to the test loop. Water samples can be taken downstream of the test module.

Test Observations

Portions of three tests were observed by the staff during the visit. A Salem integrated chemical effects test had been started the previous week. For this test all non-chemical debris had been added prior to the arrival of the staff. The chemical precipitates were added soon after the arrival of the staff. The test continued for the duration of the staff's visit. A Palo Verde integrated chemical effects test was also in progress. At the time that the staff arrived, all debris, including chemical precipitates, had been added to the test flume for the first test. The most informative part of the first Palo Verde test was the disassembly of the test rig and observations of the debris bed that had formed on the strainer. A second Palo Verde test was started later in the week. During Palo Verde's second test, the staff was able to observe the CCI practices for debris preparation and introduction. These are key determinants of whether test methods will produce prototypical or conservative results. Observations for each test are recorded below.

Salem Test

The Salem test was started on April 15, 2008. The test was a full load test for Salem Unit 1. Previous testing had determined that the greatest challenge to the Salem strainer was a full debris load (vs. a thin bed). The last batch of non-chemical debris had been added to the test flume on April 19, 2008. When the staff arrived on April 21, 2008, the test fluid was clear indicating a high degree of filtering of particulate debris. CCI personnel were preparing to add chemical precipitates to the flume.

The Salem strainers have surface areas of approximately 4850 ft^2 for Unit 1 and 4650 ft^2 for Unit 2. For scaling for the tests, 500 ft^2 is subtracted from the total installed strainer area to account for miscellaneous debris that could accumulate on the strainer during a loss of coolant accident (LOCA). The Salem testing matrix included tests at scaled flow rates for two Residual Heat Removal (RHR) pumps and a single RHR pump taking suction from the sump. At Salem, only the RHR pumps take direct suction from the sump. Depending upon the strainer head loss determined through testing, Salem will determine whether a single pump or double pump flow rate will result in the limiting net positive suction head (NPSH) margin. The flow rates for Unit 1 are 9000 and 5110 gpm and for Unit 2 are 9000 and 4980 gpm. The test flow rates were scaled from these numbers. Debris scaling for the Salem test was based on the limiting amount of debris expected to transport to the strainer. The Salem containments contain a relatively large amount of fibrous insulation as well of significant amounts of Kaowool and some Min-K. Salem Unit 2 has a lower fibrous load, but significantly more Min-K, than does Unit 1. The full load theoretical bed thickness for the Unit 1 test was about 0.90 inches and for Unit 2 was about 0.34 inches. Min-K has been shown to lead to high head losses during some tests. The staff witnessed only testing for Unit 1.

The test flume for this test was configured to model the installation of the Salem strainer. The test included a front and rear side of the strainer and a debris interceptor in front of the front side of the strainer. See Figure 2 which represents the test setup. The debris interceptor is not shown. It is placed several inches upstream of the front face of the strainer. In addition, the figure shows a plate installed between the return header and the strainer for the purpose of adding turbulence to the flume thus allowing complete transport of debris. This plate was not used in the testing observed by the staff. The bottom of the strainer was about three inches off the floor of the flume and there was a perforated plate across this bottom annulus at the rear side of the strainer.

CCI personnel described the initial parts of the test that had occurred prior to the staff's arrival. CCI stated that the fibrous debris added to the test flume had been prepared very finely, was introduced as far as possible from the strainer (about two meters), and was diluted when added to the flume. The fibrous and particulate debris was maintained in separate containers and added to the flume in alternate batches resulting in a relatively homogeneous addition. According to CCI personnel, the addition of fibrous debris resulted in clouding the water, indicating that it was prepared relatively finely. After all of the debris was added some small amount settled and was agitated to resuspend it and allow it to transport to the strainer. The staff observed that the head loss was 141 mbar with a flow rate of 28.5 m^3/h and a fluid temperature of 27^o C. The head loss had been relatively stable for about 3.5 days.

The staff observed the final mixing of the chemical precipitates. The precipitates were prepared per WCAP-16530 methodology. The pH of the sodium aluminum silicate (NaAlSi) was 10.2 prior to addition to the loop. The one-hour settlement properties of the precipitates were measured. The NaAlSi had a one-hour settled volume of 8.7 ml. This is slightly lower than the WCAP requirement for tests that allow near-field settling. 86 liters of chemical precipitate solution had been prepared and were added to the flume over a period of about 15 minutes. When the precipitate was added to the flume, a large fluffy bed of debris that had collected between the debris interceptor and front of the strainer was compressed significantly. See Figures 3 and 4.

Within about 5 minutes of adding the batch of precipitates, head loss increased to about 175 mbar (from the initial value of 141 mbar). Some chemical debris was observed to settle out in front of the debris interceptor. This debris was agitated with a drill driven propeller to resuspend it and allow it to transport to the strainer. After the agitation head loss increased to about 190 mbar. Some precipitate settlement also occurred on the rear side of the strainer. Salem personnel determined that this was prototypical of the plant and decided not to agitate this area of the flume. Although the decision seemed reasonable, the staff noted that Salem and CCI should justify that the settlement is prototypical of the plant, including both flow and debris settlement characteristics.

The loop was run overnight, and a second batch of NaAlSi was added to the flume at about 1130 on April 22, 2008. Prior to this addition head loss was about 195 mbar and the fluid had cleared somewhat, but not completely. The staff noted that there was a flow path tunneling under the strainer with flow appearing to go from the front to the rear of the strainer. The flow tunnel originated on the sides at the front of the strainer and exited more centrally at the rear of the strainer. See Figure 7. The staff noted that CCI and Salem would have to ensure that there was no significant amount of non-prototypical bypass of the strainer via this flow path. At about 1130, the second batch of NaAlSi was added to the flume. Following the addition of the precipitate head loss decreased to about 160 mbar. The head loss then slowly increased to about 170 mbar. At about 1605 the third and final batch of NaAlSi was added to the flume. Following this addition, head loss decreased to about 158 mbar.

The test was again allowed to run overnight. Head loss had increased to about 168 mbar by 0800 on April 23, 2008. At about 1100 a single batch of aluminum oxyhydroxide (AlOH) was added to the flume. There were no noticeable changes in head loss following this chemical precipitate addition. Head loss slowly increased to about 172 mbar by 1400.

After the chemical additions, the staff also noted that the debris bed on the rear face of the strainer which resulted in a relatively uniform and flat coverage of the pockets collapsed inward to conform to each pocket. See Figures 5 and 6. Because the test fluid was quite cloudy it was difficult to closely observe this phenomenon. It is likely that the pockets were full of a relatively low density debris mixture that was compressed by the flow after the chemical precipitates made the bed less porous. The collapse of the bed into the pockets would have increased the flow area the fluid passed through and may have been the cause for the reduced head loss during the chemical additions.

The staff reviewed the thin bed test procedure and agreed that the procedure, including debris introduction sequence, was appropriate to determine whether a thin bed or full debris load would be more challenging to the strainer. Results of the thin bed testing were not provided to the staff for review.

Palo Verde Test 1

The first Palo Verde test had started on April 14, 2008. All of the non-chemical debris was added on the first day of the test. The chemical debris was added on April 18 through April 19, 2008. On April 21, 2008, when the staff arrived at the test facility, the head loss was about 88 mbar at a flow rate of 46.5 m^3/h. The test fluid was cloudy although the final chemical precipitates had been added 2 days earlier. The cloudiness indicated that there was insufficient fiber to remove further particulate, or that there were significant areas where flow was bypassing the fiber bed due to a non-uniform debris distribution.

According to the test procedure and conversations with Palo Verde personnel, the fibrous debris added to the flume was 60% fine and 40% small pieces. The Palo Verde test engineer stated that the debris loading combined the worst-case fiber loading with the worst-case particulate loading from the limiting loop break. Subsequent to the development of the fibrous debris amounts for testing, some fibrous insulation was removed from the D-rings in the Palo Verde units. The test was therefore conducted with a conservative amount of fibrous debris.

Palo Verde has two sumps for each unit. There is one sump per each Emergency Core Cooling System (ECCS) train. Therefore, the strainers and sumps are fully redundant. Each strainer is greater than 3100 ft^2 in surface area. For scaling purposes, 400 ft^2 is subtracted from each strainer area to account for the accumulation of miscellaneous debris. The test was run based on a scaled flow rate assuming all pumps (Low Pressure Safety Injection (LPSI), High Pressure Safety Injection (HPSI), and Containment Spray (CS)) were operating at runout flow (11,600 gpm). It is likely that within one hour, the flow rate would be reduced to 6600 gpm or less (CS and HPSI). The test was started at a flow rate scaled to the two-pump flow. In order to determine the effects of the higher flow rate associated with all three pumps operating, the flow rate was increased to a scaled 11600 gpm two days after all chemical precipitates had been added. The head loss increased from about 40 mbar to about 88 mbar. Because Palo Verde has such a low fibrous debris load it was determined that separate thin bed testing was not required. The testing was conducted with a full load of debris, which for the case of Palo Verde also accomplished the thin bed test. The staff reviewed this decision and found it to be acceptable. However, it was noted by the staff that for plants with fibrous loads that result in theoretical beds thicker than Palo Verde (about 1/10 inch) that a thin bed test should be performed in addition to, or as part of the full load test, or justification be provided for not performing a thin bed test. The Palo Verde debris consisted of Nukon and Thermolag insulation as fibers and various coatings and dirt as particulates. The Thermolag, although termed fibrous, remained largely in chunks. The Thermolag debris was cut into small pieces and jet blasted with a hydrolaser to break it down into smaller particles. However, it remained largely undamaged and stayed in chunk form. Palo Verde also had epoxy coatings crushed and sieved to a nominal size of 13 microns. Based on the effort required to grind the epoxy to the required size, the Palo Verde test engineer believes that most epoxy coatings will not degrade into such small particles during a LOCA. The staff agreed that his assessment is probably correct.

CCI and Palo Verde personnel stated that they had observed some clean strainer area prior to the addition of the chemical debris by using an underwater camera. The fibrous and particulate debris had already been added, but the particulate had filtered such that the water was relatively clean so that observation of the strainer surface was possible.

When the staff arrived on April 21, 2008, the Palo Verde test was running at the scaled three-pump flow rate of 46.5 m^3/h and a head loss of 88 mbar. The flow rate was reduced to 26.4 m^3/h on April 22, 2008 to model the two-pump flow rate. When the flow was reduced, head loss decreased to about 35 mbar. The pump was stopped to release any entrained air and then restarted. A few small air bubbles were observed when the pump was stopped. The head loss returned to 35 mbar following this evolution. The loop was drained slowly with the pump still running. No vortexing was observed during this evolution. However, once the perforated area of the strainer was exposed to air, small bubbles started returning to the flume through the return header. After the strainer was exposed to air, the head loss appeared to increase. It was later determined that this was due to the liquid level behind the strainer decreasing, thus increasing the measured differential pressure. Once the level was about ½ inch below the top of the top pocket, the pump flow rate began to decline and the pump was secured. According to the Palo Verde test engineer, with a clean strainer, about one foot of the strainer could be exposed without any air entrainment. When the pump was stopped, the level in the flume decreased by about 3 inches. This was due to the water levels behind and in front of the strainer equalizing.

After the flume was drained it was inspected. There was very little settlement of debris on the bottom of the flume. There was some small amount of debris piled against the bottom of the strainer. Inspection of the strainer revealed that some of the debris had fallen off the tops and sides of the pockets when the flume was drained. Some pockets' debris appeared to be undisturbed. Some of these pockets had small open strainer areas on the top surfaces. It was evident that debris accumulated preferentially on the bottom surface of the pockets. See Figures 8 through 10 for post-test photos of the strainer.

<u>Palo Verde Test 2</u>

The test flume was cleaned and refilled for a repeat of the Palo Verde full-load test. During this process, the staff observed that the pump was run with the top two rows of pockets exposed above the water level with no visual signs of air entrainment in the pump. On April 23, 2008, CCI prepared the debris for introduction into the flume. Prior to debris introduction, the clean strainer head loss was 0.8 mbar at 26 m^3/h and 13.8^o C.

The particulate and fibrous debris were maintained in separate containers during the preparation and addition processes. The fibrous and particulate debris were both mixed with water. The fibrous debris had previously been shredded. The fibrous debris was then further broken apart using a hydrolaser. The ultimate fiber condition was well broken up and well diluted. Most of the fibers appeared to be individual fibers, but there were a few small clumps. The debris was added to the flume at about 0900 by alternating relatively small amounts of particulate and fibrous debris resulting in a homogeneous type addition. The debris was added at the end of the flume distant from the strainer. The fibrous debris transported easily to the strainer. Most of the particulate debris transported to the strainer. The particulate that did not transport was agitated with a drill-driven propeller to resuspend it. Some chunks of thermolag floated for a while before sinking to a pocket or the bottom of the flume. There was also some floating foamy debris on the surface of the water. By 1400, the head loss was about 20 mbar with a flow rate of 26 m^3/h and a temperature of 15.8^o C. At this time the water was somewhat cloudy due to the particulate that was in suspension. Later the water cleared up somewhat, indicating that the particulate had filtered out. Pictures taken after the water cleared indicated that there was some open strainer area.

On the following day (April 24, 2008), the head loss had increased to about 30 mbar at the same flow rate and temperature. This indicated that more particulate had filtered out or the bed had shifted or changed morphology to increase head loss. The reason was not apparent to the staff, but the water was very clear by this time. Figure 11 is an underwater picture showing that some pockets did not have complete coverage as the top pocket surfaces were not fully covered. The chemicals had not been added to the test at this point. The chemical precipitates for this test were added after the staff departed from the test lab.

Additional Discussions with CCI and Licensees

Prior to departing from the test site the NRC staff members held an exit call with individuals from CCI, Palo Verde, Salem, and Calvert Cliffs. During the exit meeting, the staff emphasized the following points:

- For thin bed testing, the concept that must be put into practice is to include a full particulate load with limited fiber. The amounts of fiber should be varied to attempt to find whether a thin filtering bed will result. It was clear that the CCI protocol covered this issue properly.
- The staff understood that CCI had produced a paper that provides justification that the CCI chemical injection methodology is conservative with respect to the WCAP-16530 methodology. The staff requested a copy of the paper.
- The staff noted that the Salem test setup should be inspected upon disassembly to ensure that non-prototypical bypass of the debris bed was not occurring.
- The staff also noted that for the Salem test (and others that credit debris settling) the flow characteristics in the test loop should be shown to be prototypical or conservative with respect to actual plant conditions. In addition, the settlement properties of the surrogate debris, including chemical precipitates, should be prototypical or conservative with respect to plant debris, including meeting the applicable WCAP-16530 settlement requirements.
- The staff noted that the debris preparation and introduction techniques used by CCI during the testing observed by the staff on this trip appeared to result in conservative or prototypical transport of the debris to the strainer. It was noted that the fibrous debris was easily suspendable and diluted such that agglomeration did not occur and transport was enhanced.

- The staff expressed appreciation to CCI, Palo Verde, and Salem for allowing the opportunity to witness the tests.

Key Observations

- The staff had questions concerning the preparation of fibrous debris and its introduction, and the prototypicality of the flow within the test flume. These factors can have a large effect on the head losses that result during testing. Based on observations during one of the PVNGS tests, the staff found that the debris was being prepared and introduced in a manner that would result in prototypical debris bed formation. This test was the only instance during this trip in which the staff was able to observe debris preparation and introduction. During observations of the PVNGS test and the introduction of chemical debris into the Salem test, the staff determined that the flow patterns in the test flume would likely result in prototypical debris bed formation.

- The staff observed integrated testing that included fibrous, particulate, and chemical debris. The chemical debris was prepared using the guidance from Westinghouse WCAP-16530-NP, Revision 0, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191.” The WCAP methodology has been reviewed by the staff, and a safety evaluation has been written providing the staff’s acceptance of the methodology including conditions and limitations on its use. Some previous integrated chemical effects head loss testing at CCI had been conducted using a CCI-specific procedure for generation of the chemical debris. The staff has requested information from CCI to show that the CCI procedure resulted in conservative or prototypical chemical effects head losses during testing. Based on conversations during the visit, CCI committed to provide an evaluation of their procedure with the intent of showing its conservatism or prototypicality. After the staff members returned to headquarters, CCI provided an evaluation to this effect. The staff review of the evaluation is not complete. The evaluation is important to the staff review of several licensees’ Generic Letter 2004-02 responses because their strainer testing was performed using the CCI methodology.

- During observations of the Salem integrated chemical effects head loss testing, the staff verified that CCI was generally implementing the WCAP-16530-NP methodology satisfactorily.

- During observations of the PVNGS testing, the staff observed that the test strainer had some areas where debris had not collected. Although head loss across the strainer increased due to the debris load, it was limited, likely by the small portions of open strainer. When the test flume was drained and the strainer and debris bed observed, it was apparent that the debris accumulated preferentially toward the upward facing horizontal surfaces of the strainer. This provides some indication that complex geometry strainers can provide advantages when compared to flat type strainers. However, the positive aspects observed during this testing cannot be applied to all situations. The prototypical flow patterns and debris loading can have a large impact on head loss. For example, the Salem test conducted on a similar type of strainer resulted in significantly higher head losses. The higher head losses were due, at least in part, to higher debris loading which completely covered the strainer surfaces.

- Fibrous debris that is prepared finely readily transports to the strainer under prototypical conditions for most plants. For the Salem and PVNGS tests, the debris required little agitation to ensure that it transported. However, CCNPP started testing the week after the staff left the facility and has a significantly lower velocity approaching the strainer. The staff was contacted by CCNPP engineering staff who stated that significant settling was occurring in the test flume. This was likely due to the lower flow velocities expected at CCNPP. CCNPP will be expected to provide details of how the settling issue was addressed or evaluated to ensure that the test results are prototypical or conservative as part of its Generic Letter 2004-02 closeout.

- The staff provided several observations to CCI regarding aspects of the observed testing. Licensees using CCI testing will be expected to provide analysis and justification for any significant settlement of chemical or non-chemical debris in the test flumes. In addition, licensees using CCI testing will be expected to provide assurance that the test fluid is not able to bypass the debris bed in a manner that would not be prototypical of a plant configuration.

Summary

The staff was successful in fulfilling the essential trip missions, as follows:

1) The staff attained additional information regarding the testing used to evaluate the performance of Salem's strainer. This information is directly applicable to the questions raised during the Salem GSI-191 audit. The staff's observation of the Salem test in conjunction with the PVNGS testing provided adequate information for the staff to determine that the Salem head loss testing is generally being conducted prototypically or conservatively.

2) The staff attained additional knowledge and insights as to how CCI performs integrated chemical effects head loss and vortex testing. The staff's observation of PVNGS and Salem testing provided adequate information such that the staff believes that the test methods currently employed by CCI are generally prototypical or conservative. This information will be used during the staff review of licensee supplemental responses to Generic Letter 2004-02.

3) The staff gained additional information regarding the CCI chemical test methodology. In addition to the information gained verbally during the trip, the staff received a commitment from CCI to provide a paper that describes the previously used CCI-specific methodology with justification as to why it results in conservative or prototypical head losses during testing. The CCI paper was provided to the staff after returning from the trip and is still under review.

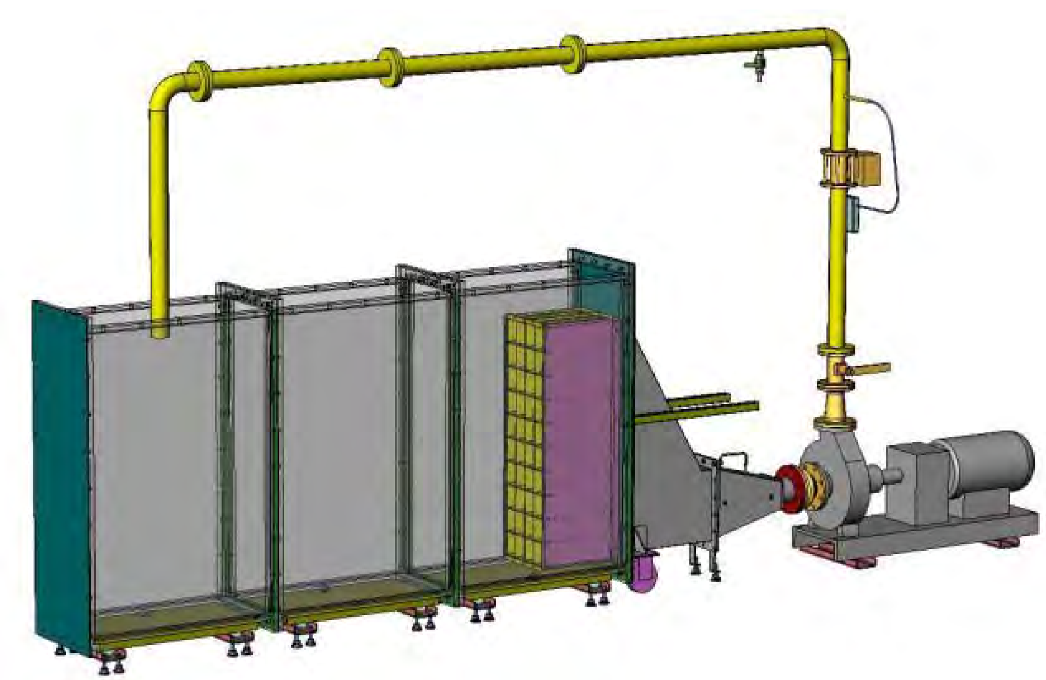

Figure 1 - Typical CCI Test Loop (Palo Verde)

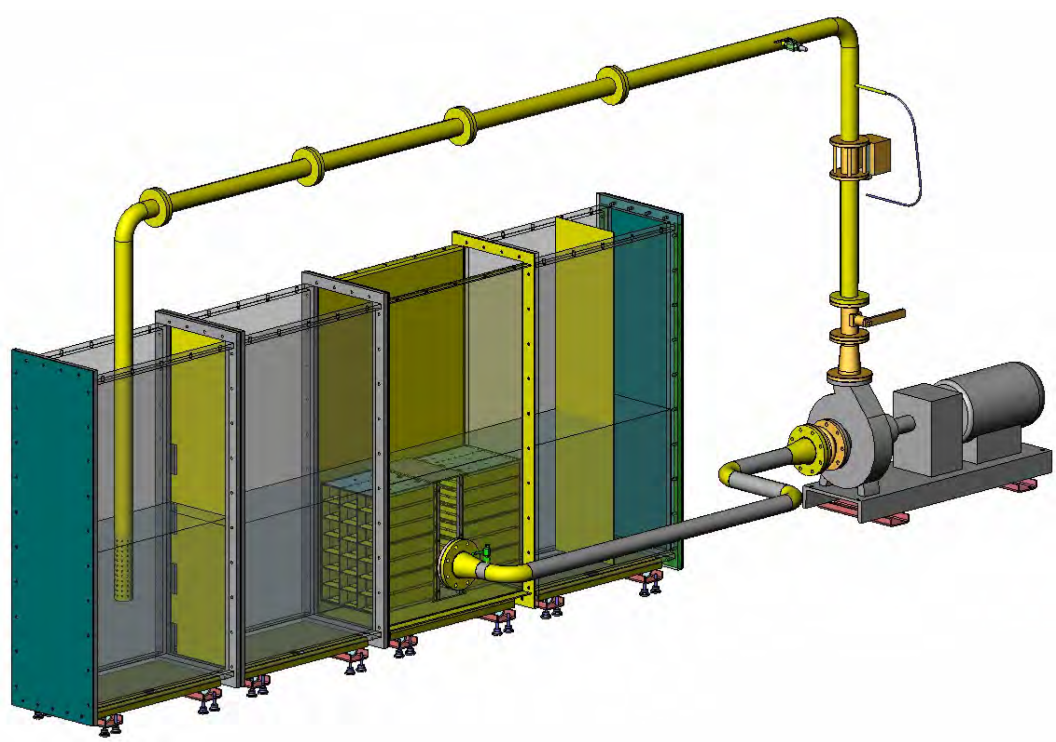

Figure 2 - CCI Test Loop for Salem

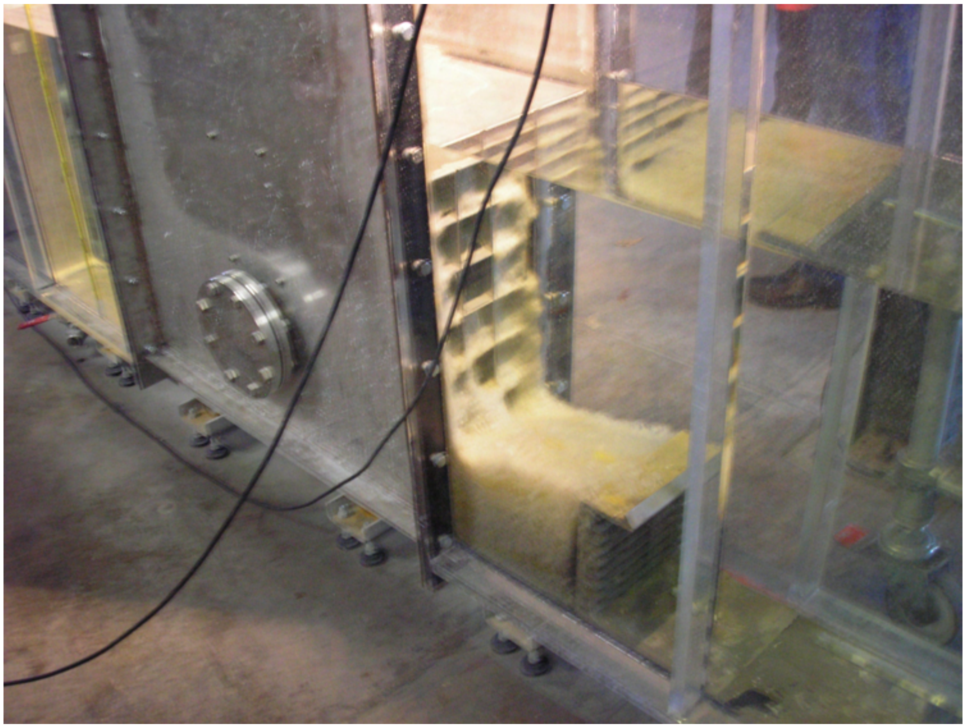

Figure 3 - Fluffy Bed, Prior to Chemical Addition

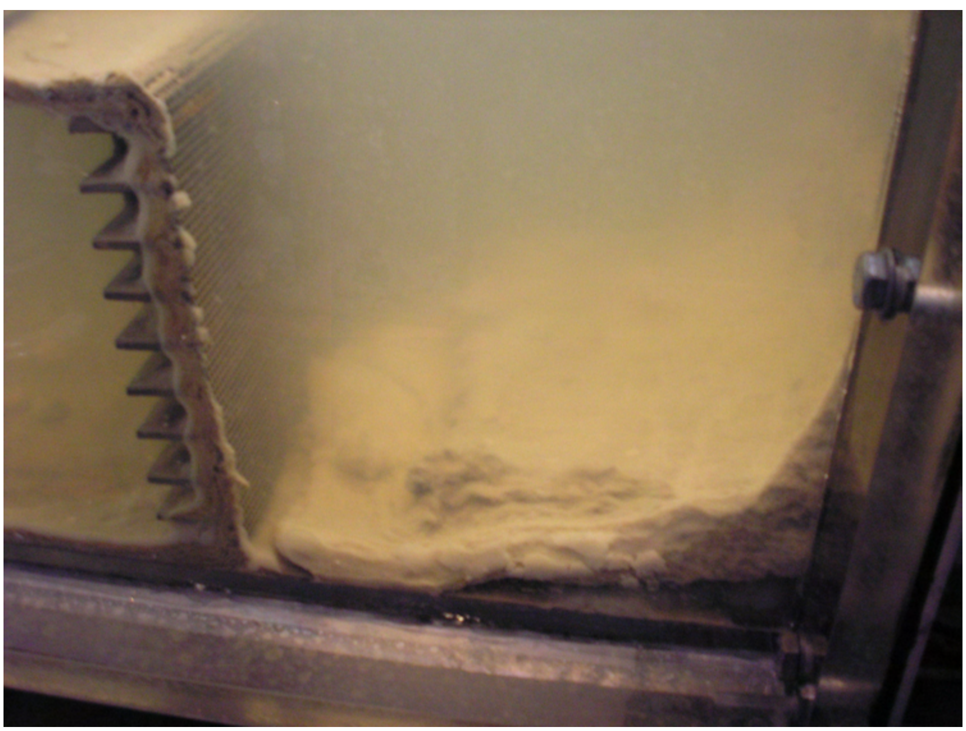

Figure 4 - Fluffy Bed Compressed Following Chemical Addition

Figure 5 - Flat Bed-Salem

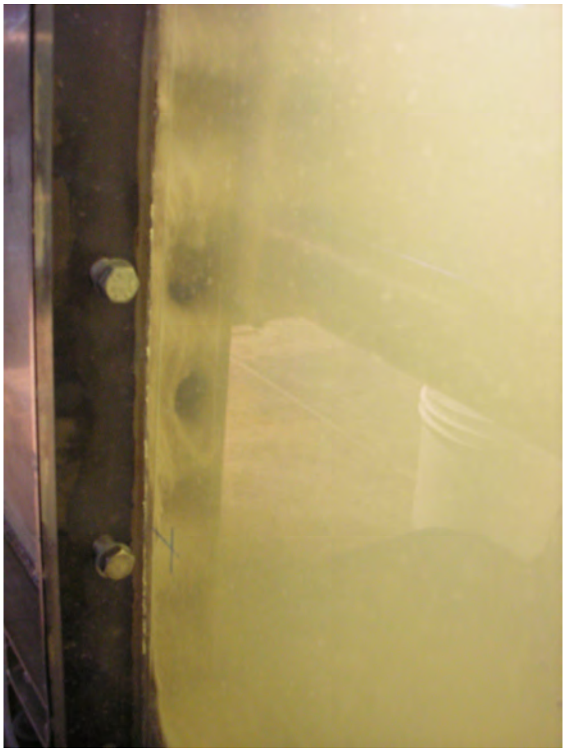

Figure 6 - Bed Collapse into Pockets-Salem

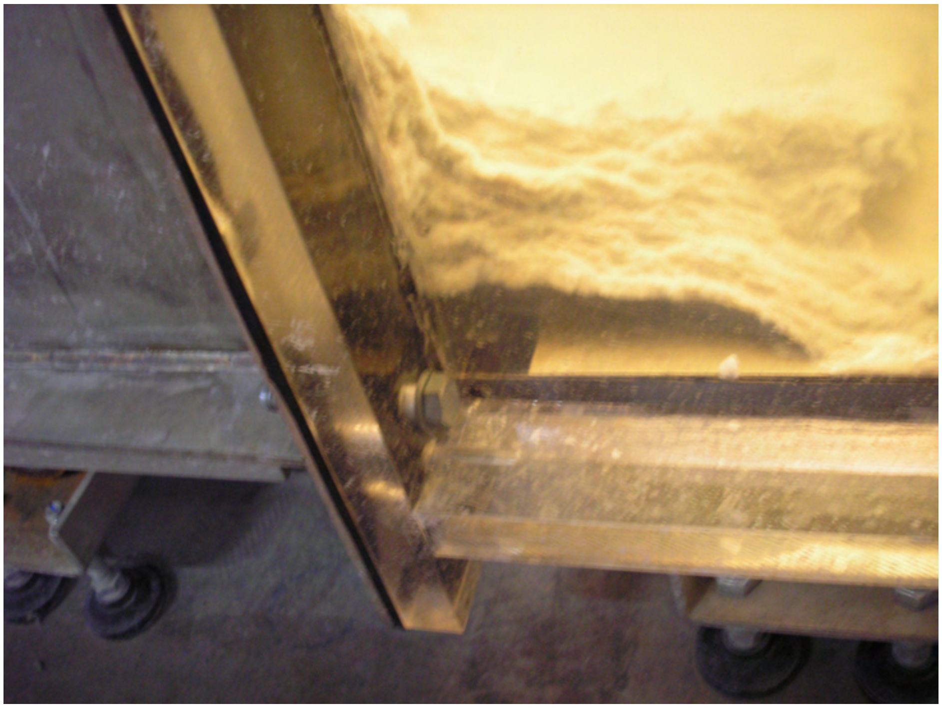

Figure 7 – Upstream View of Apparent Flow Path Under Debris Bed-Salem

Figure 8 - Palo Verde Post Test-Water Drained

Figure 9 - Palo Verde Post Test

Figure 10 - Palo Verde Post Test

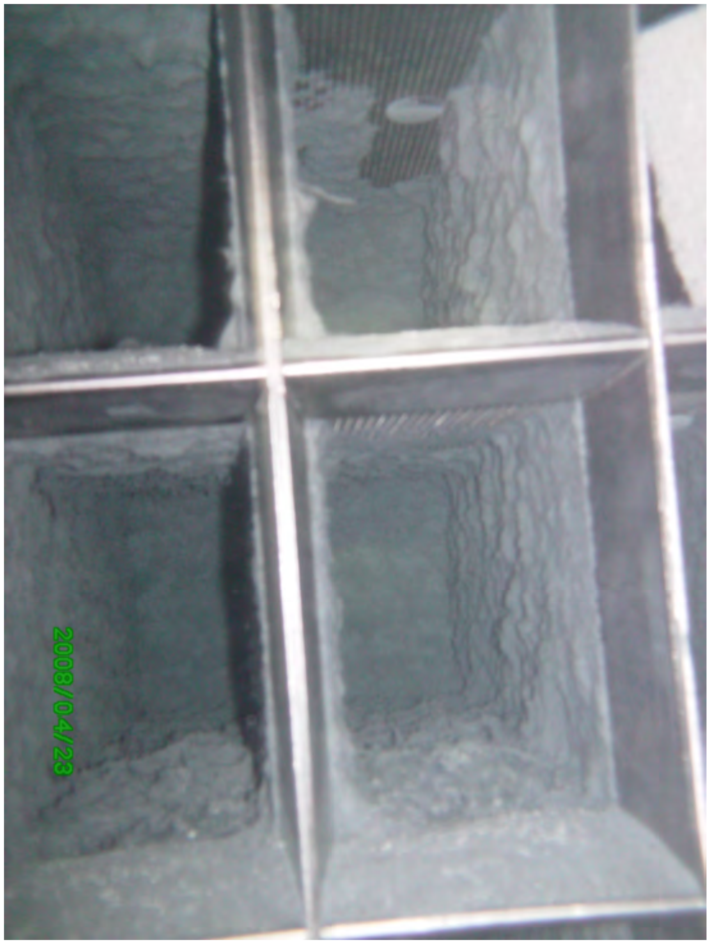

Figure 11 - Palo Verde Under Water-Pre-Chemical Addition-Open Strainer Apparent