From:	Singal, Balwant
To:	Kee, Ernie
Cc:	Bailey, Stewart; Smith, Stephen
Subject:	RE: Public Meeting for ECCS Debris Screen Penetration Testing Plan
Date:	Thursday, August 30, 2012 3:45:00 PM
Attachments:	Preliminary NRC Staff Comments.docx ALION-PLN-STPNOC-8511-01 (Rev 0C).pdf

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Ernie:

Attached are the copies of the following documents:

- ALION Document No. ALION-PLN-STPNOC-8511-01, Revision 0C (Provided to U.S. Nuclear Regulatory Commission (NRC) Staff by STP Nuclear Operating Company
on August 15, 2012)

- Preliminary NRC Staff Comments

Please note that these comments are as a result of preliminary review by the NRC staff and there may be additional comments once a detailed review is performed. However, it is suggested that any future discussions on this topic be conducted only in a noticed public meeting.

Thanks.

Balwant K. Singal
Senior Project Manager (Comanche Peak and STP)
Nuclear Regulatory Commission
Division of Operating Reactor Licensing
Balwant.Singal@nrc.gov
Tel: (301) 415-3016
Fax: (301) 415-1222

From: Kee, Ernie [mailto:keeej@STPEGS.COM]
Sent: Wednesday, August 15, 2012 5:45 PM
To: Singal, Balwant
Cc: Blossom, Steven; Paul, Jamie; Grantom, Carl; Schulz, Deborah
Subject: Public Meeting for ECCS Debris Screen Penetration Testing Plan

Balwant,

Please find attached the proposed test plan for ECCS screen debris bypass (which we refer to as screen penetration to avoid confusion with the term core bypass).

We would like to start this testing in early September (possibly the first week) and would appreciate a Public Meeting to review the plan with the Staff as soon as possible. We presented a DRAFT protocol plan in a Public Meeting in March this year but the attached document has more detail and finalized test design.

Ernie Kee
979.479.2312

South Texas Project (STP) CFD Data Analysis Report
Document No. ALION-PLN-STPNOC-8511-01, Revision 0C
(Bypass Test Protocol)
U.S. Nuclear Regulatory Commission (NRC) Staff Comments

STP Nuclear Operating Company (STPNOC) provided the South Texas Project (STP) CFD Data Analysis Report, Document No. ALION-PLN-STPNOC-8511-01, Revision 0C [Bypass Test Protocol] (copy attached) by e-mail dated August 15, 2012, for NRC staff comments. Following are the NRC staff comments as a result of a preliminary review. Please note that the NRC staff may have additional comments/questions after a detailed review of the plan. However, it is suggested that any future discussions with the NRC staff should be in public forum (public meeting).

NRC Staff Comments:

1) How will the results of the fourth short term test using buffered, borated water be evaluated for repeatability? With only a single test how will the results be shown to be statistically valid?
2) Under Section 3.1.6 of the document, debris types, the staff agrees that fiber length rather than diameter is more likely to be strongly correlated to bypass if all other factors remain constant. However, the fiber diameter could affect other aspects of bypass such as fiber flexibility which could allow longer strands to pass through the strainer. Additionally, some fiber types may be more fragile and break into smaller pieces under similar debris generation conditions resulting in a higher probability of bypass. These attributes should be considered in the bypass evaluation.
3) It is important to validate that the fiber preparation method results in the generation of debris that meets the acceptance criteria of the Nuclear Energy Institute (NEI) protocol.
4) Will the fiber be heat treated as part of the preparation procedure?
5) The reviewer did not validate the probability of debris volume distribution provided in the protocol.
6) What ZOI was used to calculate the debris volume values?
7) The sensitivity tests being run with 1 cu ft of fiber may not form a filtering bed over the entire strainer. If a filtering bed covering the entire strainer is not formed at this load, the sensitivity tests may not provide a good understanding of bypass at higher loads and conclusions from the tests may not be valid at higher loads.
8) Development of the test matrix for the long term tests will be an important step in the bypass experiments and evaluation.
9) How will the baseline background weight gain (discussion in Section 4 of the document) be treated?
10) How is it verified that all flow is through the filters?
11) What parameters are used to control pool depth during the testing? Also, Is this important?

12) The minimum of 5 pool turnovers is adequate for systems that are well mixed. If significant amounts of fiber are floating or settled additional time may be required to ensure close to 100% filtration.
13) After all debris is either filtered or captured on the strainer, fiber may continue to slowly migrate though the strainer until the bed becomes stable. This potential should be taken into consideration when termination criteria are determined.
14) How are filter bags controlled to ensure they are not damaged or fiber lost during handling, weighing, photographing, etc?
15) Is pressure drop (dP) across the filters measured? Can the filters be damaged by high dP resulting in fiber loss?
16) Why would characteristics of fiber captured on filters be biased compared to the sampled fiber? It seems that the filter would collect a full range of fiber sizes while the sample probe may not.
17) May not be related to testing, but a consideration – Do STP procedures allow pumps on a single strainer to be stopped and restarted? How does this affect bypass?

TECHNICAL DOCUMENT COVER PAGE

Document No: ALION-PLN-STPNOC-8511-01	Revision: 0C	Page 1 of 26
Document Title: South Texas Project Risk Informed Strainer Penetration Test Plan		
Project No: 261-8511		
Project Name: South Texas Project GSI-191 Risk Informed Analysis		
Client: South Texas Project Nuclear Operating Company (STPNOC)		

Document Purpose/Summary:

This document presents the Alion test plan for the South Texas Project (STP) fiber only strainer penetration testing, which will utilize the Alden Research Labs (ARL) test facility.

This report is not safety related

DESIGN VERIFICATION METHOD

☒ Design Review

☐ Alternative Calculation

☐ Qualification Testing

Professional Engineer Approval (if required) Not Required ______________________ Date ____________
Signature

	Printed/Typed Name	Signature	Date
Prepared By:	Joseph E. Tezak		
Reviewed By:	Timothy D. Sande		
Approved By:	Todd Anselmi		

REVISION HISTORY LOG

Document Number: ALION-PLN-STPNOC-8511-01 Revision: 0C

Document Title: South Texas Project Risk Informed Strainer Penetration Test Plan

Revision	Date	Description
0C	See Cover Page	Draft document incorporating internal and STP team comments

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DEFINITIONS AND ACRONYMS

Acronym	Definition
ARL	Alden Research Labs
BWR	Boiling Water Reactor
ECCS	Emergency Core Cooling System
LOCA	Loss of Coolant Accident
NRC	Nuclear Regulatory Commission
PCI	Performance Contracting Incorporated
PWR	Pressurized Water Reactor
RO	Reverse Osmosis
STP	South Texas Project

1 PURPOSE

The first step in considering downstream effects is to generate a collection of data that represents the quantity and physical characteristics of the debris that penetrates the strainer. A reasonable vehicle to collect such data is prototypical strainer testing. This document develops the plan for conducting fiber only penetration testing for the purpose of determining the quantity and characteristics of fibrous debris that can potentially penetrate the STP emergency core cooling system (ECCS) suction strainers in a post-loss of coolant accident (LOCA) environment.

2 TEST OBJECTIVES

The test objective is to quantify and characterize the fibrous insulation debris that would penetrate through the ECCS suction strainers during the ECCS response timeline. Tests will be conducted to determine the quantity of fiber that can be expected to penetrate the strainers during ECCS operation. Tests will be structured to obtain data that can be used to develop an empirical tool that will allow STP to determine the quantity of fiber expected to penetrate the strainer, with respect to known operating parameters. A test report, which will describe the testing and the methodology required for penetration analysis, will accompany the testing results.

The testing will provide adequate data for STP to determine the fiber penetration quantity and characteristics at specific times for various plant conditions during ECCS operation.

3 TECHNICAL APPROACH

This section serves as an overview to outline the testing variables, the tests to be performed, and the general guidelines for test execution. An overview of sample preparation, filter preparation, and filter replacement is provided. However, more detailed instructions will be provided in the specific test procedures.

3.1 Test Variables

To adequately and conservatively capture the various ECCS operating modes and their effect on fiber penetration, numerous test variables have been defined. Some of these variables shall require completion of multiple tests to determine their effect on fiber penetration, while others can be satisfactorily omitted via a conservative approach or explanation. These variables are discussed below and are subsequently listed and described as either "fixed" or "requires testing" in Table 3.1.

Table 3.1 – Fiber Penetration Test Variable Summary

Variable	Variable Type
Strainer Geometry and Hole Size	Fixed
Approach Velocity (Flow Rate)	Requires Testing
Water Chemistry	Requires Testing
Water Temperature	Fixed
Tank Turbulence Level	Fixed
Debris Type	Fixed
Debris Size	Fixed
Volumetric Debris Concentration	Requires Testing
Debris Quantity	Requires Testing
Debris Introduction and Accumulation	Fixed
Penetrated Fiber Collection	Fixed

3.1.1 Strainer Geometry

All tests will be performed with an STP prototypical PCI stacked disk strainer. The test module has a surface area of 91.44 ft^2 [1] with 3/32" holes in perforated plate [2].

3.1.2 Approach Velocity (Flow Rate)

A range of flow rates can be applied during testing to determine the impact of approach velocity on penetration quantity. The test flow rates selected will include high flow conditions that yield approach velocities near the upper range of the plant strainer approach velocities, as well as lower flow conditions. The approach velocity is calculated by dividing the flow rate by the gross unobstructed screen area.

STP has a strainer area of 1818.5 ft^2 and a maximum flow rate of 7,020 gpm when the CS, LHSI, and HHSI pumps are all performing under runout conditions. This yields a maximum approach velocity of 0.0086 ft/s.

$$\frac{7{,}020\ gal}{min} \times \frac{0.133681\ ft^3}{gal} \times \frac{min}{60\ sec} \times \frac{1}{1818.5\ ft^2} = 0.0086\ \frac{ft}{s} \qquad \text{Equation 1}$$

As the surface area of the test strainer has been established as 91.44 ft^2, in order to achieve an approach velocity of 0.0086 ft/s, the flow rate through the test strainer must be 353.0 gpm.

$$91.44\ ft^2 \times \frac{0.0086\ ft}{sec} \times \frac{gal}{0.133681\ ft^3} \times \frac{60\ sec}{min} = 353.0\ gpm \qquad \text{Equation 2}$$

The tech spec flow rate of a HHSI pump is 1,620 gpm, which represents the smallest of the three safety pump flow demands [3]. Using this nominal lower flow value, a minimum approach velocity of 0.0020 ft/s is calculated[1].

$$\frac{1{,}620\ gal}{min} \times \frac{0.133681\ ft^3}{gal} \times \frac{min}{60\ sec} \times \frac{1}{1818.5\ ft^2} = 0.0020\ \frac{ft}{s} \qquad \text{Equation 3}$$

As the surface area of the test strainer has been established as 91.44 ft^2, in order to achieve an approach velocity of 0.0020 ft/s, the flow rate through the test strainer must be 82.1 gpm.

$$91.44\ ft^2 \times \frac{0.0020\ ft}{sec} \times \frac{gal}{0.133681\ ft^3} \times \frac{60\ sec}{min} = 82.1\ gpm \qquad \text{Equation 4}$$

Depending on the results of the initial tests, additional intermediate approach velocities may be tested.

[1] Flow rates could be even lower than this for small breaks. However, for practical reasons, this is a reasonable lower limit to test.

3.1.3 Water Chemistry

Plant water chemistry has been shown to result in effects that could reduce the porosity of the debris bed. However, it is much simpler and more economical to use filtered tap water for testing. It is hypothesized that use of plant chemistry water will not have an impact on fiber penetration since the penetration is believed to be a function of parameters such as hole size, fiber length, and drag on the fibers, and unrelated to the zeta potential or other chemical interactions that can affect head loss. However, it is necessary to experimentally evaluate the effect that different types of water may have on fiber penetration. Water chemistry sensitivity cases must be run to determine if the penetration testing should utilize filtered tap water or buffered and borated reverse osmosis (RO) water.

The logic for the short term water chemistry tests follows:

- **Run a penetration test using filtered tap water, as defined by the test matrix.**
- **Run a second identical penetration test using filtered tap water, as defined by the test matrix.**
- **Run a third identical penetration test using filtered tap water, as defined by the test matrix.**
- **Run a fourth penetration test that is identical except for the use of buffered and borated RO water, as defined by the test matrix.**
- **The results of the fourth test will be statistically compared to the first three tests. If the comparison is similar, water chemistry can be disregarded as a variable and all further testing can be run with filtered tap water for more favorable testing costs and convenience.**
- **If the results of the fourth test are not statistically similar to the first three tests, water chemistry will be considered an important parameter and all further testing will be run with buffered and borated RO water.**

3.1.4 Water Temperature

The tests will be performed at a water temperature of 120°F. In addition to being more prototypical of a post-LOCA environment than room temperature, water at higher temperatures contains less dissolved gas, which has been found to result in less floating debris. Testing at higher water temperatures makes it easier to ensure that all debris added to the test will reach the strainer and therefore is recommended. Note that temperature variations may have a slight impact on penetration since the reduced viscosity at higher temperatures would exert less drag on the fibers. However, since 120 °F is on the low end of the containment pool temperature range, it is reasonable to test at these conditions.

3.1.5 Tank Turbulence Level

A level of turbulence shall be provided by submerged mixing motors. These motors shall provide enough tank turbulence to suspend the debris off of the test tank floor while not stripping fiber off of the strainer. It is necessary to keep debris in suspension during the test as the final results used in determining the penetration quantities will be based on the mass of fiber transported through the strainer during the tests. This level of turbulence shall be maintained until the completion of each test.

3.1.6 Debris Types

The different fibrous insulation types present at STP include Nukon (175 lb/ft^3, 7 µm diameter), Thermal-Wrap (159 lb/ft^3, 5.5 µm diameter), and latent fiber (assumed the same as Nukon) [4]. When compared to the strainer perforated plate hole diameter, the Thermal-Wrap fiber diameter is 433 times smaller and the Nukon fiber diameter is 340 times smaller. Since both fiber types have fiber diameters that are greater than two orders of magnitude smaller than the perforated plate hole diameter and are both low density fiberglass insulation products with nearly the same microscopic densities, it is reasonable to conduct the testing with only Nukon.

Note that although particulate debris is present at STP (microtherm, dirt/dust, and coatings), it will not be included in the penetration testing. This is reasonable because as a fiber bed forms on the strainer, introduction of particulate would only serve to hasten bed formation and subsequently inhibit fiber penetration. Also, if particulate was added to the test, much of the particulate would pass through the strainer and collect in the capture filters. This would prevent accurate measurements of the mass of fiber that would collect in the same filters.

3.1.7 Debris Sizes

As discussed above in Section 3.1.6, Nukon alone will be used for the strainer penetration testing. The Nukon shall be prepared as fines in accordance with an ARL modified NEI preparation protocol [5]. Testing only with fines is conservative as this is the fiber size class that contains the most amount of fiber small enough to penetrate through the strainer perforated plate and therefore will result in the largest penetration quantity. Using small or large pieces of fiber in the testing would hasten bed formation by occupying available strainer surface area and inhibiting individual fiber penetration.

3.1.8 Volumetric Debris Concentration

Volumetric debris concentration is the volume of fiber divided by the volume of water. The individual batches of fiber introduced to the tests shall be sized with respect to the test tank volume to yield fiber concentrations that represent the range of plant concentrations. Each test shall have multiple batch additions, which will result in a net total fiber quantity that matches the corresponding scaled fiber quantity for the presumed accident condition. The fiber concentration within the test is therefore controlled by controlling the batch addition size. During debris introduction, the test tank fiber concentration gradually increases and then decreases again once all fiber from the batch has been added. The batch size thus controls the maximum debris concentration within the test tank. Multiple batches also afford an opportunity to collect time-dependent accumulation data. Each batch requires a sufficient circulation time in order to accurately and fully measure penetration at the present debris load.

Debris concentration is a potentially important parameter to test for impact on fiber penetration. Extreme high concentration can be visualized as the volume of fiber being introduced to the test tank all at once. Extreme low concentration can be visualized as the same volume of fiber being introduced to the tank in infinitely small batches. It is important to recognize that the joint range of concentration and debris volume that occurs in the accident space is constrained by the range of sump-pool water volume. So there is no need to investigate concentration and total debris load as purely independent parameters.

It is hypothesized that penetration increases with decreasing concentration, up to a point where lowering concentration no longer affects penetration. Lower concentrations would build a fiber bed slowest and allow fiber more time to penetrate. This hypothesis further justifies incremental fiber addition to attain desired total loading, because the concentration will decline steadily following the introduction of each batch. However, extreme low concentrations are not practical to test for since these tests would take an impractical amount of time to complete. A series of concentration sensitivity cases will be run to determine this variable's impact on fiber penetration.

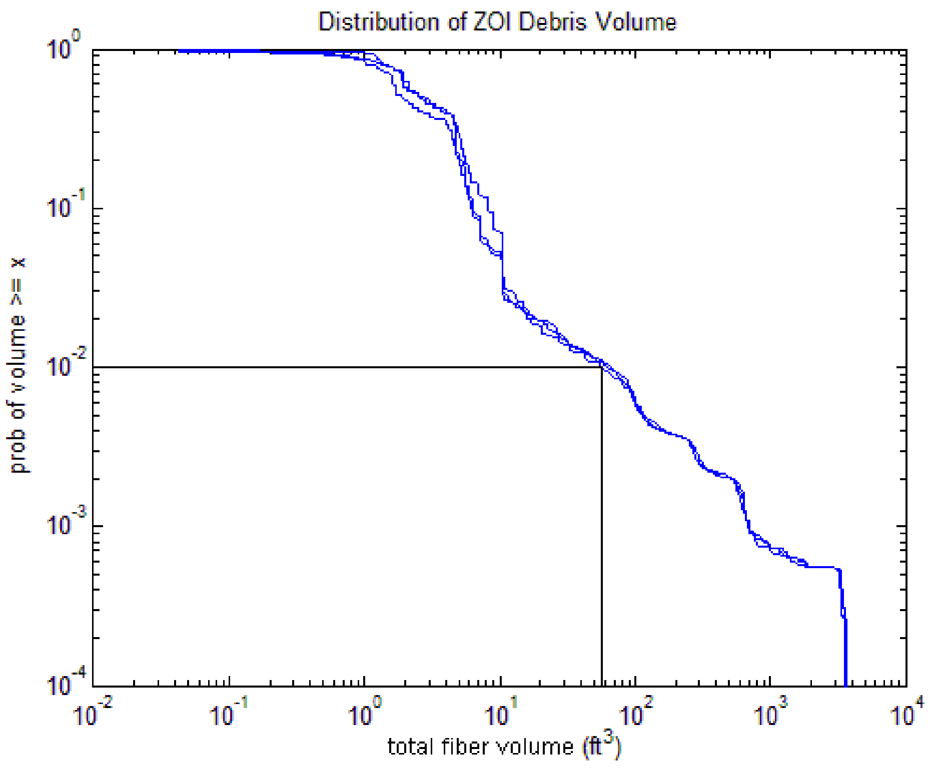

Figure 3.1-1 – Distribution of Possible Fiber Debris Volume at STP

As shown above in Figure 3.1-1, approximately 99% of the breaks will be bounded by a maximum fiber load of 60 ft^3 [6] (assume 100% fines with 100% transport). From the debris generation calculation [4], the maximum LBLOCA fiber load is 2,321 ft^3 (assume 60% fines with 100% transport to obtain a loading of 1,393 ft^3) and a latent fiber only load is 12.5 ft^3 (assume 100% fines with 100% transport). This latent fiber value would be representative of the minimum fiber load that would occur for a small SBLOCA. The minimum and maximum pool volumes at STP are 39,533 ft^3 and 69,444 ft^3, respectively [7].

The above values result in a wide range of concentrations of 6% $(\frac{2{,}321\ ft^3}{39{,}533\ ft^3})$ to 0.02% $(\frac{12.5\ ft^3}{69{,}444\ ft^3})$. Using the "99%" fiber load of 60 ft^3 over the range of pool volumes, maximum and minimum pool concentrations of 0.15% $(\frac{60\ ft^3}{39{,}533\ ft^3})$ to 0.09% $(\frac{60\ ft^3}{69{,}444\ ft^3})$ are calculated.

As discussed previously, it is not practical to test at extremely low concentrations because the tests will take a prohibitively long time to complete. However, the lower concentrations are hypothesized to have higher penetration, thus the tests will examine concentrations in the lower range.

ARL has specified that the test tank volume will be approximately 830 gallons (110.95 ft^3). The maximum fiber concentration that will be tested is 0.9%, which results in a test batch size of 1 ft^3. The minimum concentration that will be tested is 0.09%, which results in a batch size of 0.1 ft^3. To gather a third data point, a third concentration of 0.45% may be tested, which would result in a batch size of 0.5 ft^3.

The logic for the short term concentration tests follows:

- **Run a 0.9% concentration test.**
- **Run a 0.09% concentration test.**
  - If the fiber penetration values are similar for the 0.9% and 0.09% concentration tests, the 0.45% concentration test will not need to be run and the remaining testing can be run at the 0.9% concentration value.
  - If the fiber penetration values are not similar for the 0.9% and 0.09% concentration tests, the 0.45% concentration test will need to be run.
- **Run a 0.45% concentration test.**
  - If the fiber penetration values are similar for the 0.45% and 0.09% concentration tests, the 0.09% concentration testing will not need to be run and the remaining testing can be run at the 0.45% concentration values.
  - If the fiber penetration values for 0.45% are not similar to either the 0.9% or 0.09% concentration tests, a hold shall be placed on testing to determine the appropriate way to proceed.

3.1.9 Debris Quantity

Two cumulative debris quantities shall be used, dependent upon if the test being conducted is a short term sensitivity test or a longer term test.

For the sensitivity testing, a cumulative quantity of 1 ft^3 of fiber shall be used in each test. This is the volume of fiber needed to generate a theoretical uniform 1/8" bed on the prototypical strainer.

$$91.44\,ft^2 \times (0.125\,in/12) = 0.95\,ft^3 \qquad \text{Equation 5}$$

For the longer term testing, a cumulative quantity of 4 ft^3 of fiber shall be used in each test. This is the volume of fiber needed to generate a theoretical uniform 1/2" bed.

$$91.44\,ft^2 \times (0.5\,in/12) = 3.81\,ft^3 \qquad \text{Equation 6}$$

Fiber will be added in batches up to the total quantity so that estimates of fiber penetration at fiber quantities less than the overall debris addition quantity can also be evaluated using the same test. The incremental debris addition provides a means of "sweeping" across the debris-volume parameter while holding the debris concentration parameter constant.

3.1.10 Debris Introduction and Accumulation

The individual batches of fiber shall be introduced to the test tank such that agglomerations are minimized and any debris bed that is developing or has been developed is not disturbed. The timing of each batch's introduction to the tank is prescribed in the test matrices. The manner in which the debris accumulates on the strainer is a function of the variables previously described, specifically the strainer geometry, the tank turbulence and debris properties.

3.1.11 Penetrated Fiber Collection

Nominal 5-micron pore bags shall be used for fiber collection. The Nukon fines to be used have a characteristic diameter of 7 microns. The larger diameter, combined with the random orientation of the fiber as it contacts the filter bag, suggests that the capture efficiency of the bags will be greater than the rated value cited for particulates.

A manifold of parallel bag filters allows complete collection of penetrated fiber from each incremental fiber addition. By mass balance, the cumulative penetration data also define the mass loading on the bed that is present at the end of each fiber addition.

3.2 Sensitivity Tests

Per the variables defined in Section 3.1, two groups of short term sensitivity tests will be run and will then be followed by the longer term full batch testing. The logic for the sensitivity testing is shown below in the sensitivity test matrix outlined in Table 3.2. The sensitivity tests will also investigate the timing required for debris to penetrate the strainer by switching filter bags at increments of 5, 10, and 20 pool turnovers.

Table 3.2 – Short Term Sensitivity Study Test Matrix

Test #	Water	Concentration	Batch Size x # of Batches	Approach Velocity (Test Flow Rate)	Approximate Test Length
Test 1	Tap	0.9%	1 ft^3 x 1 (2.4 lbs x 1)	0.0086 fps (353.0 gpm)	48 minutes
Test 2 (Repeatability)	Tap	0.9%	1 ft^3 x 1 (2.4 lbs x 1)	0.0086 fps (353.0 gpm)	48 minutes
Test 3 (Repeatability)	Tap	0.9%	1 ft^3 x 1 (2.4 lbs x 1)	0.0086 fps (353.0 gpm)	48 minutes
Test 4	Buffered / Borated RO	0.9%	1 ft^3 x 1 (2.4 lbs x 1)	0.0086 fps (353.0 gpm)	48 minutes
Test 5	Determined in T1 vs T4	0.09%	0.1 ft^3 x 10 (0.24 lbs x 10)	0.0086 fps (353.0 gpm)	TBD (based on required pool turnovers)
Test 6 (if necessary)	Determined in T1 vs T4	0.45%	0.5 ft^3 x 2 (1.2 lbs x 2)	0.0086 fps (353.0 gpm)	TBD (based on required pool turnovers)

The first four sensitivity tests are designed to determine if all subsequent testing (including the last two sensitivity tests) can be run with filtered tap water or if the tests will need to be completed with plant specific buffered and borated RO water. Test 1 through Test 3 are identical and will be run to determine repeatability. Test 4 is identical to Test 1 through Test 3 except for the usage of buffered and borated RO water instead of filtered tap water. To determine the acceptability of using tap water throughout the rest of the testing, the mass quantity of fiber captured during Test 4 will be statistically compared to the results of Test 1 through Test 3. The initial sensitivity tests will also be used to investigate the number of pool turnovers required for the remaining tests. In addition to collecting incremental filter measurements, isokinetic grab samples will be taken at each pool turnover between the strainer and the filter to measure the decreasing concentration of penetrating fiber.

As stated previously, it is hypothesized that penetration increases with decreasing concentration, up to a point where lowering concentration no longer affects penetration. Tests 5 and 6 have been designed to support possible elimination of concentration as a variable and to allow tests to be run at higher concentrations such that tests can be completed more quickly. Figure 3.2-1 shows the potential outcomes of the chosen concentrations to be tested. Only the relative trend of each case is relevant to this discussion, so magnitudes between cases (graphically separated for visual convenience) should not be compared. Each case is described as follows:

- Case 1 – Penetration dependent on concentration over the entire range tested. May be non-conservative for STP prototypical conditions; could require testing at lower concentrations (0.045%).
- Case 2 – Penetration dependent on concentration at some point between 0.45% and 0.9%. This desired outcome allows for use of a 0.45% concentration for all tests.
- Case 3 – Penetration independent of concentration in range tested; use 0.9% for all tests. This desired outcome allows for use of a 0.9% concentration for all tests
- Case 4 – Penetration does not fit hypothesis.

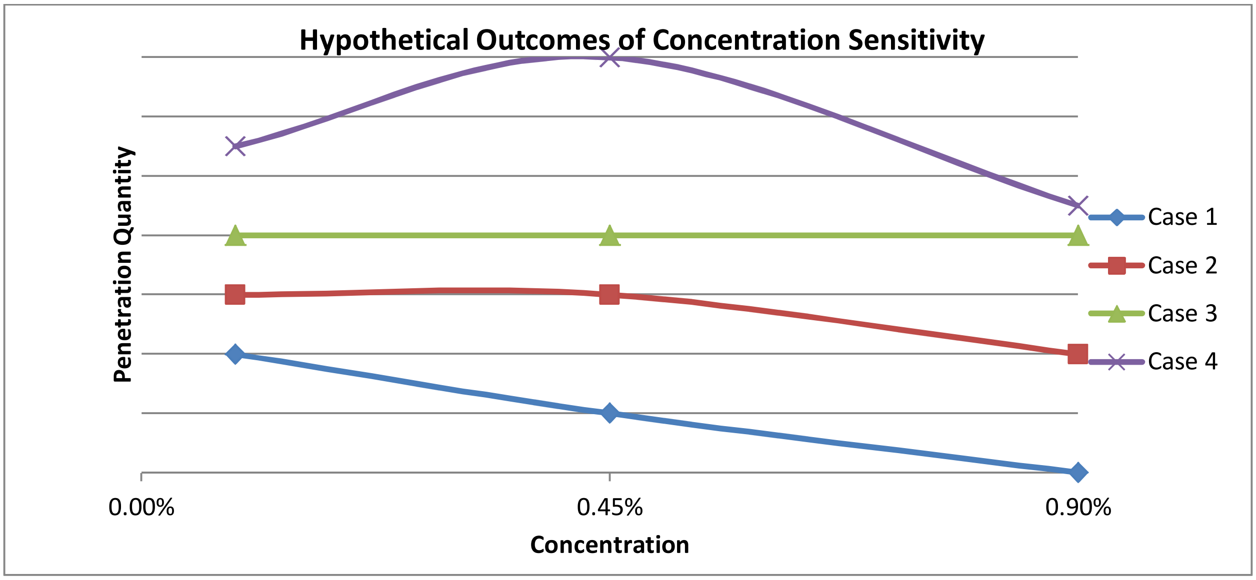

Figure 3.2-1 – Potential Outcomes of Concentration Sensitivities

Test 5 is designed to determine if debris concentration is a variable that can be entirely or partially eliminated. If the quantity of fiber penetration in Test 5 is similar to that in Test 1 through Test 3 or Test 4 (dependent on water type), then concentration can be eliminated as a variable and all further testing can be completed at a concentration of 0.9%. If the results of Test 5 are not similar to any of the previous tests, then concentration cannot be fully eliminated and Test 6 shall be run.

If the quantity of fiber penetration in Test 6 is statistically similar to that in Test 5, then the longer term testing will need to be run at 0.45% concentration. If not, additional evaluation will be necessary prior to proceeding.
If the data show results that correspond to Case 1 or Case 4 as shown in Figure 3.2-1, a hold will be placed on the testing such that an appropriate concentration value can be added to the test matrix.

3.3 Long Term Tests

Per the variables defined in Section 3.1, once the short term sensitivity tests are run, the long term full batch testing can be completed. This longer term testing will incorporate approach velocity sensitivity into the test matrix. The longer term tests will be run using the water chemistry and concentration values determined in the short term sensitivity tests. The tests will be run with a total fiber quantity equal to a ½ inch theoretical fiber bed thickness at approach velocities ranging from 0.0086 ft/s down to 0.0020 ft/s.

3.4 Overall Test Approach

The overall test approach will be to incrementally add fiber batches into the test tank and allow the debris to transport to a prototype strainer module. For each test, debris additions will be cumulative to facilitate the formation of a debris bed on the strainer. Each incremental addition will contribute to the debris bed thickness. Any fiber that penetrates the strainer shall be collected in a downstream filter system. Throughout the testing, filters must be changed after debris additions to determine the incremental effect of debris loading on penetration quantity. The filter system will be configured with multiple elements in parallel to allow undisturbed flow through the strainer as flow is diverted between the filters. The weight gain of the filter bags shall be analyzed to measure and characterize the fiber penetration. In addition to the bag filtering system, "grab samples" will be collected to characterize the rate at which the penetration tapers off as the debris bed forms and to allow penetration debris size distribution characterization.

4 TEST DESCRIPTION

Prior to testing, the filters will be dried in a lab oven at 200°F for 2 hour drying increments to ensure that any moisture in the filters has been removed. Between the drying increments, the filter bags will be weighed. The filter bags will be considered dry when the filter weight change is less than 0.05 g across three consecutive measurements[2]. The pre-drying establishes a baseline weight to be measured. This pre-weight is the weight of the clean filter bag without any fiber prior to use during testing. This value shall be compared to the weight of the filter bag after testing to calculate the quantity of penetrated fiber captured for each incremental addition of fiber.

The fiber debris that is to be used for testing shall be processed into fibrous fines in accordance with an ARL modified NEI protocol [5].

The test tank and hardware shall be thoroughly cleaned prior to each test. The appropriate hardware shall be installed, and the tank shall be filled with buffered/borated RO water or filtered tap water (dependent upon the outcome of the sensitivity study) to the specified level in the test facility (approximately 830 gallons). This volume has been provided by ARL and will facilitate laboratory equipment capacity and provide the proper concentration between debris volume and test pool volume.

The filter bags shall be installed into housings and shall be valved inline at the test flow rate. After 10 pool turnovers, one set of bags shall be removed and marked CONTROL. These bags will serve as a reference for the baseline background weight gain. Filters should be dried using the same requirements stated above.

At the specified parameters in the test matrices, a measured amount of fiber fines shall be added per the test matrix. The debris will be allowed to reach the strainer via turbulence and approach velocities at the specified flow rate. All water passing through the strainer shall be filtered by the pre-weighed filter bags.

After all debris has been added in accordance with the test matrix and the required number of pool turnovers has been achieved, the filters shall be valved out and the filter bags removed. The used filter bags shall be put into an oven and allowed to dry. Each is weighed multiple times (with a minimum of 2 hour increments) until the weight change is less than 0.05 g across three consecutive measurements.

The test tank shall then be cleaned, reset, and new filter bags and fiber fines generated for the next test.

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[2] This acceptance criterion may need to be modified based on the size of the filters and the sensitivity of the scales.

4.1 Test Apparatus

The testing will be performed in the ARL test tank. The test tank shall allow for the measurement and control of all facility relevant flow rates. Differential pressure across the strainer and differential pressure across the filter bag assembly shall be able to be measured in real-time. The water downstream of the strainer shall be passed through the filters before passing through the pump and being transported back into the tank. Mixing motors shall provide enough turbulence to prevent debris from settling in the tank.

4.2 Supporting Equipment

The filter bags will be dried in ovens prior to and after testing. The penetrated fiber weight gain will be measured with analytical balances verified daily with calibrated mass sets. The physical characteristics of the fiber penetration will be analyzed via microscopy, including the application of a scanning electron microscope for fiber length measurements and imaging.

As-received fiber insulation will be prepared into fines using the NEI protocol [5].

5-micron polyester felt bags with a temperature rating above the drying temperature of the oven shall be used to capture penetrated fiber. The filter bags shall be inspected for tears or damage and photographed. Each filter bag should be labeled with an identifier (A, B, etc.) on the cloth handle, and a drying log should be initialized for each upon placing into an oven. The oven must be maintained around 200 °F for a period of 24 hours to ensure complete stabilization of the baseline environment. The filter bags will be considered dry when the filter weight change is less than 0.05 g across three consecutive measurements. Upon this stable measurement, the bag should be removed from the oven and placed in a clean, labeled sample bag until testing. This process must be repeated for all filter bags used in testing.

4.3 Fiber Preparation

All fibrous debris preparation shall follow the NEI protocol [5] with a scaled-up modification as described below. This procedure produces the required size distribution and fiber fines that are easily transportable and readily disperse in the test tank.

The scaled-up version of the NEI protocol debris preparation will be performed with the objective of increasing the size of the prepared batches, avoiding excessive dilution, and reducing the amount of time to process the debris into fines. The suggested method is a tank filled with water and debris, with several high pressure nozzles. Rather than adding water as long as the high pressure spray is operating, a fixed amount of water will be added initially, which then will be recirculated through the spray nozzles. A filter will be installed over the return line intake to keep fiber from entering the spray line. Recirculation of the water will prevent very large volumes of diluted fiber, and the use of multiple high pressure spray nozzles would increase the speed of the process. The spray nozzles will be oriented such that they establish continuous rotation of the water and debris in the tank to allow all debris to be exposed to the agitation in the immediate vicinity of the spray. To demonstrate the adequacy of the scaled-up process, a batch of fines generated using it will be documented visually and then compared to a batch of fines prepared using the standard NEI protocol.

4.4 Test Tank Preparation

Before any test, the below should be performed to ensure the loop is clean and the test equipment is functioning properly.

- The Test Tank must be thoroughly cleaned prior to each test to prevent contamination of the filter bags.
- If not already completed, the test loop should be filled with the appropriate type of water and then recirculated for a minimum of 10 pool turnovers at the maximum calculated test flow rate to remove all residual debris from the test loop.
- Ensure the data gathering system is functioning properly.
- After the above actions have been completed the flow will be redirected to a new filter and the fiber will be added in accordance with the test matrix.

4.5 Hydraulic Test Conditions

Testing shall be conducted per the Test Matrix. The hydraulic conditions are maintained by controlling the test flow rate to within +5/-0% of the prescribed flow rate.
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4.6 Testing

Testing shall be conducted per the Test Matrix established in Sections 3.2 and 3.3.

4.6.1 Test Control

All testing actions and control must be noted in the test log. This includes flow adjustments, water sampling, debris addition (beginning and completion), stirring (including the duration of the stir), filter removal and installation, and all other acts that affect the testing environment. The test logs shall describe critical information about the test without recourse to the test engineer.

Adjustments and flow alignments may induce flow variations. However, the flow rate of the system shall be maintained to ensure debris remains on the strainer without excessive bed disturbance.

Debris shall not be allowed to settle in the Test Tank. If debris settling begins to occur, additional agitation is required to ensure that non-representative debris settling is minimized. A paddle may be used to suspend settled debris, although agitation must not disturb the debris bed on or around the strainer. If settled debris is found resistant to manual stirring, it shall be collected and reintroduced. Small quantities of settled debris remaining on the floor area shall be photographed, noted in the test log, and collected for measurement and drying.

Any floating debris is to be collected from the water surface without disturbing the strainer debris bed and re-introduced to the test in the same manner as the bulk batch. Very small residual floating debris quantities may be collected for drying and measurement to determine the amount of fiber that was removed from the test. The total batch amount added to the test will be adjusted by the collected debris weight for the determination of the penetration fraction, or determination of amount of penetrated debris.

The entire flow downstream of the strainer shall be passed through a filter cartridge assembly during penetration testing.

Water temperature shall be controlled at 120 (+/-2) °F during testing.

Test acceptance criteria is provided in Section 5.

4.6.2 Control Filter Bag

At the beginning of testing before debris introduction, a set of clean filter bags should be subjected to the test flow rate for 10 pool turnovers to gather baseline background mass gain caused by the collection of any particulates remaining in the water after tank cleaning.

4.6.3 Debris Introduction

See Section 4.3 for the debris preparation requirements. Batches of fiber will be added per the Test Matrix. The fiber batches shall be introduced in a manner that ensures the debris is sufficiently dilute to avoid significant agglomeration and clumping.

4.6.4 Pool Turnovers and Debris Interval Timing

To ensure that all fiber added during each test step reaches the strainer, a minimum interval of 5 pool turnovers at the specified test flow rate is required. This pool turnover quantity parallels the NRC guidance related to PWR head loss testing [8]. Specifically, this guidance states that five pool turnovers are adequate to ensure filtration when the bed filtration efficiency is near one, see Figure 4.6-1.

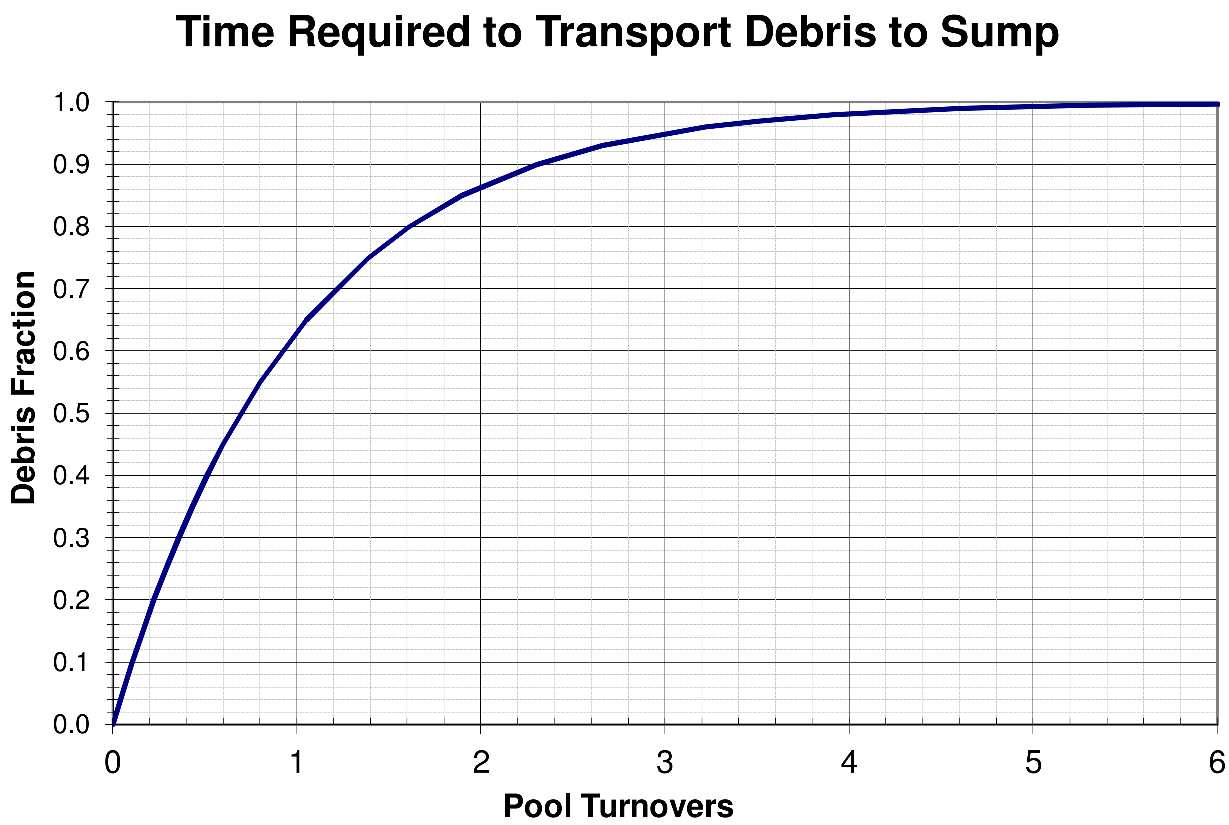

Figure 4.6-1 – Debris Fraction Transported to Sump as a Function of Pool Turnover

This guidance can be implemented to provide reasonable assurance that the full volume of the test tank has flowed through the strainer. The multiple volume circulations of the test pool, combined with the use of mixing devices, will ensure that all debris reaches the strainer surfaces.

4.6.5 Filter Bag Removal

Filter swapping, which is the removal of one set of filter bags at a specified time and replacement with a set of clean, pre-dried filter bags, can be accomplished whenever necessary.

4.6.6 Filter Bag Processing

Upon removal from the test system, the filter bags shall be photographed inside and out. It shall be allowed to drip-dry to remove excess water, and then transported to the drying oven. The drying log must reflect when the filter began drying after testing. The oven must be maintained at a nominal 200 °F to ensure complete drying. Three measurements within 0.05 g of each other will signal that the filter bag is dry and that the weight gain consists only of collected fiber and not non-evaporated water. Upon this stable measurement, the bag shall be removed from the oven and placed in a clean, labeled sample bag until possible further analysis. This process must be repeated for all filter bags used in testing.

4.6.7 Grab Sampling

Grab sampling will be implemented during most tests. Grab sampling is accomplished by collecting a volume of water from the flow downstream of the strainer and upstream of the filter assemblies. Sampling is accomplished through a set of nozzles distributed over the cross-section of the pipe. During sampling, the flow rate through the nozzles is such that the nozzle velocity matches the average cross-sectional pipe velocity (iso-kinetic sampling), thus ensuring that the sampling process is not biased. The grab samples represent a snap-shot of the penetrating fiber concentration and can be used to define the decreasing penetration rate as fiber accumulates on the strainer from an introduced fiber batch. The grab sample volume can be adjusted for the expected concentration to ensure that a meaningful measurement is obtained. The collected penetration in the filter bags can be adjusted for the collected water volume. In general the fiber attributed to grab sample collection is less than the uncertainty of the weight convergence of the filter bags. The grab samples may also be investigated using SEM analysis or other analytical methods for fiber length and diameter distribution.

4.6.8 Fiber Characterization

To avoid biasing the results, sample characterization will be performed based on the isokinetic grab samples rather than the fiber captured in the filters. To characterize the physical parameters of the penetrated fiber, samples can be sent to an SEM lab or other processing facility for fiber length measurements. The results can include calculated averages as well as magnified images of samples.

5 TEST ACCEPTANCE CRITERIA

In accordance with the test objective, the acceptance criterion for this testing is to conduct the fiber penetration test in accordance with the Test Matrix and applicable test procedures outlined in this document and to successfully collect and record data. The flow rate for the duration of the test has to be maintained above that designated as the target for the test. The weight gain measured in the clean facility verification filter bags shall be less than 1g. The number of pool turnovers required for the longer term testing will be determined in the initial sensitivity testing.

6 TEST DOCUMENTATION AND RECORDS

The test matrix provides the guidance as to the characteristics of the tests currently planned. A test procedure allowing the specified tests to be implemented will be developed by ARL. This procedure shall require signature documentation for the performance and witnessing of critical steps. A log book will be dedicated to the testing and will be used to record observations as required by the test procedure as well as ongoing written documentation of the test conditions to provide a back-up test record to the electronic data acquisition record.

A Test Equipment Verification Procedure shall provide the means to verify the calibration and setup of each instrument except the flow meter before testing to ensure error-free data acquisition. Furthermore, the procedure shall be conducted immediately after the conclusion of testing to check for instrument failure or inaccuracies produced during testing.

7 DEBRIS HANDLING REQUIREMENTS

This test plan identifies a test matrix using fiberglass insulation. All appropriate MSDS should be followed and care should be taken when handling the insulation.

8 QUALITY ASSURANCE REQUIREMENTS

The goal of the test plan is to develop fiber penetration data for use in a risk-informed approach. Thus, this testing is not Safety Related.

9 REFERENCES

1) 66-9088089, "South Texas Project Test Report for ECCS Strainer Testing", Revision 0, July 2008.

2) TDI-6005-01, "Vendor Technical Information for SFS Surface Area, Flow and Volume Calculations", Revision 1.

3) STP Units 1 and 2 Technical Specification 4.5.2.g (Unit 1 – Amendment 188, Unit 2 – Amendment 175).

4) ALION-CAL-STPEGS-2916-002, "GSI-191 Containment Recirculation Sump Evaluation: Debris Generation", Revision 2.

5) "ZOI Fibrous Debris Preparation: Processing, Storage, and Handling", Revision 1, January 2012.

6) "Risk-Informed Resolution of GSI-191 at South Texas Project Electric Generating Station", 12/15/2011

7) ALION-CAL-STP-008511-01, "STP Post-LOCA Water Volume Analysis", Revision 1A DRAFT.

8) "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing", March 2008.