The purpose of this document is to provide both the existing Sure-Flow® Strainer User's Group (SFSUG) as well as other perspective clients with recent information about the SFS Team's 'refined' Large Flume Test Protocol (LFTP). The LFTP has been developed and implemented to integrate debris transport and debris settlement to define plant specific strainer head loss performance and fibrous debris only bypass performance of ECCS strainers. To date, the LFTP has been implemented almost exclusively for Performance Contracting, Inc.'s **Sure-Flow® Strainer** (SFS); however, the LFTP can be implemented for other ECCS screens.

The SFS Team refers to Performance Contracting, Inc. (PCI), and its SFS Team partners, AREVA, NP, Inc. (AREVA) and Alden Research Laboratory, Inc. (Alden). The SFS Team has been deeply involved with the various ECCS/CSS strainer debris blockage issues (i.e., RG 1.82, USI-A43, GSI-191 & GL 2004-02) as they relate to both PWRs and BWRs since 1980.

The LFTP was specifically developed at the request of the SFS Users Group (SFS UG), most importantly for those plants that have significant quantities of fibrous insulation as a result of their GL 2004-02 and GSI-191 design basis, commonly known as high-fiber plants. The 'refined' LFTP is also expected to provide benefits to low-fiber plants struggling with the increased quantity of fibers bypassing their ECCS/CSS strainers.

The LFTP is unique from all other test protocols / facilities; such as the Closed Vertical Pipe Loop (CVPL) and small flumes or tanks which must apply mixing energy during the test to artificially suspend debris with the intent to deposit all debris on the test strainer or at least to the greatest extent possible.

The LFTP is the only protocol that the USNRC staff currently recognizes which allows for debris settlement due to gravity during transport in a flow stream that very conservatively models the last 20 to 30 feet of flow to the ECCS/CSS strainers. The benefits of this protocol are obvious; and more importantly, this protocol is the most realistic when compared to the actual post-LOCA containment fluid flow conditions. Although the LFTP is conservative "by design" to gain NRC staff acceptance, the LFTP is intended to represent a more realistic measure of transport and head loss; albeit possibly a less conservative testing approach compared to other test protocols.

The LFTP was originally developed with the NRC staff's involvement from April 2007 through December 2007. SFS licensee test programs implementing the LFTP began in January 2008. The SFS Team was led to believe based on staff involvement and discussions that the test results would be accepted as licensee tests were implemented and completed. The LFTP continued to evolve based on comments from the staff. After completing all SFSUG tests in November 2008, licensees began to receive RAIs that challenged the test results due to concerns and / or issues; some of which were not previously identified by the staff to the SFS Team to address. Unfortunately, most of the test results were deemed unacceptable for reference by licensees to resolve GL 2004-02.

The staff's primary concern with the LFTP was focused on the level of conservatism and / or uncertainty associated with various elements of the LFTP. Given this basis for rejection of the test results, the SFS Team initiated another round of protocol reviews with the staff beginning in April 2010 and lasting through March 2011 to resolve all open issues; and to present better our technical positions which the staff did not fully understand. The objective of this effort was to revise the LFTP and allow the Team to continue to implement this test protocol for the SFS UG and others. During this period, and to further support a 'refined' LFTP, sensitivity testing was also implemented at Alden to clarify and better support some elements of the LFTP.

The following is a list of the various major issues discussed and resolved with the staff to utilize and implement the 'refined' LFTP going forward.

Large Flume Test Protocol – NRC Issues / Items

- CFD Modeling of the Licensee Plant Specific Containment
- Licensee Plant Specific Large Test Flume Configuration
- Debris Types, Debris Surrogates and Debris Forms (Major Debris Types Only)
- Non-Chemical Debris Introduction & Sequencing
- Chemical Debris Introduction & Sequencing
- Termination Criteria
- Narrow Flume Effect Issue
- Debris Pile Issue (*)

(*) Note: The staff has decided this is a plant specific design basis issue. The staff no longer sees this issue as a restraint to the Team implementing the LFTP going forward.

Closure Status & Activities

The Team has gained acceptance from the NRC on the path forward to implement what we define as the "refined LFTP". The following excerpt is taken from the documented proprietary minutes of the February 2, 2011 conference call with the NRC:

> ***"PCI inquired and the staff noted during the meeting that PCI has essentially addressed all of the open issues to the extent possible such that PCI could implement the refined Large Flume Test Protocol (LFTP), with the understanding of the staff's need to review several plant specific issues or Hold Points prior to implementation."***

The SFS Team has also committed to the following in order to finalize the staff review of the 'refined' LFTP:

- The entire "refined" Large Flume Test Protocol will be summarized in a PCI document to incorporate staff discussions and agreements. This proprietary document is intended to be "referenced" in test plans implemented going forward to expedite NRC reviews for acceptance. This summary will be the test protocol "guideline" for future U.S. licensee test plans.

- The SFS Team is requesting the staff review a white paper on the momentum transfer of pipe breaks to the recirculation pool with the intent to reduce the energy level / turbulence required in the LFTP. This is not a restraint to using the current methodology for defining the pipe break as a stream of solid water. If our new approach is accepted the water would break up before reaching the recirculation pool which reduces the conservatism of this design input to the LFTP and better reflect plant conditions.

- The SFS Team is now evaluating how to best use the 'refined' LFTP to define and improve debris by-pass testing. This effort includes evaluation of the new PCI **Sure-Trap™**, an upstream filter intended to trap and hold fibers before the fibers reach the ECCS strainer(s). See the separate summary of the PCI **Sure-Trap™** for more information about this new hardware.

- Licensee testing using the 'refined' LFTP is now possible; assuming there is interest by a client to do so. This effort would be coordinated with oversight by the NRC staff, as appropriate and at their discretion.

Frequently Asked Questions

1. Does the observed settling of fibrous debris include fiber fines?

RESPONSE: Yes, to the extent that fibrous debris can be observed in the test flume. Underwater cameras in the immediate vicinity of the strainer have been utilized to observe transport of fine and small fibrous debris moving to and/or settling near the strainer. In addition during fiber only tests, such as for fiber by-pass testing, the fibrous debris can be observed to settle along the licensee specific CFD-generated flume flow path to the strainer when utilizing prototypical post-LOCA hot water (i.e., 120 °F) for the LFTP.

Note: Settling of fibers is dependent on the plant specific flow velocities and TKE turbulence duplicated in the test flume. Some licensee plant conditions allow more settling of debris than others, as is expected. However, by observation of prior tests the SFS Team believes 50% - 95% settlement of fibrous debris occurs within the test flume based on conservatively generated CFD plant specific post-LOCA fluid flow velocities.

2. Is there a way for a licensee that does not have a SFS and is not a SFS UG member to implement the 'refined' LFTP and participate in the settling testing at Alden's facility?

RESPONSE: Yes; however, it is not as simple as testing a 'different vendor's test strainer or module. The 'refined' LFTP is an integrated test that incorporates debris transport, debris settling, strainer head loss and by-pass testing. The objective of the 'refined' LFTP is to take full advantage of gravity and the low or slow flow stream velocities along the fluid's flow path to the plant specific strainer array.

In order to accomplish this, a plant specific CFD analysis of the licensee's containment is needed, including a detailed analysis of approximately the last 30' leading up to the strainer array. The CFD is performed based on agreements reached with the staff in support of the 'refined' LFTP. The SFS Team has already performed CFDs on varying and complex strainer configurations, including plants with strainers positioned apart from each other in open space, along the outer annulus, in a submerged suppression pool and for varying strainer module quantities/sizes (i.e., non-symmetrical configuration layouts).

This conservatively performed CFD forms the basis for defining the construction of a licensee plant specific large test flume. The large test flume is approximately 30' in length and incorporates a variety of flume widths defined to agree with and bound the licensee plant specific CFD. The varying widths of the test flume will conservatively represent the changing flow velocity within the plant's post-LOCA containment for the flow path to the strainer array. One or more strainer modules are placed at the end of the large test flume. The flume flow rate is scaled to the area of the licensee's operating strainer module(s).

Debris (i.e., non-chemical, chemical, and in some cases miscellaneous debris) is introduced to the flume with the pumps running in a defined conservative sequence. The debris will transport and/or settle in the flume based on the varying flow velocities and debris characteristics.

Not surprisingly, the debris volume that does reach the strainer module(s) is significantly reduced from that of a CVPL or as experienced when correctly implementing a small flume/tank test that incorporates artificial mixing energy to assure debris transport. This is the primary reason that licensees with large fibrous insulation and/or non-qualified coating particulate debris volumes are interested in the 'refined' LFTP as a possible solution for achieving acceptable strainer head loss and fiber only by-pass test results. Better performance results from this testing approach may prevent the removal of some or all existing fibrous insulation to ultimately resolve GSI-191.

The SFS Team believes that the 'refined' LFTP offers a clear alternative and significant advantage to those licensee plants whose design basis are high fiber plants or RMI plants with a potential for small quantities of fibers that have experienced high head losses from other protocols. In addition, there are potentially other benefits with the implementation of the 'refined' LFTP related to fiber only by-pass. Again, reductions to the measured fiber bypass test results are possible since less fibrous debris is expected to reach the strainer(s) due to debris settlement within the test flume.

In summary, this letter provides an overview of the issues and current status associated with the 'refined' LFTP. We encourage you to discuss with us any technical or regulatory/licensing questions that have not been fully addressed by this letter. Simply contact us at your convenience. PCI looks forward to your call and further discussions as to how the SFS Team may assist you.