

Salem Strainer Bypass Test Fiber Debris Preparation Method Comparison

1.0 PURPOSE

The purpose of this whitepaper is to compare the Salem strainer bypass test fiber debris preparation method to that outlined in the January, 2012, NEI guidance (Ref. 7.1).

2.0 BACKGROUND

A detailed discussion of the 2006 and 2008 Salem fiber bypass tests was previously provided to the NRC in Section 3f.4 of the Salem final supplemental response (Ref. 7.2). Some of the pertinent details provided in the supplemental response are repeated herein. The fiber preparation methodology was also presented to the ACRS on May 15, 2007 (Ref. 7.5).

The 2006 Salem strainer bypass tests were performed at CCI in March and April of 2006. The 2008 fiber bypass tests were performed at CCI in November and December of 2008 to confirm that the information from the 2006 fiber bypass tests was conservative.

The primary difference between the two sets of tests was that the fiber preparation methods in the 2008 tests included baking the fibers, while the 2006 tests did not bake the fibers. Also, the 2008 tests included three fiber types in the fiber debris mixture (NUKON, Kaowool, and Fiberglas) while the 2006 tests were run primarily with NUKON only (1 test included Kaowool). In addition, the 2008 tests were run with a Salem specific 2-sided test strainer module in the CCI multi-functional test loop (MFTL) while the 2006 tests were run with a 1-sided test strainer module in the MFTL (Section 3f.4.2.2.2 of Ref. 7.2).

The NRC Staff witnessed Salem strainer head loss tests performed in the 2 sided MFTL on April 20-25, 2008. The NRC observations from these tests are documented in a trip report dated July 16, 2008 (ADAMS Accession No. ML081640193, Ref. 7.3). In this report, the NRC concluded that the test methods, including fiber debris preparation methodology, employed by CCI were generally prototypical or conservative. Both the 2006 and 2008 fiber debris bypass tests utilized the same fiber preparation methodology as was witnessed. In addition, in the fall of 2007, fiber debris samples similar to the debris used in MFTL testing prepared by CCI were provided to the NRC staff for review (as documented in the response to Draft Audit Open Item #6 in Attachment 3 to the SR, Ref. 7.2).

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3.0 TESTING METHODOLOGY

The 2008 Salem bypass test fiber debris preparation sequence consists of the following items which are repeated from Sections 3f.4.1.5.7.1, 3f.4.1.5.11 and 3f.4.1.6.5 of the supplemental response (Ref. 7.2).

- a) The fibers were freed from the jacketing (if jacketed).
- b) Then the fibers were baked by placing them in an oven with a regulated temperature of 250°C for 24 hours. The baking was meant to simulate the exposure of fiber insulation in the plant to hot surfaces such as the steam generator, pressurizer, and piping. This step does not apply to Fiberglas preparation since it is not installed on hot piping in the plant.
- c) The fibers were hand cut into pieces approximately 50 mm x 50 mm.
- d) The dry material was weighed.
- e) The fibers were split into batches of 3 to 4 dm³ (0.1 to 0.14 ft³) and soaked in ~2 liters of water (½ gal) until the fiber appeared saturated. In the tests, NUKON and Kaowool were mixed together into the same fiber slurry while Fiberglas was mixed in a separate slurry.
- f) The fiber pieces were decomposed by a high pressure water jet with a capacity of 100 bar (1,450 psi) and with the jet a distance of ± 0.05 m to the water surface. Each fiber batch was blasted for approximately 4 minutes.
- g) Water added during fiber decomposition with the water jet was not drained as some of the fiber fines would be lost.
- h) It was ensured by visual means that the insulation was decomposed in the water into fine pieces with no clumps of fibers remaining intact and individual fiber pieces smaller than 8 mm.
- i) Several batches could be mixed together to a main batch (portion) according to the test description.
- j) During the debris addition sequences, the fiber slurries were periodically mixed/re-suspended in the debris preparation buckets to breakup and prevent debris agglomeration (Section 3f.4.1.5.11 of Ref. 7.2).
- k) The maximum fiber concentration in the buckets was approximately 11 to 12.5 grams per liter of fiber fines (Section 3f.4.1.5.11 of Ref. 7.2). This is consistent with NEI procedures which state that the batches should be combined such that the combined mixture results in a fiber mass to volume of water ratio less than or equal to approximately 25 gm / l (Ref. 7.1).

4.0 DIFFERENCES BETWEEN 2006 AND 2008 SALEM FIBER BYPASS TESTS

The 2006 fiber debris preparation procedure is similar to the 2008 tests as noted in Section 3f.4.1.3.5 of the Supplemental Response (Ref. 7.2) with the exception of:

- a) Fibers were not baked in 2006
- b) Fibers were leaf shredded in 2006 and hand cut in 2008 (prior to soaking)

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5.0 COMPARISON TO NEI RECOMMENDATIONS FOR BYPASS TESTING

The methodology used to prepare the fiber insulation is generally consistent with NEI's recommended procedure (Ref. 7.1). Minor differences between the fiber preparation used by Salem in the bypass tests and recommended by NEI are noted and expanded upon below.

5.1 Hot Plate Heating

During CCI tests, fibers were baked by placing them in an oven with a regulated temperature of 250°C (482°F) for 24 hours. The NEI procedure (Ref. 7.1) states that fiber shall be heated on a hot plate at a temperature of 300°C ± 38°C (572°F ± 68°F) for 6 to 8 hours. Inspection criteria for acceptance is a gradient of color in the fiberglass from the hot face to approximately half way through the thickness of the insulation sheet (Ref. 7.1). Given that the NEI methodology allows for 6 hours at 262°C (300°C-38°C), 250°C for 24 hours from both sides (oven versus hot plate) is considered acceptable and possibly more conservative despite using a baking temperature 12°C lower than that recommended by NEI.

5.2 Fiber to Water Ratio Prior to Blasting

The fiber to water ratio for the debris portions that were placed into the test flume is consistent with the NEI procedure recommendation (< 25 g/l). However, the NEI procedure also recommends that prior to fiber separation the fiber to water ratio in the bucket should be less than or equal to 0.72 lbs/gallon (86 gm/liter) of water (Ref. 7.1). According to Section 3f.4.1.5.7.1 of the supplemental response (Ref. 7.2), before fiber separation, the fibers were split into batches of 3 to 4 dm³ (0.1 to 0.14 ft³) and soaked in ~2 liters of water (½ gal) until the fiber appeared saturated. Depending on the mixture of NUKON and Kaowool in the test, the fiber concentration prior to separation may be slightly more than the NEI procedure recommendation. The fiber to water ratio prior to mixing was as high as 1.4 lbs/gallon. However, exceedances prior to jet blasting are acceptable since the concentration is immediately reduced when external water (from water jet blasting) is added.

5.3 Water Jet Pressure

CCI used a high pressure water jet with a capacity of 100 bar (1,450 psi) to decompose the fiber samples. However, the NEI procedure recommends using a commercially available 1,500 psi high pressure water jet. The slight difference in jet pressure (1,450 psi versus 1,500 psi) is insignificant. The water jet pressure is limited by what is commercially available in the testing locale. While a 1,500 psi jet is standard in the United States, a 100 bar jet is standard in Switzerland, and not vice versa.

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6.0 CONCLUSION

Overall, the fiber debris preparation method used in the Salem strainer bypass tests is consistent with that proposed by the NEI as an industry standard with a few minor deviations as noted above. These minor deviations are not expected to result in any significant differences in the bypass test results.

7.0 REFERENCES

- 7.1 Letter from J. Butler (NEI) to S. Bailey (NRC), Subject: Fibrous Debris Preparation Procedure for ECCS Recirculation Sump Strainer Testing, Revision 1, dated January 30, 2012 (ADAMS Accession No. ML120481052), including Attachment entitled, "ZOI Fibrous Debris Preparation: Processing, Storage and Handling," Revision 1, January 2012, (ADAMS Accession No. ML120481057).
- 7.2 PSEG Letter No. LR-N12-0124 from Carl J. Fricker (Salem) to NRC, Subject: "Final Supplemental Response to Generic Letter 2004-02," dated 4/27/2012 (ADAMS Accession No. ML12129A388) including Attachments 1 through 8 (ADAMS Accession No. ML12129A389 and ML12129A390).
- 7.3 Memorandum to Michael L. Scott (Office of Nuclear Reactor Regulation) from Stephen J. Smith and Matthew G. Yoder (Office of Nuclear Reactor Regulation), "Foreign Travel Trip Report—NRC Staff visit to Winterthur, Switzerland, to Observe Sump Strainer Testing Performed by Control Components, Incorporated – Detailed Technical Description," July 16, 2008. (ADAMS Accession No. ML081640193)
- 7.4 VTD 901382, Rev. 3, CCI Report Q.003.84 808, Revision 6, 11/21/2008, "Containment Sump Strainer Replacement: Salem MFT Thin Bed and Bypass Test Specification.
- 7.5 Official Transcript of Proceedings, Work Order No. NRC-1577, "Advisory Committee on Reactor Safeguards Thermal Hydraulic Phenomena Subcommittee," May 15, 2007.