Progress Energy

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JAN 31 2011

Serial: HNP-11-006
10 CFR 50.54(f)

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

SHEARON HARRIS NUCLEAR POWER PLANT, UNIT NO. 1
DOCKET NO. 50-400/RENEWED LICENSE NO. NPF-63
UPDATED RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS" (TAC NO. MC4688)

References:

1. Letter from C. L. Burton to the Nuclear Regulatory Commission (Serial: HNP-10-023), "Response to Request for Additional Information Regarding Supplemental Response to Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors' (TAC NO. MC4688)," dated April 27, 2010

2. Letter from M. Vaaler, Nuclear Regulatory Commission to C. L. Burton, "Shearon Harris Nuclear Power Plant, Unit 1 – Request for Additional Information Regarding Supplemental Responses to Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors' (TAC NO. MC4688)," dated December 30, 2009

3. Letter from M. Vaaler, Nuclear Regulatory Commission, to C. L. Burton, "Shearon Harris Nuclear Power Plant, Unit 1 – Supplemental Response Regarding Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors' (TAC NO. MC4688)," dated June 18, 2010

Ladies and Gentlemen:

Harris Nuclear Plant (HNP) provided responses dated April 27, 2010 (Reference 1) to the NRC's request for additional information (RAI) (Reference 2) regarding supplemental response to NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors." Since additional testing was required to be performed subsequent to that submittal, HNP agreed to report the results of the additional testing to the NRC by January 31, 2011, as confirmed in the NRC letter dated June 18, 2010 (Reference 3).

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The results of this additional testing are provided in this submittal.

This document contains no new regulatory commitment.

Please refer any questions regarding this submittal to Mr. John Caves, Supervisor – Licensing/Regulatory Programs, at (919) 362-3137.

I declare, under penalty of perjury, that the foregoing is true and correct.
Executed on [JAN 3 1 2011]

Sincerely,

Christopher L. Burton

CLB/kms

Enclosure: Updated Response to Request for Additional Information Regarding Supplemental Responses to Generic Letter 2004-02

cc: Mr. J. D. Austin, NRC Sr. Resident Inspector, HNP
Mr. V. M. McCree, NRC Regional Administrator, Region II
Mrs. B. L. Mozafari, NRC Project Manager, HNP

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By letter dated December 30, 2009, the NRC provided a request for additional information (RAI) regarding the Shearon Harris Nuclear Power Plant (HNP), Unit No. 1, response to NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors." In HNP's April 27, 2010, initial response to the RAIs, Carolina Power and Light Company, also known as Progress Energy Carolinas, Inc., committed to perform additional testing and to provide the results of that testing to the NRC by January 31, 2011. This Enclosure contains HNP's updated RAI responses which incorporate the results of this retesting.

Although there were no changes to the Request 21 RAI response submitted April 27, 2010, that response is repeated here, providing a complete RAI response submittal.

Break Selection
<u>*NRC Request 4:*</u>

The RAI noted that a zone of influence (ZOI) reduction for encapsulated Min-K from 28.6D to 4D was used based on Continuum Dynamics, Inc. testing of Diamond Power reflective metal insulation. The RAI requested the details of the testing conducted to justify the ZOI reductions.

The response provided additional information regarding the construction of the insulation system installed in the plant and the testing conducted on the Diamond Power reflective metal insulation. The staff reviewed the additional information as well as the test reports that were cited. The staff could not verify that the seams in the test cassettes were riveted similarly to the plant cassettes.

The response claimed that the Min-K insulation is less likely to deform than the aluminum foils within the cassettes that were tested. The staff considers that the assertion that a less deformable fill material would result in less damage does not have a technical basis because less deformation may cause increased stresses in other components of the insulation system. In addition, the licensee reduced the destruction pressure from that measured in testing for conservatism.

The assertion that the cassettes would not be damaged outside a 4D ZOI rests on a comparative analysis between the tested and installed insulation systems. However, the comparative analysis did not show that the tested and installed cassettes were constructed similarly enough to ensure that the 4D ZOI is sufficiently conservative.

Although some conservatism was added to the evaluation, the staff is not able to conclude that the 4D ZOI assumption is conservative because of the large variability in cassette construction, test results, and questions regarding the scaling of jet impingement tests. Therefore, please provide additional information to demonstrate that the 4D ZOI is justified.

<u>HNP Response:</u>

In order to fully address GL 2004-02, HNP has opted to replace the Min-K insulation on the Pressurizer power operated relief valve (PORV) and safety relief valve (SRV) loop seal piping with a low-density fibrous insulation material that is less problematic from a sump strainer head loss standpoint. The Min-K insulation that will be replaced represents all Min-K insulation that could be damaged by a loss-of-coolant accident (LOCA). HNP has recalculated debris quantities and characteristics with the replacement material and has demonstrated that the debris transported to the sump strainer due to a break of the Pressurizer PORV or SRV piping is bounded by the debris generated by the tested break of the crossover leg nozzle of Steam Generator 'B'.

Head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

Walkdowns in preparation for the Min-K insulation material replacement occurred during the fall 2010 Refueling Outage, with replacement scheduled during the spring 2012 Refueling Outage 17.

Debris Transport
<u>NRC Request 6:</u>

Part 1: The RAI requested further justification for crediting the settlement of fine debris assuming that the analyses used Stokes' Law as the basis. The staff deduced that more than 15 percent inactive pool volume was likely credited for holdup of fine debris (a value which the safety evaluation recommended as a limit).

Latent fibrous debris is a significant contributor to the limiting strainer head loss based on existing testing. Therefore, please clarify whether more than 15 percent of latent debris was credited with being held up in inactive volumes (including non-operating sumps). If so, provide a basis for this assumption considering Section 3.6.3 of the associated safety evaluation.

<u>HNP Response:</u>

Part 1: In the previous analysis, more than 15 percent of latent fine debris was credited with being held up in inactive volumes. The latent debris capture in the incore instrumentation tunnel/reactor cavity was truncated at 15 percent, although the calculated value was 23 percent. The non-operating sump was then credited with capturing an additional 8 percent of the latent debris. Debris transport calculations have been revised to credit no more than 15 percent latent fine debris as being held up in inactive volumes.

Strainer head loss testing was repeated using the revised debris loads consistent with the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038).

NRC Request 6:

Part 2: The RAI requested further justification for crediting the settlement of fine debris assuming that Stokes' Law was used as the basis. The staff understood the following main points based on the supplemental responses: (1) the case where the Stokes' Law approach is credited is not considered to be the limiting break based on existing strainer testing, and (2) the quantity of fine fiber assumed to settle during recirculation is fairly limited (about 5.1 cubic feet, which is approximately 7.6 percent of the fine fiber quantity at the strainer).

The staff did not consider that the response adequately justified the settlement, however, because (1) it was not clear that the crossover leg testing was performed in a prototypical manner, and (2) given the uncertainties with the Stokes' Law settling approach, when combined with uncertainties associated with latent debris being held up in inactive pool volumes and with the estimation of debris erosion, it was not clear that the limiting quantity of fine fibrous debris was considered in the licensee's evaluation.

As such, it was not clear to the staff that the fine fibrous debris credited with settling during recirculation can be considered insignificant. Therefore, please provide a technical basis to justify the current Stokes' Law approach used to credit the settlement of fine debris, or else demonstrate that a bounding quantity of fine fibrous debris was included in the strainer head loss tests.

HNP Response:

Part 2: In order to ensure a bounding quantity of fine fibrous debris is considered, the assumption that this type of debris will settle per Stokes' Law was removed. As mentioned in the Part 1 response above, applicable debris transport calculations were revised and strainer head loss testing was repeated using the revised debris loads consistent with the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

NRC Request 8:

The RAI requested further justification for the crediting of debris retention on gratings in upper containment. The staff did not consider the response to have fully addressed the question for the following reasons:

a. *It appears the analysis may have assumed a 50 percent capture percentage for each level in a series of gratings. The staff would expect downstream gratings to have reduced capture percentages, since the less transportable debris pieces would be preferentially filtered out on upstream gratings.*

b. *Part of the response was based on data for 6-inch x 4-inch debris pieces, which, although grouped with small pieces in the HNP analysis, would be considered large pieces, per Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," guidance, rather than small pieces.*

   Furthermore, per the blowdown data in NUREG/CR-6369, "Drywell Debris Transport Study," these 6-inch x 4-inch pieces would seemingly tend not to pass through gratings to the extent the analyses assumed during the blowdown phase (which would impact the credit taken for such pieces subsequently being retained on the upper side of gratings during washdown).

c. *Although the uniform spray flow areal densities in pressurized water reactors are typically significantly lower than the spray flow rate tested in NUREG/CR-6369, a substantial fraction of the debris interdicted by gratings would likely be exposed to more concentrated streams of drainage.*

d. *It is not clear to the staff why a significant amount of debris blown to upper containment would be capable of gravitationally settling in sheltered areas of containment where spray cannot reach.*

Please address these remaining points related to the credit taken for retention of debris pieces on gratings in upper containment, or demonstrate that the total fiber used in the strainer testing was prototypical or conservative.

<u>HNP Response:</u>

HNP has opted to conservatively assume no debris retention on gratings and upper containment. Applicable debris transport calculations have been revised and strainer head loss testing was repeated using the revised debris loads consistent with the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

<u>NRC Request 10:</u>

This RAI requested further justification to demonstrate the adequacy of the testing credited to support an erosion percentage of 10 percent for small and large pieces of unjacketed low-density *fiberglass. Based on the information provided in the supplemental response, the staff considers it possible that the erosion testing being credited could be the generic testing performed by Alion as reported in the February 23, 2009, RAI response from the San Onofre Nuclear Generating Station (ADAMS Accession No. ML090580024).*

The staff is concerned that these test results may be spurious, because the longer-duration tests showed a significantly lower cumulative erosion percentage than the shorter-duration tests. Therefore, please identify the vendor that performed the debris erosion testing credited by HNP and provide a graph of the percent of eroded debris as a function of time for the erosion tests that were performed. In addition, please provide justification that the tests are valid if anomalous behavior is apparent in the test results.

HNP Response:

Since the time Alion performed the fiber erosion testing initially credited by HNP, they have revised their 30-day erosion testing protocol. Although retesting results support an overall erosion fraction of approximately 6% for HNP, HNP will continue to use the more conservative erosion allowance of ten percent for small and large pieces of unjacketed low-density fiberglass.

Head Loss and Vortexing

NRC Request 13:

This RAI requested the basis for (1) attributing the lower head loss associated with the test without debris bypass eliminators (DBEs) installed solely to the removal of this mesh and (2) the position that the expected variation associated with a repeat test performed for the HNP strainer design without DBEs could not exceed the small demonstrated margin (0.12 ft) available for the residual heat removal pumps.

The supplemental response provided additional information regarding the tests conducted with (test 3) and without (test 4) the DBE mesh. The RAI response states that the tests were conducted identically with the exception of the installation of the DBE. Graphs of the test results were provided; however, the graphs were too compressed along the time scale to allow the staff to compare behavior of the head loss during the addition of the various debris types.

In addition, the difference in bed formation was attributed to the DBE. The supplemental response stated that a bed forms across the DBE and also that the DBE affects the bed formation on the strainer surface, resulting in a more uniform bed. However, the staff has not observed or been made aware of other cases in which an Enercon strainer DBE has formed a debris bed. In addition, the assertion that the DBE results in a more uniform debris bed on the top hat surface is contrary to observations made by Alion during most similar tests.

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The response also stated that during non-chemical testing, two Microtherm tests were performed with relatively similar results, thereby showing test repeatability. In addition, the response stated that Min-K is fabricated from the same constituents as Microtherm and therefore should behave similarly. However, the staff noted that the response to RAI 14 pointed out significant differences between the percentages of each constituent making up the two types of insulation; therefore, the staff believes that the chemical effects tests conducted with the two different materials should not be compared.

The staff concludes that there is not enough information to justify that the full difference between test 3 and test 4 was due solely to the absence of the DBE in test 4. Further information may be available to assist in this justification, and is requested in order for the staff to complete its review. For example, the licensee could provide higher resolution test traces of head loss during debris addition to provide additional insight. The licensee could also provide details of industry experience for other problematic debris tests both with and without the DBE installed in Enercon strainers.

<u>HNP Response:</u>

During the spring 2012 refueling outage, HNP will be replacing the encapsulated Min-K insulation on the Pressurizer PORV and SRV loop seal piping with a low-density fibrous insulation material that is less problematic from a sump strainer head loss standpoint. HNP has recalculated debris quantities and characteristics with the replacement material and has demonstrated that the debris transported to the sump strainer due to a break of the Pressurizer PORV or SRV piping is bounded by the debris generated by the tested break of the crossover leg nozzle of Steam Generator 'B'. Head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). In order for the testing to be more representative of the final installed HNP strainer design, these additional tests were conducted without the use of Debris Bypass Eliminator mesh. The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

In order to mitigate some of the effects of head loss on predicted strainer performance, HNP is crediting delayed chemical precipitate formation based on the correlations found in the Argonne National Laboratory (ANL) report titled "Aluminum Solubility in Boron Containing Solutions as a Function of pH and Temperature", September 19, 2008.

The aluminum solubility limit for HNP's sump pool has been calculated using equation (4) from the above ANL report. Comparing the amount of dissolved aluminum in the HNP sump pool to this calculated aluminum solubility limit indicates that the sump pool will reach equilibrium without the solubility limit being exceeded. Therefore, no aluminum based precipitates are projected to form during the 30 days following a LOCA.

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However, to further address cooling of the sump pool as well as modeling uncertainties, it is assumed that the full chemical load precipitates when the sump pool temperature cools to 140°F, which occurs approximately 10 days following a LOCA. The Residual Heat Removal pump (RHR) and Containment Spray pump net positive suction head (NPSH) calculations were revised to consider non-chemical debris sump strainer head loss at a sump pool temperature of 212°F and debris head loss with chemicals at a sump pool temperature of 140°F since these sump pool temperatures are the two most limiting points in terms of $NPSH_A$.

A sump pool temperature of 212°F corresponds to the saturation temperature for the minimum containment pressure allowed in Technical Specifications, (-) 1" wg (14.66 psia). At higher sump temperatures, strainer head loss is less (due to lower water viscosity) which results in a greater $NPSH_A$ and at temperatures below 212°F, the minimum allowed pre-accident containment pressure maintains the sump pool in a subcooled condition. Subcooling decreases vapor pressure and increases strainer head loss due to higher water viscosity. However, since the rate of vapor pressure decrease exceeds the rate of strainer head loss increase, $NPSH_A$ and NPSH margin increase at temperatures below 212°F. As an example, the vapor pressure of water decreases from 35.38 ft at 212°F to 0.20 ft at 32°F (a decrease of 35.18 ft) while per the strainer head loss analysis, the head loss across the strainer increases from 0.26 ft at 212°F to 4.71 ft at 32°F (an increase of only 4.45 ft).

A sump pool temperature of 140°F corresponds with the maximum temperature at which chemical precipitates are postulated to form in the sump pool and begin affecting $NPSH_A$. This temperature is most limiting in terms of NPSH margin for a strainer debris load with chemicals since the effects of additional subcooling (i.e., rate of vapor pressure decrease) exceeds the effects of viscosity increase (i.e., rate of strainer head loss increase) at lower temperatures and thus $NPSH_A$ and NPSH margin increase.

The amount of aluminum released and in the sump pool was obtained by using HNP-specific inputs in an Excel spreadsheet developed by Westinghouse in conjunction with WCAP-16530-NP. The maximum sump pH profile (9.42 at equilibrium) was used as input to the spreadsheet because higher pH values result in conservatively larger amounts of released aluminum. In addition, the released aluminum amounts corresponding to the RCS Loop break were selected for comparison to the ANL Solubility limit since this break yields the highest amount of released aluminum of the three limiting breaks considered (RCS Loop, RV Nozzle, Pressurizer Safety Line).

The minimum sump water volume was assumed for calculating dissolved aluminum since this was shown to result in the highest dissolved aluminum concentration for the given pH profile. The sump pool aluminum concentration at equilibrium (30 days) was found to be 10.6 ppm. The ANL solubility limit was calculated using equation (4) from the ANL report. The minimum sump pH profile (8.48 at equilibrium) was used in this calculation because it results in a lower, and thus more conservative, aluminum solubility limit. Based on the minimum pH and a sump temperature of 133°F (from the HNP Containment Analysis) the aluminum solubility limit at 30 days was found to be 55.6 ppm. This represents a margin of 45 ppm over the projected amount of dissolved aluminum in the sump pool at this time. HNP is crediting that aluminum based precipitates do not form until the sump pool cools to 140°F. At this temperature the aluminum solubility limit is 82.2 ppm and the amount of dissolved aluminum is 9.6 ppm. This represents a margin of 72.6 ppm above the point where aluminum based precipitates will form at this temperature.

<u>NRC Request 14:</u>

The RAI raised questions regarding the repeatability of the Alion testing based on the results of HNP test cases using Min-K and Microtherm [microporous insulation]. Specifically, given that Min-K and Microtherm are composed essentially of the same base materials (silicon dioxide and titanium dioxide), and given that the amounts of Min-K and Microtherm in the material-specific testing were close to the same (11.6 cubic feet (ft) and 12.1 ft, respectively), the staff asked for the basis for why these two similar materials had significantly different head loss results in the tests with the DBE mesh installed. Although the final HNP strainer configuration does not contain a DBE mesh, this observation demonstrates the potential for a lack of repeatability in the head loss test results.

The supplemental response stated that although the materials are composed of the same constituents, the percentage of each constituent is sufficiently different, such that the head loss from tests of the two materials would be expected to be different. The staff understands that there are differences in the amount of each constituent in the insulation. However, the information provided does not remove doubt about the consistency of test results attained during the strainer testing.

The staff noted the following during its review: 1) the fibrous portion of the microporous debris should not be a large contributor to any differences due to the other fibrous debris (latent) included in the test; 2) the amount of fumed silica in each test was approximately the same; 3) the titanium dioxide was significantly higher in the Microtherm test, yet this test had lower head loss; and 4) unless the titanium dioxide is a contributor to reduced head loss, or the fibrous debris added to the test(s) for latent debris was not prepared properly as fines, it is difficult to understand how the test results are consistent. Therefore, please address the above stated staff concerns regarding test repeatability.

<u>HNP Response:</u>

Microtherm head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

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Additional Min-K testing was not conducted since HNP has opted to replace the Min-K insulation on the Pressurizer PORV and SRV loop seal piping with a low-density fibrous insulation material that is less problematic from a strainer head loss standpoint.

NRC Request 15:

The RAI requested the fibrous debris size distribution used for testing, as well as a comparison to the size distribution predicted by the transport evaluation.

The supplemental response provided additional information on the fibrous debris sizing. The test debris was stated to be within size classes 1-4 as defined by NUREG/CR-6808, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance," and deemed to be readily transportable. However, the response provided neither a predicted size distribution for the debris at the strainer nor a comparison to the size distribution used during the testing.

Based on the percentage of fiber calculated to be available for the crossover leg break, the use of size class 1-4 fibers is likely conservative for the test corresponding to that break. However, this size distribution is not representative of typical latent debris. For the hot-leg and pressurizer cubicle break, all fiber should have been size class 1-3, with a relatively low percentage of size 3 fibers because almost all fibers for these breaks are latent (treated as individual fibers).

Based on the response to RAI 15, the staff could not determine that the fibrous debris used for the pressurizer and hot-leg breaks was representative of latent debris which would provide a conservative test condition for these breaks. Further information may be available to assist in this determination, and is requested in order for the staff to complete its review.

HNP Response:

Head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038).

The following tables provide the debris size distribution of the debris at the sump for the fibrous insulation and latent fiber quantities for the limiting crossover leg break at the steam generator (SG) nozzle and for a break at the reactor vessel hot-leg nozzle, as determined by the debris generation and transport analyses. The pressurizer break was not retested as debris generated and transported to the sump strainer due to a break of the pressurizer PORV or SRV piping is bounded by the debris generated and transported by the tested break of the crossover leg.

In contrast to previous testing which utilized a single category of small fines, the fibrous debris used in the re-testing was separated into two categories. Classes 1-3 "fines" were used to represent the "fines" in the debris generation and transport analyses, the latent debris source term, and the fraction of "small pieces" and "large pieces" which are determined to reach the sump strainers by erosion, for all tests. Classes 1-4 were conservatively used to represent the "small pieces", "large pieces", and "intact pieces" from the debris generation evaluation.

While the fibrous "fines" debris portion of the full load debris fibrous quantity was utilized for the Thin-Bed test, the fibrous "small" debris portion was omitted as complete screen coverage was established after the addition of only the fibrous "fines". The Full Load fiber test utilized

Table 1. Fibrous Debris Size Distribution for a Crossover-Leg Break (Thin-Bed & Full Load tests)

Debris Type	Debris Size	Debris Quantity Generated	Debris Transport Fraction		Debris Quantity at Sump B Curb	Debris Quantity Held Up at Curb	Debris Quantity at Sump B
Nukon™	Fines	8 ft³	94%		8 ft³	0 ft³	8 ft³
	Small Pieces (<6")	33 ft³	Eroded to fines	8%	3 ft³	0 ft³	3 ft³
			Intact	27%	9 ft³	0 ft³	9 ft³
	Large Pieces (>6")	5 ft³	Eroded to fines	10%	1 ft³	0 ft³	1 ft³
			Intact	8%	0 ft³	0 ft³	0 ft³
	Intact Pieces (>6")	6 ft³	9%		1 ft³	0 ft³	1 ft³
	Total	**52 ft³**	**42%**		**22 ft³**	**0 ft³**	**22 ft³**
Thermal-Wrap™	Fines	65 ft³	94%		61 ft³	0 ft³	61 ft³
	Small Pieces (<6")	233 ft³	Eroded to fines	8%	19 ft³	0 ft³	19 ft³
			Intact	27%	63 ft³	0 ft³	63 ft³
	Large Pieces (>6")	110 ft³	Eroded to fines	10%	11 ft³	0 ft³	11 ft³
			Intact	8%	9 ft³	0 ft³	9 ft³
	Intact Pieces (>6")	118 ft³	9%		11 ft³	0 ft³	11 ft³
	Total	**526 ft³**	**33%**		**174 ft³**	**0 ft³**	**174 ft³**
Latent Fiber	Total (Fines)	30 lb	85%		26 lb	0 lb	26 lb

Note: Nukon™ was used as the surrogate for latent fiber. Nukon™ has an as-fabricated density of 2.4 lbm/ft³.

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Table 2. Fibrous Debris Size Distribution for a Hot-leg RV Nozzle Break (Microtherm test)

Debris Type	Debris Size	Debris Quantity Generated	Debris Transport Fraction	Debris Quantity at Sump B Curb	Debris Quantity Held Up at Curb	Debris Quantity at Sump B
Temp-Mat™	Fines	0.234 ft^3	99%	0.23 ft^3	0 ft^3	0.23 ft^3
	Small Pieces (<6”)	0.936 ft^3	Eroded to fines 8%	0.07 ft^3	0 ft^3	0.07 ft^3
			Intact 27%	0.25 ft^3	0 ft^3	0.25 ft^3
	Total	**1.17 ft^3**	**47%**	**0.55 ft^3**	**0 ft^3**	**0.55 ft^3**
Latent Fiber	Total (Fines)	30 lb	95%	29 lb	0 lb	29 lb

Note: Nukon™ was used as the surrogate for latent fiber. Nukon™ has an as-fabricated density of 2.4 lbm/ft^3.

the entire full load fibrous debris quantity. For the Microtherm test, since complete screen coverage was not attained prior to the introduction of the entire fibrous debris quantity, the entire Microtherm test fibrous debris quantity was utilized for the test. The Attachment to this Enclosure includes a summary of the latest testing and the results obtained.

<u>*NRC Request 16:*</u>

This RAI requested details of the debris addition procedures used.

The supplemental response stated that the debris was mixed with water into a homogeneous slurry using 5 gallon buckets prior to introduction into the test flume. About 1-3 pounds of debris was added to each bucket for mixing with water. Stirring was used as necessary to ensure that a majority of the debris was transported to the strainer. The response stated that the addition methods resulted in thorough mixing and dispersion of the debris and lack of agglomeration while allowing the debris to transport to the strainer.

The description provided by the response indicates that the debris introduction was conducted in a manner that would prevent agglomeration. Additionally, the response indicated that stirring prevented excessive debris settlement and that mixing of the debris typically occurred just prior to addition to the test tank.

However, during a trip to Alion to observe testing, the staff identified issues regarding debris preparation and introduction that could affect head loss and transport during testing (refer to the trip report located at ADAMS Accession No. ML071230203). The staff noted that these issues were likely more important for tests with low fibrous loads.

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Therefore, for HNP the debris preparation and introduction issues would have the most impact on the Min-K and Microtherm tests. The staff considers it likely that the debris addition practices for the HNP testing were similar to those used during the testing that the staff observed. Based these observations of similar testing, the HNP testing may not have used a conservative debris introduction process.

Accordingly, please address the above staff concerns and demonstrate that the HNP testing led to prototypical or conservative results for the strainer head loss.

<u>HNP Response:</u>

Head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). This was done to ensure the representative debris tested was prepared and introduced in a manner consistent with NRC guidance.

All fiber fines were double-shredded with a leaf shredder and all fiber smalls were single-shredded with a leaf shredder. For all tests, shredded fiber was inspected to ensure that it met the size distribution requirements. Once the shredded fiber had been inspected, the required quantity was weighed out and boiled in water for 10 minutes to remove the binder that exists in the NUKON™ and Temp-Mat™ samples. The boiled fiber was then placed in a bucket of water at a temperature within ± 10°F of the temperature of the water used for testing. The dilution ratio of fiber to water during the mixing was 0.25 lbs of fiber to 4 gallons of water for fibrous fines and 0.5 lbs of fiber to 4 gallons of water for fibrous smalls which represents a much greater dilution of fiber during preparation than that used in previous testing.

The fiber was then mixed thoroughly with a paint mixer attached to an electric drill until a homogeneous slurry was formed. For the fibrous fines, each bucket was mixed with a paint mixer for 4 minutes. For the fibrous smalls, each bucket was mixed with a paint mixer until no visible clumps remained. The slurry was sampled to visually verify that the fiber met the required size distribution. This method of debris preparation was applied to all fibrous debris types, including NUKON™, Thermal Wrap, and Temp-Mat™. The complete contents of the buckets were added to the test tank to ensure no loss of fine fibrous debris.

The different types of particulate debris, Microtherm, Silica Sand, and Green Silicon Carbide were received in their powdered forms. The particulate was then mixed thoroughly with water using a paint mixer attached to an electric drill until a homogeneous slurry was formed. The chemical precipitates were prepared in accordance with WCAP-16530-NP, kept in separate containers and added separately to the tank following addition of all conventional debris. The one-hour settling volume for each batch of chemical precipitates was determined at the time that the batch was produced. All sodium aluminum silicate and aluminum oxyhydroxide batches had one-hour settling volumes greater than 7.0 ml. All batches were tested within twenty-four hours of being used and met the one hour settling volume acceptance criteria of 6.0 ml.

Debris was introduced into the tank in areas of high velocity along the far tank wall opposite the suction point exiting the tank to maximize transport of the debris to the strainers. Mechanical mixers were added to areas of low velocity near the front of the tank opposite the sparger. Extra care was exercised to prevent turbulence from the return flow and internal mixing from negatively affecting debris deposition. For all tests, the fiber and particulate was added in batches with the test tank pump and mechanical mixers in operation. A relatively flat head loss profile (less than 1 percent change over a given time period) and a minimum number of pool turnovers (5) are examples of criteria required prior to proceeding to the next test batch or prior to test termination. The Attachment to the Enclosure includes a summary of this latest testing and the results obtained.

<u>NRC Request 19:</u>

This RAI requested information to show that a valid thin bed test was conducted such that: (1) fibrous debris preparation and introduction would result in prototypical transport and bed formation (note that the staff considers that the most transportable debris will reach the strainer first); (2) flow conditions, including any stirring used during testing, would allow prototypical bed formation; (3) the installation of the DBE would not change the prototypicality of bed formation on the strainer, or verification that testing was conducted with the same top hat arrangement (i.e., no DBE) installed in the plant; and (4) various incremental amounts of fiber were used in conjunction with limiting particulate debris loads during thin bed testing.

The supplemental response provided additional information on how head loss testing was conducted with respect to acceptable thin bed test practices. The information provided answered some areas adequately. The response regarding flow conditions (item 2) was acceptable overall. However, the other items were not addressed satisfactorily.

The response regarding item 1 stated that fibrous debris was prepared such that a range of individual fibers through -1-inch tufts was represented in the testing. For the Nukon case, which was the only case for which a thin bed test needed to be conducted, the fibrous debris should have been added such that the fine fibrous debris was introduced before the small fibrous debris, and the particulate debris should have been added prior to any fibrous debris. This position is documented in the "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). However, this was not the case for the HNP testing, as all the debris was mixed together.

The response to item 3 indicated that the installation of the DBE results in a more uniform debris bed, and would therefore result in a higher likelihood of thin bed formation. However, this statement is in conflict with information that has been provided to the staff during discussions

with Alion. According to Alion, the installation of the DBE is likely to result in a less uniform bed. Testing with the DBE installed appears, therefore, to be non-conservative for thin bed considerations when compared to the strainer installed in the plant (i.e., no DBE).
With respect to item 4, the response stated that for the Min-K and Microtherm tests, batching of fiber is not required due to the low amounts of fibrous debris created by the break. The staff considers this acceptable. However, for the
Nukon break, the two amounts of fiber tested would result in 1/8-inch and -3/4-inch theoretical bed thicknesses. These two test points do not include the likely limiting thin bed thickness for the strainers used during Alion testing. The NRC staff guidance document cited above recommends that debris be batched in small increments to determine the limiting thin bed.

Based on the above, the staff concludes that a valid thin bed test may not have been conducted. Therefore, please address the above concerns regarding the adequacy of thin bed testing for HNP.

<u>HNP Response:</u>

Head loss testing was repeated using the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038).

Test One of the testing series was a thin bed test of the limiting fibrous debris break case. After the initial clean screen flow sweep, the test continued with a single debris addition constituting the entire particulate debris load. The particulate load was allowed to stabilize for ten pool turnovers to ensure uniform distribution of the particulate debris in the test tank. The fibrous "fines" debris was then added to the tank in four separate, approximately equal additions. After the final addition of the fibrous "fines" debris it was determined that complete screen coverage had been achieved (with an equivalent bed thickness of ~0.48 inches) and therefore the fibrous "smalls" debris was not added to the test tank.

Each of the first three fibrous "fines" debris additions was allowed to stabilize for ten pool turnovers. The final fibrous addition was allowed to stabilize until there was no change in head loss over an hour. Following the addition of the particulate and fibrous non-chemical debris, chemical precipitate debris was added in eight distinct additions. The first six chemical precipitate additions were allowed to stabilize for ten pool turnovers. The seventh chemical precipitate addition was allowed to stabilize until the change in head loss was less than 1 percent over an hour. The eighth and final chemical precipitate addition was allowed to stabilize until there was no change in head loss over an hour. The Attachment to the Enclosure includes a summary of this latest testing and the results obtained.

For the additional testing to be more representative of the final installed HNP strainer design, these additional tests were conducted without the use of Debris Bypass Eliminator mesh.

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NRC Request 21:

The original submittal stated that the vortexing evaluation was completed using a residual heat removal (RHR) pump runout flow (4500 gallons per minute (gpm)). It was not clear to the staff whether containment spray flow was included in the evaluation. It was also not clear whether either testing or the clean strainer head loss calculation included the containment spray flow. The staff requested additional information regarding the pump flows that were used to furnish inputs for head loss scaling, as well as the bases for these flows.

The supplemental response provided additional information that clarified the flow rates used for both the test scaling and clean strainer head loss calculations. The response for the clean strainer head loss portion of the question is acceptable. However, based on the response, the staff could not determine why the vortexing evaluation was conducted at RHR runout flow (4500 gpm) versus maximum sump flow (5754 gpm).

The response implies that only the RHR or the containment spray pump can take suction from the sump at any given time, but this is not how the flow through the sump is described in the initial supplemental response (see page A1-31), which indicates that the RHR and containment spray pumps both take suction through the same strainer. In addition, the installation of a vortex suppressor over the strainer, as described in the initial supplemental response, indicates that a vortex from the sump pool surface is of concern.

Accordingly, please provide information to justify that the vortexing evaluation should only consider the RHR flow, and not the containment spray flow, since both pumps take suction through the strainer surface during recirculation.

HNP Response: (no change from HNP-10-023)

Each HNP sump is arranged in two halves separated by a concrete divider wall. The residual heat removal (RHR) pump suction is on one side of the wall and the containment spray pump suction is on the other with a flow-balancing opening located at the bottom of the divider wall. Due to this arrangement, a limiting case for vortexing would be one that considers the maximum flow that could be directed through one half of a sump's strainer screen area. Since the RHR pump runout flow of 4,500 gpm bounds the maximum flow rate of 1,863 gpm from the sump to a containment spray pump, 4,500 gpm was selected as the flow rate to use in the vortexing evaluation. The maximum flow rate through the RHR half of the sump strainer would actually be less than 4,500 gpm because the flow-balancing opening allows a portion of the RHR pump flow to be drawn through the containment spray half of the sump strainer screen.

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Net Positive Suction Head
NRC Request 26:

The RAI requested a description of the methodology used to compute the maximum pump flows for the RHR and containment spray pumps. Although an adequate response was provided regarding the containment spray pumps, the staff considers the response concerning the RHR pumps to be inadequate because: (1) rather than describing the methodology used, the response merely identified the vendor that performed the calculation; and (2) the response indicated that the flow rate used for the sump performance analysis was representative (e.g., as opposed to a bounding or calculated value).

Accordingly, please describe the methodology used to determine the RHR pump maximum flow rate, as well as provide the basis for considering this flow rate to be a conservative or prototypical input to the sump strainer performance analysis.

HNP Response:

In HNP's sump strainer performance analysis, two maximum RHR pump flow rates are considered. For the purpose of determining net positive suction head required, a RHR pump runout flow rate of 4,500 gpm was used. For the purpose of determining debris transport and strainer head loss, a RHR flow rate of 3,891 gpm was used. This flow rate was provided to HNP by Westinghouse as an appropriate RHR pump flow rate for both the single train failure case resulting in one RHR pump providing flow to one charging safety injection pump (CSIP) and also for the purpose of designing the original sump strainers.

A single train failure results in the transportation of all debris generated from a postulated break to the sump strainer in the operational train only. However, during a single RHR pump failure, the containment spray pump in the train with the failed RHR pump continues to operate, resulting in the distribution of debris between both strainers. The single train failure case results in the transportation of approximately 10 percent more fiber and 30 percent more particulate to a single sump strainer than occurs during the single RHR pump failure case. Single train failure also results in approximately 10 percent less sump flow than occurs in the single RHR pump failure case. However, since the significantly higher debris load for the single train failure case is considered to overwhelm the modestly higher sump flow rate for the single RHR pump failure case, the single train failure case more limiting. Since the single train failure case is limiting in terms of strainer head loss, the associated RHR pump flow rate of 3,891 gpm is prototypical.

The methodology used by Westinghouse to derive the RHR pump flow rate for the single train failure case (3,891 gpm) involved developing a system resistance curve using Zebra software, the predecessor of the PEGISYS code, and identifying its intersection with a RHR pump performance curve. HNP chose to perform a verification of this flow rate using a plant-developed system resistance curve in conjunction with pump performance curves generated

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using actual pre-operational test data. The intersection of the curves for the "B" RHR pump result in a flow rate of 3,902 gpm and the curve intersection for the "A" RHR pump result in a flow of 3,893 gpm. While these two flow rates are higher than the Westinghouse value of 3,891 gpm, the largest of the two (3,902 gpm) is only 11 gpm higher than the Westinghouse value, reflecting only a 0.28 percent increase.

The vendor pump performance curves were then compared to the HNP system resistance curve, resulting in a "B" RHR flow rate of 3,945 gpm and an "A" RHR flow rate of 3,902 gpm. Based on the highest RHR flow rate of 3,945 gpm, the resultant total sump flow for the single train failure case is 5,808 gpm. This represents less than a 1 percent difference from the analyzed sump flow of 5,754 gpm. Given the small percentage difference between the Westinghouse supplied flow rate of 3,891 gpm and the flow rates determined by HNP from test data and vendor curves, HNP considers the flow rate of 3,891 gpm to be a prototypical input to the sump strainer performance analysis. However, to ensure that the most conservative single train RHR pump flow rate is considered, HNP has used 3,945 gpm as the RHR pump flow rate during the performance of the additional strainer head loss testing. This conservatism, which is in addition to other conservatisms such as not crediting Stokes' Law settling or debris hold-up on gratings, was included in the additional sump strainer head loss testing that HNP has performed.

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ATTACHMENT

SUMMARY OF LATEST TESTING AND RESULTS OBTAINED

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Summary of Testing

Debris preparation and introduction were in accordance with the guidance in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). A summary of debris preparation, including fiber size distribution, and debris introduction is included in the response to RAI's 15 and 16. Three tests were conducted. The tests consisted of a fiber "thin bed" test, a full load test conducted with the full quantity of non-chemical and chemical debris load postulated to transport to the strainer from the limiting fibrous break at the 'B' Crossover leg, and a Microtherm test which was performed according to the "thin bed" protocol and examined the debris load transported to the strainer from a break at a Reactor Vessel hot-leg nozzle.

HNP's sump strainer system has a design basis mission time of 30 days. As each test was conducted over 2-3 days, it was necessary to extrapolate the head loss data observed during testing to determine the head loss value over the 30-day mission time. To accomplish this, the head loss data recorded during the non-chemical and chemical debris addition portions of the "thin bed" and "full load" fibrous tests were each used to produce a logarithmic curve fit. A separate curve fit was produced for the non-chemical and chemical portions of each of the tests. These curve fits could then be utilized to determine the head loss of the non-chemical and chemical debris beds for each of the tests at the conclusion of the 30-day mission time. As the head losses observed during the Microtherm test were easily bounded by those observed in the fiber "thin bed" and "full load" tests, it was deemed unnecessary to extrapolate the head loss data of the Microtherm test to the 30-day mission time. Graphical results from each test including the logarithmic curve fits are provided at the end of this summary.

Thin Bed Test:

The thin bed test was conducted with the "thin bed" protocol, including the addition of the particulate debris load in its entirety before the fine fibrous debris, per "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038).

The test began with a clean screen flow sweep followed by addition of the particulate debris load. After addition of the particulate debris load, the fine fibrous debris was added in batches. Complete screen coverage, with an equivalent bed thickness of approximately 0.48 inches, was established after the addition of the final fibrous "fines" addition. Because complete screen coverage had been established, the addition of fibrous "smalls" debris was omitted. The chemical debris load was then batched in according to the test plan. Following the addition of the chemical debris load, and stabilization of the head loss, a second flow sweep was performed across the debris laden strainer array. The water level in the test tank was then lowered to the design basis minimum water level of 4-1/8 inches above the top of the strainer array. Once the water level reduction had been completed, a final flow sweep was performed to determine the vortex formation potential of the debris laden strainer.

The maximum and final stable head loss observed prior to the introduction of chemical precipitates was 0.09 feet at an approximate test temperature of 84°F. The maximum head loss following the introduction of chemical precipitates was 1.25 feet, while the final stable head loss was 1.20 feet at an approximate test temperature of 85°F. The head loss data from the test was then extrapolated to the design basis mission time of 30 days. The extrapolated non-chemical head loss was 0.14 feet at test temperature and the extrapolated chemical head loss was 2.12 feet at test temperature. This chemical head loss represents the bounding chemical debris head loss for all three tests. Temperature corrections were then applied to this extrapolated value for its use in determining limiting $NPSH_A$ for the RHR and Containment Spray pumps. Refer to Tables 3 through 5 in this Attachment for the temperature corrected bounding test results and resultant pump NPSH and structural margins.

Full Load Fiber Test:

The full load test was conducted with the "full load" protocol, including the addition of the particulate debris load concurrently with the fibrous debris, per "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The test was conducted with the full quantity of non-chemical and chemical debris load postulated to transport to the strainer from the limiting fibrous debris break of the 'B' Crossover leg at the Steam Generator nozzle.

The test began with a clean screen flow sweep followed by the addition of the non-chemical debris. Both particulate and fibrous non-chemical debris were added in four approximately equal batches. The first and second batches included fibrous "fines" debris, while the third and fourth batches included fibrous "smalls" debris. The four debris batch additions were not separated by any stabilization requirements. After all non-chemical debris additions, the system was allowed to stabilize until there was no change in head loss over an hour. The equivalent bed thickness with the full debris load was approximately 0.88 inches. After stabilization occurred, the test continued with addition of the chemical precipitate debris. Following the addition of the chemical debris load, and stabilization of the head loss, a second flow sweep was performed across the debris laden strainer array. The water level in the test tank was then lowered to the design basis minimum water level of 4-1/8 inches above the top of the strainer array. Once the water level reduction had been completed, a final flow sweep was performed to determine the vortex formation potential of the debris laden strainer.

The maximum head loss observed prior to the introduction of chemical precipitates was 0.18 feet, while the final stable head loss was 0.17 feet at an approximate test temperature of 83°F. The maximum head loss with chemical precipitates was 0.62 feet, while the final stable head loss was 0.60 feet at an approximate test temperature of 83°F. The head loss data from the test was then extrapolated to the design basis mission time of 30 days. The extrapolated non-chemical head loss was 0.32 feet at test temperature and the extrapolated chemical head loss was 0.96 feet at test temperature. The non-chemical head loss represents the bounding non-chemical debris head loss for all three tests. Temperature corrections were then applied to this extrapolated value for its use in determining limiting $NPSH_A$ for the RHR and Containment Spray pumps. Refer to Tables 3 through 5 in this Attachment for the temperature corrected bounding test results and resultant pump NPSH and structural margins.

Microtherm Test:

The Microtherm test was conducted with the "thin bed" protocol as described in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing" (ADAMS Accession No. ML080230038). The particulate debris load was added in its entirety, followed by the microporous (Microtherm) debris, before the fibrous debris. The fibrous debris (both fines and smalls) were then added in batches in an attempt to attain complete screen coverage.

The test began with a clean screen flow sweep followed by the addition of the non-chemical debris. The non chemical debris additions began with the introduction of the Dirt/Dust (Silica sand) and Silicon Carbide, which were added in a single addition. This single addition was allowed 10 pool turnovers to ensure uniform distribution of the particulate debris in the test tank. The microporous particulate debris (Microtherm) was then added in a single addition. This debris addition was allowed a single pool turnover to distribute uniformly throughout the tank. The fibrous debris was then added in two separate additions, one consisting of the fibrous "fines" debris and another consisting of the fibrous "smalls" debris. The first fibrous debris addition was allowed 10 pool turnovers to stabilize. The second fibrous debris addition was allowed to stabilize until there was no change in head loss over an hour.

Following the addition of all fibrous debris it was determined that complete screen coverage had not been attained and therefore an additional, conservative paint chip addition was introduced to the test tank, after which the head loss across the debris bed was allowed to stabilize prior to the continuation of the test. The equivalent bed thickness after the addition of all debris was approximately 0.06 inches. After head loss stabilization occurred, the test continued with addition of the chemical precipitate debris. Following the addition of the chemical debris load, and stabilization of the head loss, a second flow sweep was performed across the debris laden strainer array. The water level in the test tank was then lowered to the design basis minimum water level of 4-1/8 inches above the top of the strainer array. Once the water level reduction had been completed, a final flow sweep was performed to determine the vortex formation potential of the debris laden strainer.

The maximum and final stable head loss observed prior to the introduction of chemical precipitates was 0.051 feet at an approximate test temperature of 86°F. The maximum head loss following the introduction of chemical precipitates was 0.058 feet, while the final stable head loss was 0.050 feet at an approximate test temperature of 89°F. As the head losses observed during the Microtherm test are easily bounded by those observed in the fiber "thin bed" and "full load" tests, it is unnecessary to extrapolate the head loss data of the Microtherm test to the 30 day mission time. Refer to Tables 3 through 5 of this Attachment for the temperature corrected bounding test results and resultant pump NPSH and structural margins.

Vortexing:

Flow sweeps were conducted with clean screens and fully loaded screens at the minimum expected water level associated with the debris load for each test. The flow sweeps determined that a sustained vortex would not form even with a debris laden strainer.

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Test Results:

As explained in the response to RAI 13, the limiting head loss occurs at a sump pool temperature of 212°F for a non-chemical debris load and a sump pool temperature of 140°F for a chemical debris load. From a strainer structural margin standpoint, a sump pool temperature of 32°F was considered as the head loss at that temperature would be bounding for structural margin.

Table 3:
Bounding Extrapolated Testing Head Losses

Debris Type	Temperature (°F)	Bounding Head Loss Value (ft-H2O)
Non-Chemical	212	0.26
Chemical	140	1.99
Chemical	32	4.71

Table 4:
RHR and Containment Spray Pump NPSH

Pump	$NPSH_A$ @ 212°F (ft-H2O)	$NPSH_A$ @ 140°F (ft-H2O)	$NPSH_R$ (ft-H2O) at max flow	NPSH margin (ft-H2O) (based on limiting $NPSH_A$)
RHR	21.23	46.52	19	2.23
Containment Spray	26.1	51.4	12	14.1

Table 5:
Structural Margin

Bounding Head Loss Value	Strainer Structural Limit	Structural Margin
4.71 ft-H2O (2.04 psid)	7 psid	4.96 psid

The head loss test results are provided in graphical format on the following pages.

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Conclusions:

Testing and analyses of the head loss across the sump strainer with various debris loads from postulated limiting LOCA's demonstrated that positive NPSH margin will be maintained for the RHR and Containment Spray pumps as well as positive margin for the strainer structural limits. Therefore, no additional modifications beyond the planned replacement of the Min-K insulation, as described in RAI 4, are required to address HNP's sump strainer performance.

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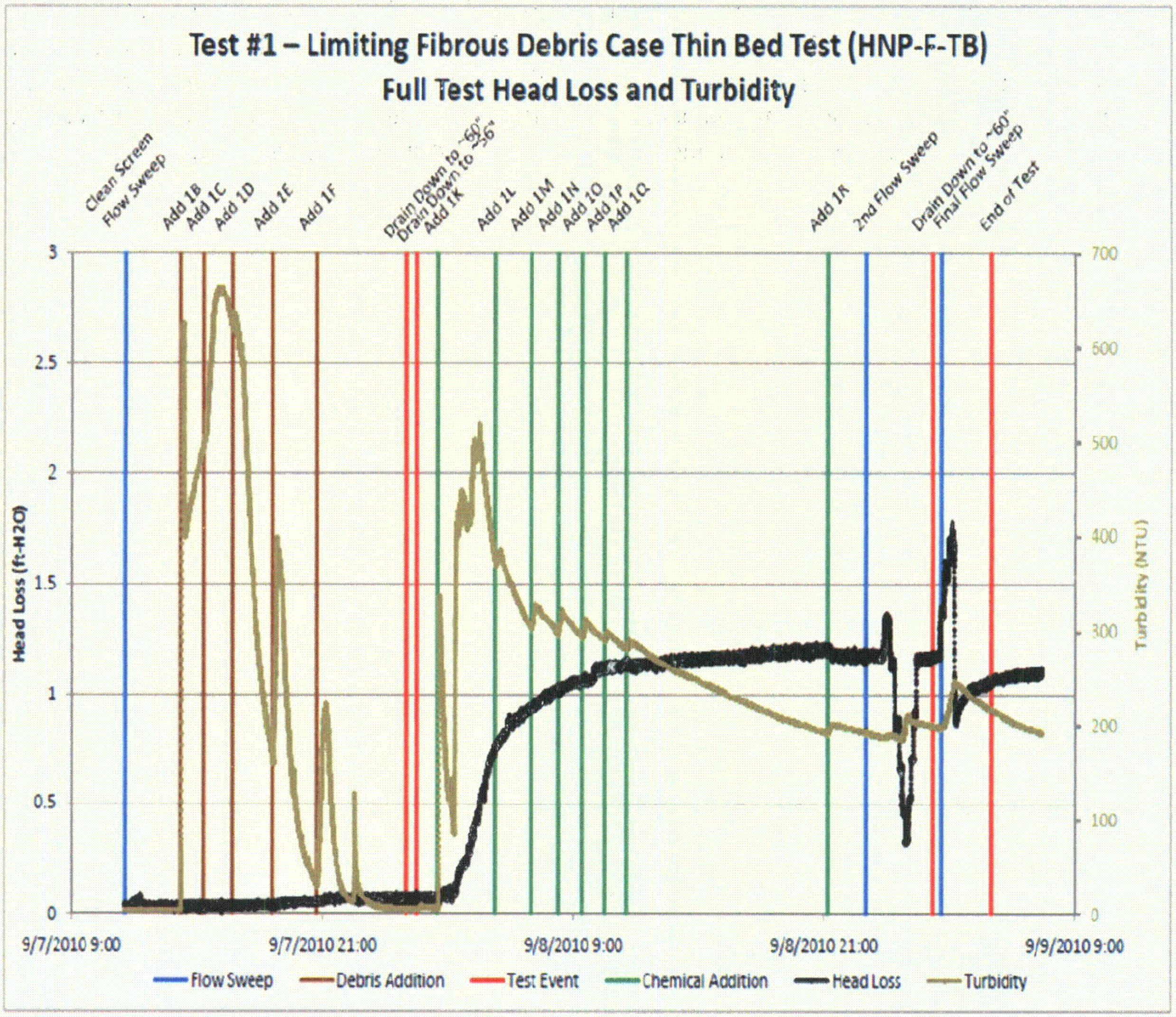
TEST RESULTS: THIN BED TEST



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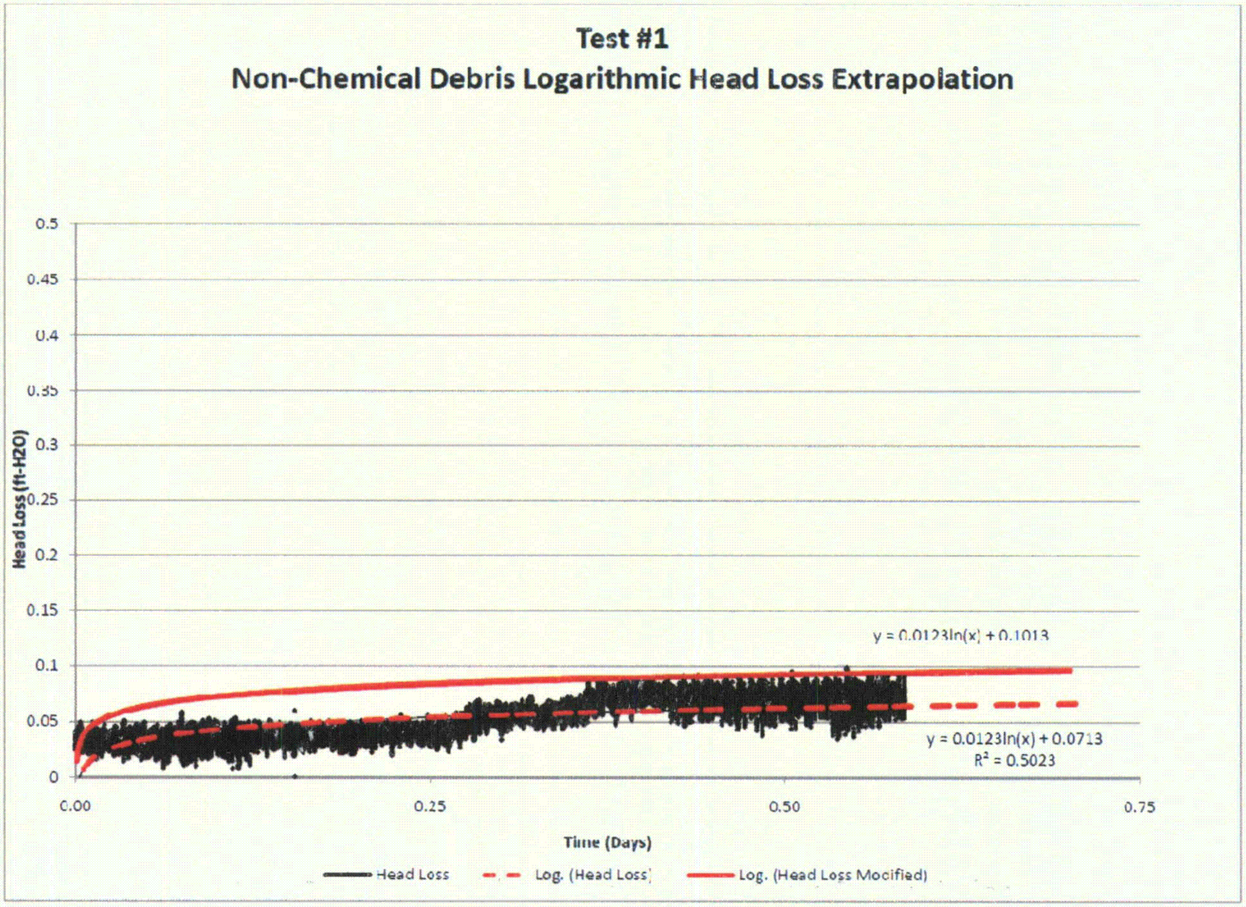
TEST RESULTS: THIN BED TEST, cont.



Note: The original (dashed line) curve fit did not conservatively bound the test data at the end of the data collection periods. Therefore, the constant term of the curve fit was artificially (but conservatively) increased by 0.03 ft-H2O in order to conservatively bound the data at the end of the data collection periods.

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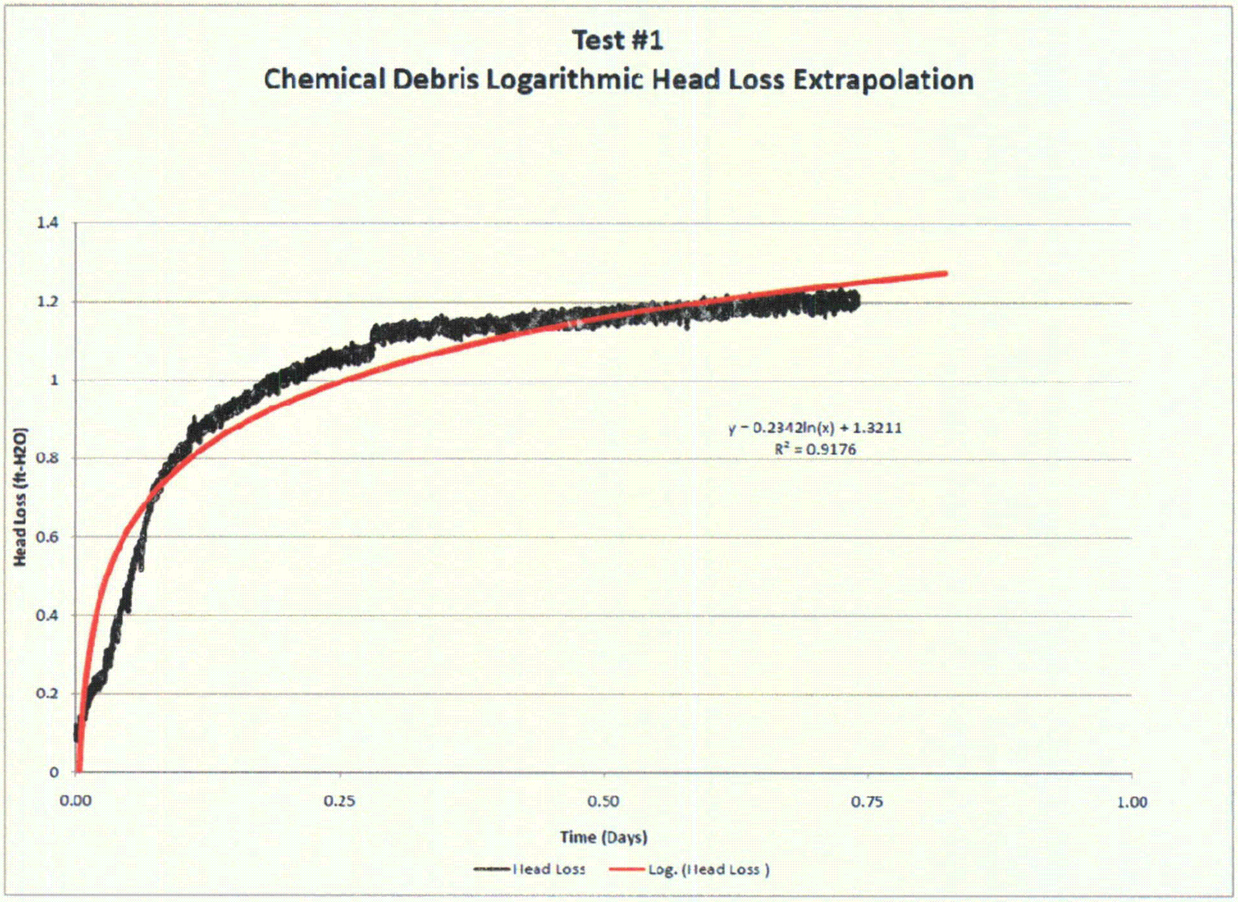
TEST RESULTS: THIN BED TEST, cont.



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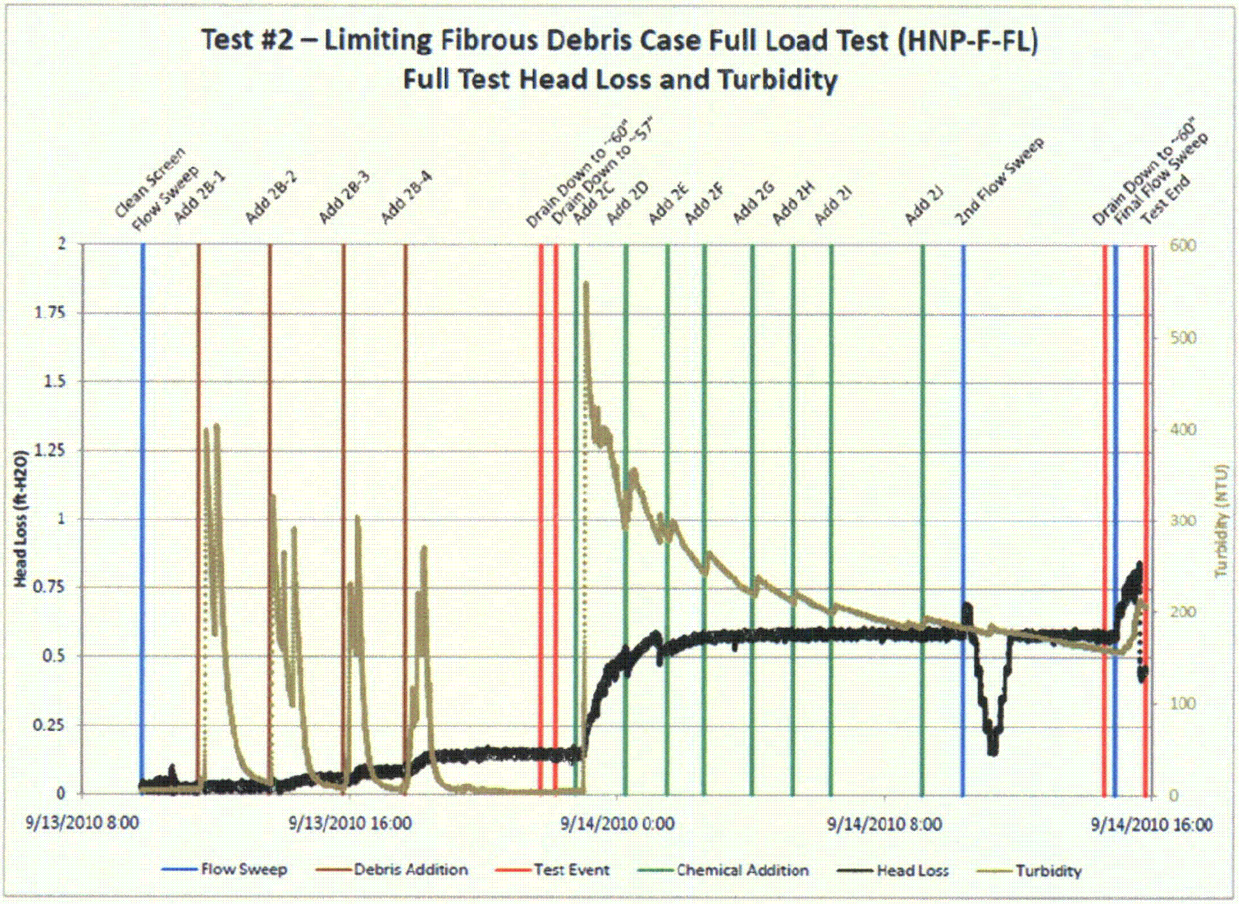
TEST RESULTS: FULL LOAD FIBER TEST



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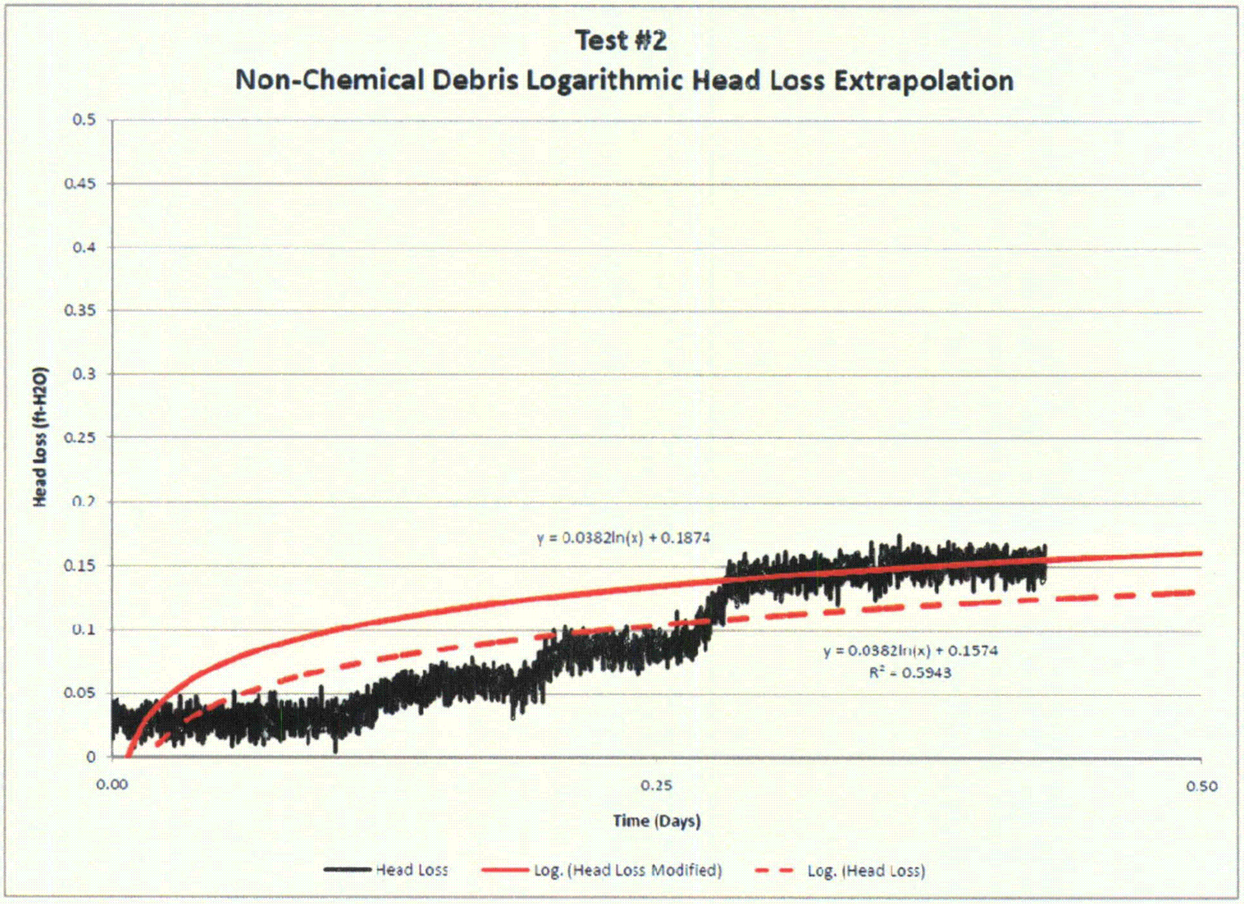
TEST RESULTS: FULL LOAD FIBER TEST, cont.



Note: The original (dashed line) curve fit did not conservatively bound the test data at the end of the data collection periods. Therefore, the constant term of the curve fit was artificially (but conservatively) increased by 0.03 ft-H2O in order to conservatively bound the data at the end of the data collection periods.

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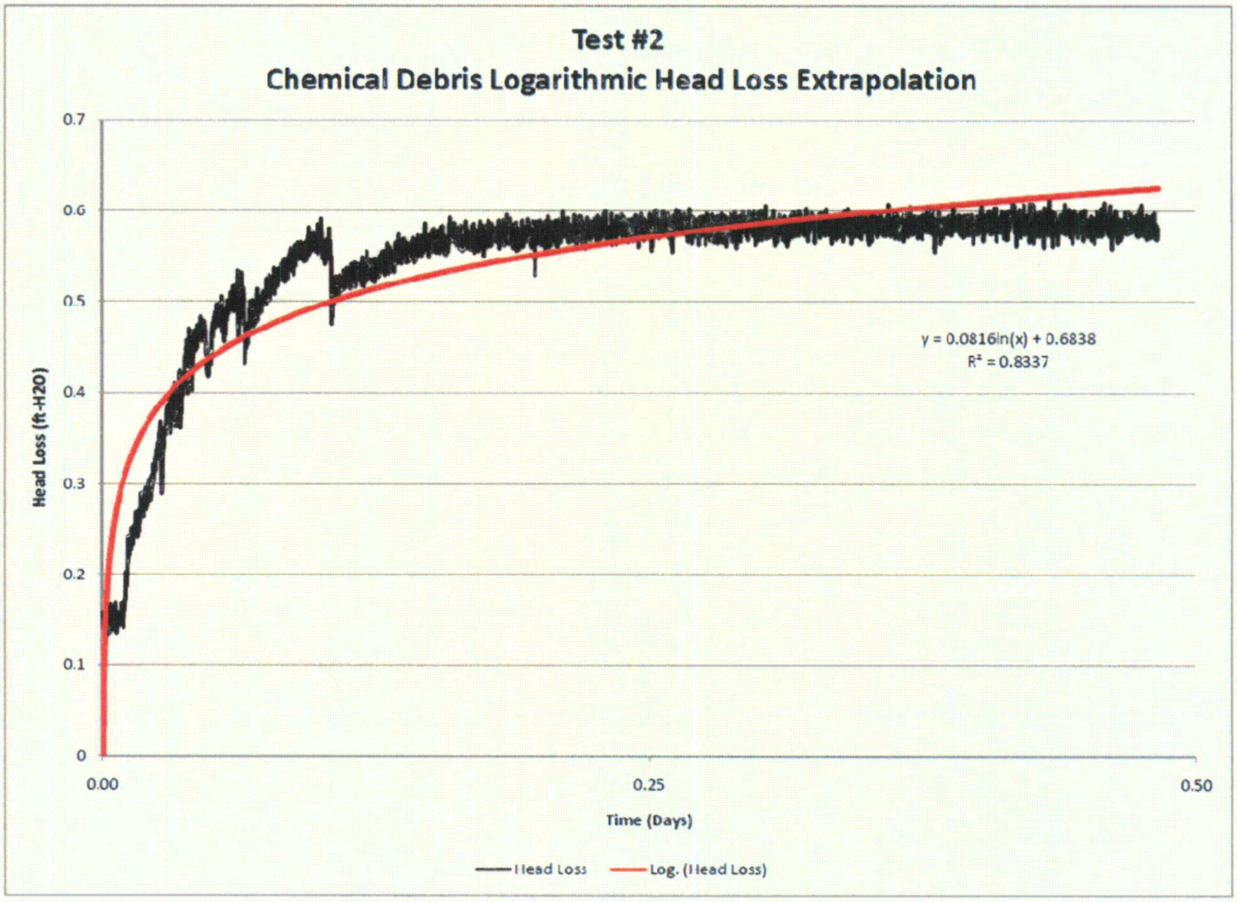
TEST RESULTS: FULL LOAD FIBER TEST, cont.



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TEST RESULTS: MICROTHERM TEST