Progress Energy

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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
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 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

2. "Summary of February 22, 2010, Meeting with Carolina Power & Light Company to Discuss 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 March 9, 2010

Ladies and Gentlemen:

On December 30, 2009, the NRC issued a request for additional information (RAI) (Reference 1) regarding Harris Nuclear Plant's (HNP) responses to NRC Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors." The NRC staff was previously provided draft RAI responses to facilitate discussion during the February 22, 2010, Category 1 public meeting. As discussed during the public meeting (Reference 2), HNP's formal RAI responses are provided in the Enclosure to this letter.

The response to RAI 13 includes a discussion of HNP's plan to credit 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." This updated information, in addition to the revised submittal date, were discussed in an April 15, 2010, phone call with the NRC reviewers and the NRC HNP Project Manager.

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This document contains no new regulatory commitment.

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

I declare, under penalty of perjury, that the foregoing is true and correct.
Executed on [APR 2 7 2010]

Sincerely,

Christopher L. Burton

CLB/kms

Enclosure: 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. L. A. Reyes, NRC Regional Administrator, Region II
Ms. M. G. Vaaler, NRC Project Manager, HNP

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By letters dated February 28, 2008 (ML080670099), March 28, 2008 (ML080940495) and January 27, 2009 (ML090300267), Carolina Power & Light Company (the licensee), now doing business as Progress Energy Carolinas, Inc., submitted supplemental responses to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," for the Shearon Harris Nuclear Power Plant, Unit 1 (HNP).

The U.S. Nuclear Regulatory Commission (NRC) staff has determined that it needs responses to the following questions, which relate to the January 27, 2009, supplemental submittal, in order to continue its review of the HNP response to GL 2004-02:

Break Selection
NRC Request 4:

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>

Rather than providing additional information to justify a 4D ZOI for encapsulated Min-K, 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 an alternate insulation material that is less problematic from a 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 will either perform additional strainer head loss testing with the replacement material or will demonstrate that the debris transported to the strainer due to a break of the pressurizer PORV or SRV piping is bounded by the debris generated by another tested break.

Head loss testing will be 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). Walkdowns to prepare for the replacement of insulation material will take place during Refueling Outage 16 in the fall of 2010. Replacement will follow during Refueling Outage 17 in the spring of 2012.

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>

In the current analysis, more than 15 percent of latent fine debris is credited with being held up in inactive volumes. The latent debris capture in the incore instrumentation tunnel/reactor cavity was truncated at 15 percent (calculated value was 23 percent), but then the non-operating sump was credited with capturing an additional 8 percent of the latent debris. Debris transport calculations will be revised to credit no more than 15 percent latent fine debris as being held up in inactive volumes. HNP will perform additional strainer head loss testing 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).

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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.

<u>HNP Response:</u>

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 will be removed. Applicable debris transport calculations will be revised and HNP will perform additional strainer head loss testing 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).

<u>NRC Request 8:</u>

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.

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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.

HNP Response:

HNP has opted to conservatively assume no debris retention on gratings and upper containment. Applicable debris transport calculations will be revised and HNP will perform additional strainer head loss testing 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 10:

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:

Alion performed the fiber erosion testing initially credited by HNP. Alion has since revised their 30-day erosion testing protocol and has performed retesting. The results of that test will be credited by HNP to support an erosion percentage 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.

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.

HNP Response:

HNP will be replacing the encapsulated Min-K insulation on the pressurizer PORV and SRV loop seal piping with an alternate insulation material that is less problematic from a strainer head loss standpoint. HNP will either perform additional strainer head loss testing with the replacement material or will demonstrate that the debris transported to the strainer due to a break of the pressurizer PORV or SRV piping is bounded by the debris generated by another tested break. Head loss testing will be 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). In order for the additional testing to be more representative of the final installed HNP strainer design, these additional tests will be conducted without the use of Debris Bypass Eliminator mesh.

To mitigate some of the effects of head loss on predicted strainer performance, HNP plans to credit 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," dated September 19, 2008.

The aluminum solubility limit for HNP's sump pool has been calculated using equation (4) from the above ANL report. The comparison of this limit with the amount of dissolved aluminum in the sump pool indicates that, since the solubility limit is not exceeded, HNP's sump pool will reach equilibrium (30 days post-LOCA) without the formation of aluminum based precipitates. However, to address further cooling of the sump pool as well as modeling uncertainties, it will be assumed that the full chemical load precipitates when the sump pool temperature cools to 140° F, which occurs approximately 10 days following a LOCA.

Post-LOCA, the potential amount of aluminum in the sump pool was obtained by using HNP-specific inputs in an Excel spreadsheet developed by Westinghouse in conjunction with WCAP-16530-NP. Because higher pH values result in larger amounts of released aluminum, the maximum sump pH profile (9.42 at equilibrium) was conservatively used as input to the spreadsheet.

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Based on the RCS Loop break yielding the highest amount of released aluminum of the three limiting breaks considered (RCS Loop, RV Nozzle, Pressurizer Safety Line), the released aluminum amounts corresponding to the RCS Loop break were selected for comparison to the ANL solubility limit. 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.

Based on the above considerations, the sump pool aluminum concentration at equilibrium (30 days post-LOCA) is calculated as 10.58 ppm. The minimum sump pH profile of 8.48 at equilibrium was used in the aluminum solubility limit calculation, resulting in a lower, and thus more conservative, aluminum solubility limit. Incorporating this minimum pH, the aluminum solubility limit at 30 days post-LOCA at a sump pool temperature of 133° F (based on the HNP Containment Analysis), is 55.6 ppm, representing a margin of 45 ppm over the calculated sump pool aluminum concentration at equilibrium (30 days post-LOCA).

As stated above, HNP intends to credit that aluminum based precipitates do not form until the sump pool cools to a temperature of 140° F. At the sump pool temperature of 140° F, the resulting aluminum solubility limit is 82.2 ppm and the amount of dissolved aluminum is less than 9.55 ppm, based on the conservative method of calculation. This represents a margin of 72.7 ppm between the aluminum solubility limit and the predicted aluminum concentration at 140° F.

NRC Request 14:

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^3) and 12.1 ft^3, 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.

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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.

HNP Response:

HNP will perform additional strainer head loss testing for the Microtherm break 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). Additional Min-K testing will not be conducted since HNP has opted to replace the Min-K insulation on the pressurizer PORV and SRV loop seal piping with an alternate 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:

HNP will perform additional strainer head loss testing 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). This will ensure that the fibrous debris size distribution used in the test is representative of typical latent debris.

NRC Request 16:

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.

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 on 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.

HNP Response:

HNP will perform additional strainer head loss testing 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). This includes ensuring the representative debris tested is prepared and introduced in a manner consistent with NRC guidance.

<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 200402 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.

HNP Response:

The additional strainer head loss testing to be performed by HNP, to include thin bed testing 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), will ensure the representative debris tested is prepared and introduced in a manner consistent with NRC guidance. In order for the additional testing to be more representative of the final installed HNP strainer design, these additional tests will be conducted without the use of Debris Bypass Eliminator mesh.

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:

Each 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 side 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.

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 sump 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 is 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 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 chosen to use 3,945 gpm as the RHR pump flow rate during the performance of the additional strainer head loss testing. This conservatism is in addition to other conservatisms, such as not crediting Stokes' Law settling or debris hold-up on gratings, which will be included in the additional sump strainer head loss testing that HNP will perform.