McGuire / Catawba GL2004-02
RAI Response Categories

Jacketed Fiber Insulation ZOI Refinement RAIs *(7 for McGuire, 6 for Catawba)*

McGuire RAI #1.........corresponds to Catawba RAI #2

McGuire RAI #2.........corresponds to Catawba RAI #3

McGuire RAI #3.........has no corresponding Catawba RAI

McGuire RAI #4.........corresponds to Catawba RAI #1

McGuire RAI #5.........corresponds to Catawba RAI #5

McGuire RAI #6.........has no corresponding Catawba RAI

McGuire RAI #7.........corresponds to Catawba RAI #4

Catawba RAI #22.......has no corresponding McGuire RAI

Other Industry Report Affected RAIs *(2 for McGuire, 2 for Catawba)*

McGuire RAI #11........corresponds to Catawba RAI #9

McGuire RAI #31........corresponds to Catawba RAI #29

Miscellaneous Site-Specific RAIs *(11 for McGuire, 10 for Catawba)*

Catawba RAI #6.........has no corresponding McGuire RAI

McGuire RAI #8.........corresponds to Catawba RAI #10

McGuire RAI #9.........corresponds to Catawba RAI #7

McGuire RAI #10........corresponds to Catawba RAI #8

McGuire RAI #13........corresponds to Catawba RAI #12

McGuire RAI #14........corresponds to Catawba RAI #13

McGuire RAI #22........corresponds to Catawba RAI #20

McGuire RAI #26........has no corresponding Catawba RAI

McGuire RAI #27........has no corresponding Catawba RAI

McGuire RAI #28........corresponds to Catawba RAI #26

Catawba RAI #28........has no corresponding McGuire RAI

McGuire RAI #29........has no corresponding Catawba RAI

McGuire RAI #30........corresponds to Catawba RAI #27

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M1. Please state whether the testing identified in the test report WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and Nukon® Insulation for Wolf Creek and Callaway Nuclear Operating Plants," was specific to the McGuire Nuclear Station, Units 1 and 2, (McGuire) insulation systems. If not, please provide information that compares the McGuire encapsulation and jacketing systems structures with the systems that were used in the testing, showing that the testing conservatively or prototypically bounded potential damage to the insulation materials.

Response methodology:

- WCAP-16710-P was specific to Wolf Creek / Callaway, not McGuire
- McGuire is aware that staff is reviewing the WCAP testing methodology and is staying aware of any developments, potentially including further WCAP testing
- McGuire is also aware that while a PWROG effort is addressing some testing-related RAIs, there are inter-related site-specific RAIs that must be addressed
- McGuire jacketed fiber insulation systems (i.e., Nukon®, Thermal-Wrap®, and Owens Corning) were compared to the WCAP-tested insulation systems to show applicability of original test method and conclusions:
  - Nukon®, Thermal-Wrap®, and Owens Corning systems, in jacketed applications inside Containment, were judged by inspection to be similar enough in construction as to be bounded by the WCAP testing. All jacketed insulation at McGuire was procured and certified to the same design specification.
  - Some jacketed insulation field conditions were not accounted for in the WCAP, such as jacketing gaps, deformation, degraded latching, and temporary repairs. The WCAP results showed actual fiber release was minimal within a 5D ZOI; McGuire assumed the recommended 7D ZOI and released all fiber therein to account for uncertainty.
  - WCAP test specimen used three latches on a 36" jacket. Comparison to McGuire installed insulation shows three and often four latches on a 36" jacket. Shorter segments are representative of test specimens bounded by washer plates.
  - WCAP test specimen jackets had a 2 inch overlap between longitudinal and axial seams. McGuire jacketed insulation typically has about 1 inch overlap at these areas, but again assumes all fiber is released in a 7D ZOI.
  - WCAP specimen blankets installed in a double thickness configuration; McGuire has single- and double-thickness blanket configurations. Test results showed minimal fiber release from outside specimen and even less

from the inside specimen. Outer test specimen blanket is representative of single-thickness blanket applications at McGuire.

  - WCAP test specimen blankets were attached using Velcro fasteners; most McGuire blankets use the Velcro system but some are attached using SS wire and lacing hooks. Since all fiber within a 7D ZOI was assumed released in a 7D ZOI and the two systems are comparably robust, this was judged to not be significant.
  - The insulation system securing fiber insulation blankets and associated jackets on Steam Generators, Pressurizers, and Reactor Coolant Pumps at McGuire was excluded from the WCAP testing. The insulation in these areas at McGuire is secured using hitch pins and studs, a passive and more robust fastening system as compared to the tested mechanical latching mechanisms that are prone to detach under jet impingement. Assuming a failure of the jacketing system similar to that tested in the WCAP, then, the underlying blanket would perform consistently also.

- McGuire concludes that the WCAP-16710-P methodology applies to jacketed fiber insulation systems installed in the Containments, and that the original WCAP testing is bounding.
- This response covers McGuire question 5, and matches Catawba questions 2 and 5, also

M2. Considering that the McGuire debris generation analysis diverged from the approved guidance contained in NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0, please provide details on the testing conducted that justified the ZOI reductions for jacketed Nukon®. The information should include the jacket materials used in the testing, geometries and sizes of the targets and jet nozzle, and materials used for jackets installed in the plant. Please provide information that compares the mechanical configuration and sizes of the test targets and jets, and the potential targets and two-phase jets in the plant. Please provide an evaluation of how any differences in jet/target sizing and jet impingement angle affect the ability of the insulation system to resist damage from jet impingement. Please state whether the testing described in test report WCAP-16710-P was bounding for the McGuire insulation systems. If not, please provide information that compares the McGuire encapsulation and jacketing systems structure with the system that was used in the testing, showing that the testing conservatively or prototypically bounded potential damage to the insulation materials.

<u>Response methodology:</u>

- McGuire is part of a PWROG effort addressing testing-related RAIs regarding WCAP-16710-P
- This question is inter-related with McGuire question 1, and also Catawba question 3

M3. Please clarify if unjacketed Nukon® is present in the McGuire containment and, if so, please state whether the 17D ZOI was used instead of the 7D ZOI. Please provide the resultant debris quantities for unjacketed Nukon®. (Section 3(b)(2) of the supplemental response sent by letter dated February 28, 2008, stated that unjacketed Nukon® was present within the evaluated ZOIs. The supplemental response further stated that test report WCAP-16710-P demonstrates a refined 7D ZOI for jacketed Nukon® insulation, but was silent with respect to how unjacketed Nukon® was handled with respect to ZOI reduction from 17D to 7D.)

Response methodology:

- Unjacketed Nukon® (as well as other insulation systems) is present in the McGuire containment, and the 17D ZOI was applied to unjacketed fiber insulation per NEI 04-07 guidance
- Released fiber total within the 7D ZOI = 492 ft^3
- Released fiber total between 7D and 17D ZOI = 97 ft^3
- Total released fiber = 589 ft^3; this was rounded to 625 ft^3 for conservatism

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M4. Please state whether or not the break location selection was revisited when the ZOI for fibrous insulation was changed from 17D to 7D. If break selections were not revisited, please provide the rationale for not doing so. If the break selections were revisited, please provide the top four breaks in terms of debris generation for the 7D ZOI. (The supplemental response sent by letter dated February 28, 2008, indicates only that the break locations already identified for a 17D ZOI were reassessed for debris quantity generation and confirmed not to have changed relative ranking).

Response methodology:

- Break locations were re-evaluated after the implementation of WCAP-16710-P methodology to the jacketed fiber insulation in the McGuire Containments
- Break categories/relative ranking did not change: these were documented in McGuire GL 2004-02 Supplemental Response dated 2/28/08, Section 3(a)1:
    1. RCS breaks
    2. Locations generating 2 or more types of debris
    3. Locations with the most direct path to the strainer
    4. Locations with the largest potential particulate/fiber ratio
    5. Locations for thin-bed potential
- Four locations in top break category:
    - RCS Hot Legs
    - RCS Cold Legs
    - RCS X-over Legs
    - Pzr surge line
- McGuire limiting break location did not change after 7D ZOI methodology applied (still RC Loop B Hot Leg)
- Break location chosen not highest fiber generation, but highest transport due to proximity of break to strainer
- Break locations re-evaluated after any fiber reduction implemented
- This question relates to Catawba question 1

M5. Provide information that compares the ability of the McGuire fibrous jacketing system and the test report WCAP-16710-P tested jacketing system to resist steam jet damage. Please provide information that demonstrates that the McGuire jacketing is at least as structurally robust as the jacketing that was subjected to the test report WCAP-16710-P steam jet impingement testing.

Response methodology:

- This question is related to McGuire question 1, and the response is provided there.

M6. Please provide information that verifies that test report WCAP-16710-P testing used to justify a ZOI reduction from 17D to 7D for jacketed fiber insulation was conducted prototypically or conservatively. Include information on nozzle size, target size, and the various test configurations (jet-to-target distance and relative angle, location of jacket seams, etc) conducted to show that the testing was prototypical or conservative.

Response methodology:

- McGuire is part of a PWROG effort addressing testing-related RAIs regarding WCAP-16710-P
- This question is inter-related with McGuire question 1

M7. Please provide the fibrous size distribution (including debris amounts determined) for the debris generation calculation based on the 7D ZOI.

Response methodology:

- Total released fiber in the 7D ZOI and 17D ZOI = 589 ft^3; this was rounded to 625 ft^3 for conservatism
- Size distribution of released fiber:
  - 20% individual constituent fiber strands = 125 ft^3 (100% transport)
  - 80% small fiber pieces (<6 inches on a side) = 500 ft^3 (21% transport)
- McGuire size distribution of 80% small pieces and 20% individual strands elected to increase the volume of released fiber transporting to strainer
- This question is related to Catawba questions 4 and 22

M8. Please provide details regarding the tags and labels equipment qualifications and engineering judgments used as basis for reduction of tag and label quantities which were originally assumed to fail and reach the sump. Provide the technical basis for the conclusion that tags and labels outside the crane wall in lower containment are capable of withstanding post-loss-of-coolant accident (post-LOCA) conditions. Justify the application of the Institute of Electrical and Electronics Engineers (IEEE) Standard 323-1974, "IEEE Standard for Qualifying Class 1 E Equipment for Nuclear Power Generating Stations," in qualifying Electromark® labels for a post-LOCA environment.

Response methodology:

- Details regarding tags and labels qualification and engineering judgments used as the basis for quantity reductions were provided in the responses to 3(d)1, 3(d)2, and 3(i)5 of Enclosure 2 of the McGuire GL 2004-02 Supplemental Response dated 2/28/08.
- Reduction assumptions/methodology for the four evaluated regions of containment:
  - Lower Containment: The only area in lower containment outside the Crane Wall and not in the Ice Condenser Lower Plenum is located between the I/C end walls. Plastic tags in this vicinity are generally outside the break ZOIs and are assumed to deform but not become overly pliable (i.e., will not pass through an opening smaller than the tag).
  - Ice Condenser: Tags and labels inside the I/C Lower Plenum will fail and transport. Those located in the Upper Plenum would not be expected to fail immediately during the initial venting of break energy, but eventual detachment possible. Many tags/labels here will fall into the basket array and be trapped by the basket mesh. It was conservatively assumed that 50% of the area is basket array and 50% is open to the Lower Plenum. Any tags/labels that get into the open area are assumed to transport.
  - Elevation 738'+3" (i.e., rooms above the pipe chase): These areas are not subject to sprays or jet impingement. The rooms will eventually flood; low flow velocities are assumed, and only the tags/labels directly above the floor opening (providing ingress/egress) are assumed to transport to the pipe chase.
  - Upper Containment: Majority of tags/labels in upper containment located between the I/C end walls, the Containment Air Return Fan pit, and around the personnel hatch. These tags/labels that detach are expected to fall straight down and not fall into the Refueling Canal. It is conservatively assumed that all tags/labels that reach the fan pit will transport to the Refueling Canal. A 75% reduction of tags/labels falling

onto grating located outside the fan pit is taken due to capture. All tags and labels falling onto the operating floor are conservatively assumed to transport over the three-inch curb into the refueling canal.

- Electromark® labels have been qualified by test for post-accident conditions:
  - Heat Aging – Simulation of long-term exposure to plant ambient conditions at typical ambient temperatures and atmospheric pressure for a period of several years. On the basis of the suggestions and procedures contained in IEEE 117 and IEEE 275, the 10°C rule was utilized to extrapolate an aging temperature to demonstrate a qualified life period by accelerated aging at elevated temperatures.
  - Radiation Aging – At the conclusion of the thermal aging period the samples were inspected for degradation and loss of function, and then exposed to a cobalt-60 source of gamma radiation at a nominal dose rate of 0.5 Mrads per hour until a total accumulated dose of 200 Mrads had been received. The samples were then inspected again for wear and degradation.
  - LOCA simulation – The samples were installed inside a pressure vessel and subjected to an environmental exposure of steam and chemical spray for a period of 30 days in accordance with the suggested IEEE 323-1974 profile. At the conclusion of the exposure the samples were again inspected and compared with the control samples for suitability of function.
- The above Electromark® label testing was conducted under the general guidelines as suggested in IEEE Standard 323-1974
- This response relates to McGuire questions 10 and 29, and also to Catawba questions 8 and 10

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M9. Please provide the technical basis for the latent fiber and particulate total mass calculation. Include a description of surface types sampled, the number of samples per surface type, the accuracy of the mass measurement, the method of computing the densities for specific areas, and the extrapolation to the scale of containment.

Response methodology:

- Quantifications of latent debris based on NEI 04-07 GR/SE and NEI 02-01 guidance
  - Estimate surface area (vert / horiz)
  - Evaluate resident build-up
  - Define debris densities
  - Determine SA susceptible to build-up
  - Calculate total quantity / composition
- Containment divided into four areas
  - Lower – inside CW
  - Lower – outside CW
  - Lower – I/C
  - Upper
- Samples were taken during an outage prior to cleanup using pre-bagged and pre-weighed Masolin cloth and sticky foam
- Scale tolerance ± 0.04 grams
- Sample weights increased by an offset to account for uncertainties
- 40 samples taken
  - Horizontal Floor: 13
  - Horizontal Miscellaneous: 16
  - Vertical: 11
- Density computed by dividing specific sample mass by specific sample area
- Sample densities grouped appropriately and 95% confidence interval specific debris densities obtained
- Assuming all surfaces are susceptible, actual SAs multiplied by specific debris densities for total load
- Unit 1 bounds Unit 2 (140 lb versus 90 lb); 200 lb assumed for conservatism, with 15% assumed as latent fiber (30 lb) per NEI 04-07 guidance
- This question relates to Catawba questions 6 and 7

M10. Please provide the details of the methodology used for the tag and label refinement evaluation. Provide details of the equipment qualifications and engineering judgments used as basis for reduction of tag and label quantities which are assumed to fail and reach the sump.

Response methodology:

- This question is related to McGuire question 8, and the response is provided there.

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M11. Please provide the technical basis for the assumption of 10-percent erosion of fibrous debris in the containment pool. If testing was performed, please demonstrate the similarity of the flow conditions, chemical conditions, and fiberglass material present in the test or tests versus the conditions expected in the McGuire containment pool.

Response methodology:

- Response to this question is based on the Alion erosion testing reports the technical staff is currently reviewing
- McGuire is aware of potential vendor retesting to verify erosion parameters
- McGuire assumes an 80%-20% debris size distribution (small fiber pieces/individual fiber strands) for all released fiber
- There are no large pieces of submerged released fiber predicted in the McGuire sump pool
- The 10% erosion parameter is applied to the non-transported small piece fiber component of the total fiber volume in the containment sump pool as generated within the 7D+17D ZOIs (i.e., jacketed and unjacketed fiber insulation, respectively)
- This question relates to Catawba question 9

M12. Please provide the results of the array testing conducted at the Alion Science and Technology Corporation and the Integrated Prototype Test (IPT) testing conducted at Wyle Laboratories. For the IPT testing, in addition to head loss values, please provide the results as a function of time. Provide a thorough description of the methodology used to combine the two test results to determine the final head loss for the strainer debris bed. If a correlation was developed to determine head loss, provide the correlation along with the assumptions and bases used in the development of the correlation.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to Catawba question 11

M13. The conditions under which vortex testing was conducted for McGuire, and the plant conditions for which the testing was being conducted, are not clear from the available documentation. Based on the information provided to date, the NRC staff has been unable to determine what conditions resulted in vortex formation and whether the modifications made to eliminate vortices were tested under conditions that conservatively represented those expected in the plant post-LOCA. Vortex testing was conducted at 3-inch submergence (as stated in the Duke Energy Carolinas (Duke) response to RAI question 39 in Enclosure 1 to the supplemental response dated February 28, 2008), which is greater than the expected 2-inch minimum submergence for a small break loss-of-coolant accident (SBLOCA) (as stated in Section 3(f)(2) of Enclosure 2 of the supplemental response). Note that Duke further states in its response to RAI question 39 in Enclosure 1 that the minimum submergence for the strainer is expected to be "at least" 2 inches and separately that it is "about" 4 inches (Enclosure 1, pages 35-36). Enclosure 2, Section 3(f)(2), also states that the strainer is submerged by at least 2 inches while Enclosure 2, Section 3(f)(3), states that the grating is submerged by at least 2 inches. Enclosure 2, Section 3(f)(3), also states that the testing was performed with a "few inches" of submergence. This set of disparate strainer submergence values does not provide a coherent description of the test conditions.

Enclosure 2, Section 3(f)(3), states that the testing was conducted at velocities between 0.01 ft/sec and 0.09 ft/sec, while the maximum approach velocity for the strainer is 0.052 ft/sec, The response does not provide a basis for the 0.052 ft/sec, other than the expected maximum approach velocity is greater than nominal by about a factor of 2 (Enclosure 1, pages 35-36), and does not clearly state that testing at or above 0.052 ft/sec did not result in vortices.

Please provide information that describes the conditions expected in the plant and those present during testing, including the following information:

a. Please clarify what the actual minimum submergence for the strainer is expected to be in the plant.
b. If different evaluations for vortexing were conducted for SBLOCAs and large break loss-of-coolant accidents (LBLOCAs), please provide details for each evaluation.
c. Please provide the basis for the maximum approach velocity.
d. Please provide a quantitative value for the approach velocity during which vortices were observed to form when no vortex suppressors were installed.
e. Please provide a quantitative value for the submergence level at which the testing was conducted with no vortex suppressors installed. If the level changed (e.g., between SBLOCA and LBLOCA tests), please provide the test conditions for each test.

f. Please provide information for testing that was conducted with the vortex suppression grating in place, including the minimum submergence and maximum approach velocities that were present when vortices did not occur.

g. Provide a quantitative value for the vortex suppressor submergence in the reactor plant. If some suppressors are installed at different elevations than others, provide the submergence level for each location.

Response methodology:

- Clarifying schematics are provided for both the vortex test condition and the actual McGuire strainer configuration:
    a. Actual predicted minimum submergence of the McGuire ECCS sump strainer is measured from the surface of the sump pool to the topmost surface of the top-hat strainer modules, and is four inches
    b. Vortex evaluations were performed for the McGuire ECCS Sump Strainer design for the limiting submergence level (SBLOCA scenario) only. The testing was performed at a submergence level of three inches, which is less than the minimum predicted SBLOCA submergence level of ≥ 4 inches, and therefore conservative. The LBLOCA scenarios generate more pool volume and a higher submergence level. Details regarding the SBLOCA vortex evaluation are located in the McGuire GL 2004-02 Supplemental Response dated 2/28/08, Enclosure 1, RAI 39.
    c. For testing purposes, the as-built maximum approach velocity for the top hats closest to the ECCS suction lines was determined to be 0.051 feet per second in McGuire Unit 2, which bounds Unit 1. This approach velocity does not use the normalized flow distribution approach. Instead, the flow is distributed among the top hat modules such that the internal losses within the strainer top hat assemblies and plenums are pressure balanced. This results in a non-uniform flow distribution, which is used to determine the approach velocities. With an initially clean ECCS sump strainer surface, approach velocities for the top-hat modules closest to the pump suction line are expected to be higher than the predicted McGuire nominal approach velocity (i.e., about 0.028 feet per second) by approximately a factor of two.
    d. Vortices in the test tank appeared at approach velocities at and above 0.04 fps with no vortex suppressor in place.
    e. Minimum submergence for the vortex test condition was three inches.
    f. During the vortex suppression testing (without the vortex suppressor in place), an air-entraining vortex was present at the base of the topmost surface of the strainer module at and above approach velocities of 0.04 feet per second. At approach velocities less than that, only surface depressions existed (no fully-formed vortices were present that could

entrain air). As stated previously, the submergence level of the topmost surface of the top hat strainer module during these tests was 3 inches. Once the air-entraining vortex formed at each of the higher test increments, the vortex suppression grating was placed in the designated position, and the vortex successfully eliminated. In this testing sequence, the top of the vortex suppression grating (when installed) was even with the top surface of the test pool.

g. The submergence level of the vortex suppression gratings in the McGuire plant condition is at least 2 inches at all locations (inside and outside the Crane Wall, as measured from the top of the grating) during a SBLOCA event. The LBLOCA event produces more pool volume and therefore a higher submergence level.

- This question relates also to Catawba question 12.

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M14. Please provide a response to the question from the revised NRC Content Guide sent by letter dated November 21, 2007, relating to Enclosure 2 of the supplemental response dated February 28,2008, Section 3(f)(5), regarding the ability of the strainer to accommodate the maximum potential debris volume. This response should apply specifically to the McGuire strainer and not be a general answer (as is found in Enclosure 2, Section 3(f)(5)). The McGuire response to Enclosure 1, RAI question 40, sends the reader to Enclosure 2, Sections 3(f) and 3(o) to find this information. The information is contained in neither location.

Response methodology:

- Volumes of all debris transported to the McGuire strainer are computed:
    - Qualified epoxy coatings = 1.42 ft^3
    - Unqualified epoxy coatings = 3.8 ft^3
    - Unqualified alkyd coatings = 0.16 ft^3
    - Latent dirt/dust = 1.01 ft^3
    - Latent fiber = 12.5 ft^3
    - Total transported released fiber volume = 231.5 ft^3
- Therefore the total debris volume at the McGuire strainer (Unit 1) is 250.4 ft^3
- The total interstitial volume of the limiting McGuire sump strainer is 346 ft^3, so the complex geometry of the top-hat strainer modules is maintained
- This question relates to Catawba question 13

M15. Please provide information that verifies that the debris preparation and introduction methods used during the array test and IPT were prototypical or conservative with respect to the transport evaluation for the plant. In general, protocols for fibrous debris preparation result in debris that is coarser than predicted by the plant-specific transport calculation. In addition, the NRC staff has noted that debris introduction frequently results in agglomeration of debris such that it may not transport to the strainer prototypically or create a prototypical debris bed. Both of these issues can result in non-conservative head loss values during testing.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 14

M16. Please provide information on the flow fields in the array test. The NRC staff is concerned that non-prototypical debris distribution may have occurred during testing caused by stirring of the tank. The stirring can result in the transport of debris that would otherwise not transport, or result in washing debris from the strainer screen surfaces. Either of these phenomena can result in reduced (non-conservative) head loss values during testing.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 15

M17. Please provide debris preparation and introduction information similar to that requested in this enclosure, RAI question 15, for the testing that was used to justify that a thin bed would not form on a top hat strainer. Note that for thin bed testing, the NRC staff considers it prototypical or conservative for fine fiber to arrive at the strainer prior to less transportable debris. Overly coarse debris preparation or non-prototypical introduction to the flume may non-conservatively affect the potential for thin bed formation.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 16

M18. Please provide the criteria used to judge that differential pressure-induced effects (e.g., boreholes) did not occur during testing.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 17

M19. Please provide the scaling parameters used for calculation of debris quantities and strainer approach velocities used during testing. State whether the scaling accounted for strainer areas blocked by miscellaneous debris such as labels and tape.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 18

M20. Please provide information on whether the amount of coatings surrogate was adjusted for the volume difference created by the difference in density between the surrogate material and the potential debris in the plant.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- The volumes of the coatings surrogates used for all previous prototype testing (Confirmatory Debris Bed Formation Test, 2×3 Array Test, and the Integrated Prototype Test) were adjusted to account for the difference in densities between the surrogates and the predicted post-accident failed coatings debris in the plant. The volume adjustment accounts appropriately for the interstitial capacity of the strainer to address potential issues with uniform loading.

M21. Please discuss the NRC staff's observation that in the IPT the flow was non-prototypically directed at the top hat strainer in a direction parallel to the strainer long axis. Please address whether this non-prototypical flow direction could result in a non-prototypical formation of debris on the top hat strainer.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to Catawba question 19

M22. Please provide the clean strainer head loss for McGuire Unit 2 (only the clean strainer head loss for McGuire Unit 1 was provided).

Response methodology:

- The McGuire clean strainer head loss (CSHL) for Unit 1 is calculated as 5.71 feet of water at 60F, for the maximum recirculation flow condition.
- The McGuire CSHL for Unit 2 is calculated as 5.99 feet of water at 60F, for the maximum recirculation flow condition.
- This question also relates to Catawba question 20

M23. The supplemental response stated that the total head loss across the McGuire Emergency Core Cooling System Sump strainer (clean strainer head loss plus debris bed head loss) was conservatively predicted to be 9.8 ft at switchover to sump recirculation. No explanation was provided as to how this value was derived. It appears that the licensee is taking credit for time-dependency in head loss, since the 30-day value is 15.7 ft. Please provide the time-dependent results and calculation methodology for determining net positive suction head margin throughout the 30-day mission time.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to Catawba question 25

M24. Please provide the types and amounts of debris added to each test (Array and IPT). Include information on introduction sequence. Please provide relevant test parameters such as temperature, debris introduction times, and flow rate for the Array and IPT tests.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to Catawba question 23

M25. Please provide information on the amounts of debris that settled during testing for each test (IPT, Array, and Thin Bed). Note that Enclosure 1, response to RAI question 37, states that near-field settling was not credited during testing. However, the NRC staff observed significant settling during the IPT. Please provide a quantitative evaluation of how this settling affected head losses for each test. Please state whether this settling is prototypical of plant conditions and provide a basis for the conclusion.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to Catawba question 24

M26. Please provide verification that the unqualified epoxy coatings at McGuire are similar to the coatings used in the Electric Power Research Institute's analysis of original equipment manufacturer coatings. Also, are plant records maintained for the unqualified coatings in order to track quantities and composition?

Response methodology:

- The coated components used in the EPRI testing included many types of unqualified coatings collected directly from industry. The coatings samples included OEM and non-OEM applied epoxies in a wide age range.
- These samples are representative of the types existing in the McGuire Containments.
- The majority of unqualified epoxy coatings inside the McGuire containments are vendor-applied to OEM components and equipment, using a controlled method as described in the EPRI report.
- Plant records are maintained for all unqualified coatings in Containment at McGuire, tracking both quantities and type.

M27. Please clarify the discrepancy in quantitative values for unqualified epoxy coatings debris in Enclosure 2 to the supplemental response dated February 28, 2008, response to Section 3(e)(6), Tables 3E6-1 and 3H6-2.

Response methodology:

- In the McGuire GL 2004-02 Supplemental Response dated 2/28/08, Table 3E6-1 ("Initial Debris Transport to McGuire ECCS Sump Strainers") represents the initial unqualified epoxy coatings quantity predicted to transport to the ECCS Sump pool after a LBLOCA event. This particulate quantity was used to initially size the strainer for design and installation.
- In the McGuire GL 2004-02 Supplemental Response dated 2/28/08, Table 3H6-2 ("McGuire Unqualified Coatings Characteristics") represents the refined unqualified epoxy coatings quantity predicted to transport to the ECCS Sump pool after a LBLOCA event. This refined quantity was used in the performance evaluation of the strainer during the Integrated Prototype Test for chemical effects. The refinement is described in the Table 3H6-2 notes.

M28. Please identify and describe the main features of any procedures that comprise containment cleanliness practices.

Response methodology:

As identified in the McGuire GL 2004-02 Supplemental Response dated 2/28/08, item 3(i)(1), McGuire has implemented programmatic controls to ensure that potential sources of debris that may be introduced into containment will be assessed for adverse effects on the ECCS and Containment Spray recirculation functions.

- Containment Housekeeping / Materiel Condition
  - Extensive containment cleaning is performed during each refueling outage using water spray, vacuuming and hand wiping
  - Localized wash downs are performed as needed and visual inspections are performed on the remaining areas of containment.
  - Foreign material is removed as necessary.
  - Material control procedures require material accountability logs to be maintained in Modes 1 through 4 for items carried into and out of containment. These controls are implemented using administrative procedures.

- McGuire Technical Specification Surveillance Requirement
  - McGuire Technical Specification Surveillance Requirement 3.5.2.8 requires that the ECCS sump be visually inspected to verify there are no restrictions as a result of debris, and no evidence of structural distress or abnormal corrosion present prior to declaring the ECCS sump operable.
  - A visual inspection of containment is performed to ensure no loose material is present which could be transported to the Containment Sump and cause restriction of the ECCS pump suction during accident conditions prior to the transition from Mode 5 to Mode 4 operations.
  - McGuire Selected Licensee Commitment 16.6.1 ensures that a visual inspection is performed to identify any loose debris inside containment and ensure it is removed prior to establishing containment integrity and following entries made after containment integrity is established.

- This question relates also to Catawba question 26

M29. Please provide the technical basis for the conclusion that all labels are capable of withstanding post-LOCA conditions in containment except inside the crane wall in lower containment.

<u>Response methodology:</u>

- This question is related to McGuire question 8, and the response can be found there.

M30. The revised "Content Guide for Generic Letter 2004-02 Supplemental Responses," sent by letter dated November 21, 2007, Section 3K, requests a summary of structural qualification design margins for the various components of the sump strainer structure assembly. This summary should include interaction ratios and/or design margins for structural members, welds, concrete anchorages, and connection bolts as applicable. Please provide this information.

Response methodology:

- The design input values for the McGuire strainer:

	Design Input	Top-hat module*	ICW / Pipechase Sections	ICW Enclosure	Pipechase Vortex Suppressor
	Temperature	300 °F	300 °F	250 °F	250 °F
	Differential Pressure	10 psid	8 psid	4 psid solid plate, 2.69 psid perforated	NA
	Dead Weight	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3
	Live Load	-	-	100 psf	100 psf
	Misc. Load (Cable Tray/Conduit)	-	-	75 lb	-
Seismic	ZPA Frequency	20 Hz	20 Hz	20 Hz	20 Hz
	Damping	2%	2%	2%	2%
	Max SSE Horizontal Acc.	0.53 g	0.53 g	0.53 g	0.53 g
	Max SSE Vertical Acc.	0.35 g	0.35 g	0.35 g	0.35 g

- The response also contains tabulated values of structural design margins and interaction ratios for each component type of the McGuire strainer:

MCC-1051.00-00-0009, Thru Rev 3, Analysis of Sump Strainer Top-hat				
Top Hat Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Top-hat Loading	Bending Stress	703 psi	4509 psi	
	Axial Stress	86 psi	-	Negligible stress
	Hoop Stress	533 psi	4509 psi	
Top-hat Buckling	Bending Moment	703 psi	24086 psi	
	Axial Loading	86 psi	33011 psi	
	Circum. Loading	533 psi	1248 psi	
3/8" Diameter Studs	Max IR	0.04	1.0	
Top Cover Plate	Bending Stress	3168 psi	16875 psi	
Base Plate	Max Stress	4287 psi	16875 psi	
1/16" Fillet Weld	Max Force	83.95 lb/in	563 lb/in	allowable - 928 lbs/in

- This question relates also to Catawba question 27

M31. The NRC staff considers in-vessel downstream effects to not be fully addressed at McGuire as well as at other pressurized-water reactors. The supplemental response for McGuire refers to the evaluation methods of Section 9 of Topical Report (TR) WCAP-16406-P, Revision 1, "Evaluation of Downstream Sump Debris Effects in Support of GS-191" for in-vessel downstream evaluations and makes reference to a comparison of plant-specific parameters to those evaluated in TR WCAP-16793-NP, Revision 0, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final Safety Evaluation (SE) for TR WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for McGuire by showing that the licensee's plant conditions are bounded by the final TR WCAP-16793-NP and the corresponding final NRC staff's SE, and by addressing the conditions and limitations in the final SE. The licensee may also resolve this item by demonstrating without reference to TR WCAP-16793 or the NRC staff's SE that in-vessel downstream effects have been addressed at McGuire. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff's SE on TR WCAP-16793. The NRC staff is developing a Regulatory Issue Summary to inform the industry of the NRC staff's expectations and plans regarding resolution of this remaining aspect of GSI-191.

<u>Response methodology:</u>

- McGuire Nuclear Station will address the in-vessel downstream effects issue within 90 days of issuance of the staff's final Safety Evaluation on TR WCAP-16793.
- This question also relates to Catawba question 29

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M32. Please discuss why the IPT provided a representative debris bed on the top-hat strainer module for filtering chemical precipitates. The NRC staff observed the debris addition video and concluded that the fibrous debris introduced into the test tank was more agglomerated than what may arrive at the strainer under post-LOCA flow conditions in the plant. Please discuss whether the amount of bare strainer area observed in the test is representative of what is expected to occur with the plant strainer array if a LBLOCA were to occur. The use of chemical effects test results derived from a test which formed a non-prototypically partially clean screen fiber bed would not be appropriate.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to Catawba question 30

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C1. Please state whether or not the break location selection was revisited when the Zone of Influence (ZOI) for fibrous insulation was changed from 17D to 7D. If break selections were not revisited, please provide the rationale for not doing so. If the break selections were revisited, please provide the top four breaks in terms of debris generation for the 7D ZOI (The supplemental response sent by letter dated February 29, 2008, indicates only that the break locations already identified for a 17D ZOI were reassessed for debris quantity generation and confirmed not to have changed relative ranking.)

Response methodology:

- Break locations were revisited when Catawba adopted a 7D ZOI, and the limiting break location did change from the B loop hot leg to the B loop crossover leg.
- As reported in the Catawba RAI update letter dated July 28, 2009, Catawba is removing fiber insulation from the Unit 1 containment in the fall of 2009. Unit 2 is has been confirmed to remain bounded by Unit 1 even after fiber removal.
- While Catawba feels there is adequate justification for a 7D ZOI and remains involved in the industry defense of the reduced ZOI, a 17D ZOI is being used as the basis for current/future testing and analysis in order to bring a more timely closure to the generic letter and to reduce regulatory uncertainty.
- Break locations for the future state containment configuration have been revisited to ensure the most conservative break location has been identified and applied to strainer testing and analysis.
- Break locations will continue to be investigated as we reach closure in the areas of debris size distribution, ZOI reduction, fiber erosion, etc to ensure the most limiting break location is being considered and to ensure conservatism.
- This question relates to McGuire question 4

C2. Please state whether the testing identified in the test report WCAP-16710-P, "Jet Impingement Testing to Determine the Zone of Influence of Min-K and Nukon® Insulation for Wolf Creek and Callaway Nuclear Operating Plants," was specific to the Catawba Nuclear Station, Units 1 and 2, (Catawba) insulation systems. If not, please provide information that compares the Catawba encapsulation and jacketing systems structures with the systems that were used in the testing, showing that the testing conservatively or prototypically bounded potential damage to the insulation materials.

Response methodology:

- As reported in RAI update letter to the NRC staff dated July 28, 2009, Catawba is no longer invoking the findings of WCAP-16710-P for future testing or analysis and is reverting to an unrefined 17D ZOI. Due to the timing of the fiber removal and additional testing/analysis, this question will not be applicable to Catawba when the RAI response will be submitted.
- If the industry and the NRC reach agreement on a reduced ZOI, it is understood that this question must be answered to the staff's satisfaction prior to reducing the ZOI for Catawba and regaining margin surrendered by adopting a 17D ZOI. The methodology for answering this question for Catawba is identical to the methodology outlined in McGuire Question 1.
- This question is inter-related with McGuire question 1, and also Catawba question 5.

C3 Considering that the Catawba debris generation analysis diverged from the approved guidance in NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0, please provide details on the testing conducted that justified the ZOI reductions for jacketed Nukon®. The information should include the jacket materials used in the testing, geometries and sizes of the targets and jet nozzle, and materials used for jackets installed in the plant. Please provide information that compares the mechanical configuration and sizes of the test targets and jets versus the potential targets and twophase jets in the plant. Please evaluate how any differences in jet/target sizing and jet impingement angle affect the ability of the insulation system to resist damage from jet impingement. Please state whether the testing described in test report WCAP-1671 O-P was bounding for the Catawba insulation systems. If not, please provide information that compares the Catawba encapsulation and jacketing systems structure with the system that was used in the testing, showing that the testing conservatively or prototypically bounded potential damage to the insulation materials.

Response methodology:

- As reported in RAI update letter to the NRC staff dated July 28, 2009, Catawba is no longer invoking the findings of WCAP-16710-P for future testing or analysis and is reverting to an unrefined 17D ZOI. Due to the timing of the fiber removal and additional testing/analysis, this question will not be applicable to Catawba when the RAI response will be submitted.
- Catawba is part of a PWROG effort addressing testing-related RAIs regarding WCAP-16710-P. If the industry and the NRC reach agreement on a reduced ZOI, it is understood that this question must be answered to the staff's satisfaction prior to reducing the ZOI for Catawba and regaining margin surrendered by adopting a 17D ZOI.
- This question is inter-related with McGuire question 2

C4 The NRC staff is not convinced that Catawba's currently postulated limiting break, that results in no fine fibrous debris, but does result in 195 ft3 of small pieces and 130 ft3 of large pieces, is truly the limiting break from a final head loss perspective. Please provide the fibrous size distribution (including debris amounts determined) for the debris generation calculation based on the 7D ZOI. Please provide the basis for the determination that no fine fibrous debris would be generated by the limiting break. (The NRC staff considers the assumption of no fine fibrous debris to be non-conservative and inconsistent with previous industry and NRC insulation destruction test data that indicates that a fraction of the debris formed within a 7D ZOI would be destroyed into fines, The NRC staff guidance for break selection (NEI Guidance Report and NRC staff Safety Evaluation) requires that "pipe breaks shall be postulated with the goal of creating the largest quantity of debris and/or the worst case combination of debris types at the sump screen." Fine fiber is a basic constituent of a limiting debris bed. If a different break location would result in the generation of fine fibrous debris, even if the total debris amount is less than the currently postulated Catawba limiting break, that different break may actually be the limiting break. The licensee should evaluate each potential break location from debris generation to transport (including erosion and ensuing transport) to head loss to determine which break is actually limiting.)

<u>Response methodology:</u>

- As reported in RAI update letter to the NRC staff dated July 28, 2009, Catawba is no longer invoking the findings of WCAP-16710-P for future testing or analysis and is reverting to an unrefined 17D ZOI. Due to the timing of the fiber removal and additional testing/analysis, this question will not be applicable to Catawba when the RAI response will be submitted.
- Catawba is part of a PWROG effort addressing testing-related RAIs regarding WCAP-16710-P. If the industry and the NRC reach agreement on a reduced ZOI, it is understood that this question must be answered to the staff's satisfaction prior to reducing the ZOI for Catawba and regaining margin surrendered by adopting a 17D ZOI.
- As the question relates to the 17D ZOI adopted by Catawba, the 17D ZOI is sub-divided into three separate ZOIs, each with a separate size distribution.
- ZOI subzones and size distribution within each subzone was based on a combination of previous industry air jet testing and additional proprietary testing/analysis at various destruction pressures.
- For the 17D ZOI being considered in current testing and analysis for Catawba, he following subzones are assumed along with the size distribution for each zone:
    - o < 7D ZOI
        - ▪ 20% individual fines

        - 80% small pieces
    - >7, <12D
        - 13% individual fines
        - 54% small pieces
        - 16% large pieces
        - 17% intact blankets
    - >12D, <17D
        - 8% individual fines
        - 7% small pieces
        - 41% large pieces
        - 44% intact blankets
- This question is inter-related to McGuire question 7 and Catawba question 22

C5 Industry debris destruction testing was used as a basis to revise assumptions concerning the ZOIs and debris size distributions for Nukon®, Knauf, and Thermal Wrap low-density fiberglass insulations. Please describe the jacketing, banding and latchinq mechanisms, and cloth covers of these three types of insulation installed at Catawba and compare them to the insulation for which destruction testing was performed in order to demonstrate the applicability of the industry destruction tests results to Catawba.

Response methodology:

- This question is related to Catawba question 2, and the response is provided there.

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C6 Please specify whether latent debris samples were collected as part of the containment walkdowns performed described in the supplemental response sent by letter dated April 30, 2008, and describe how these samples were used to estimate the latent debris quantities for both units. In addition, if samples were not collected, please justify how the use of photographs and walkdown notes of the Catawba containments, as described in the response, provide assurance that the 200 lbm of latent debris assumed for the supporting calculations is bounding.

Response methodology:

- Unit 2 was considered representative of both units based on similar layouts and cleaning practices. This assumption was verified via small sampling comparisons and by ensuring appropriate conservatism in the final reported latent debris quantities.
- Quantifications of latent debris based on NEI 04-07 GR/SE and NEI 02-01 guidance
  - Estimate surface area (vert / horiz)
  - Evaluate resident build-up
  - Define debris densities
  - Determine SA susceptible to build-up
  - Calculate total quantity / composition
- Containment divided into four areas
  - Lower – inside CW
  - Lower – outside CW
  - Lower – I/C
  - Upper
- Samples were taken during an outage prior to cleanup using pre-bagged and pre-weighed Masolin cloth and sticky foam
- Scale tolerance ± 0.04 grams
- Sample weights increased by an offset to account for uncertainties
- 59 samples taken
  - Horizontal Floor: 18
  - Horizontal Miscellaneous: 25
  - Vertical: 16

- Density computed by dividing specific sample mass by specific sample area
- Sample densities grouped appropriately and 95% confidence interval specific debris densities obtained
- Assuming all surfaces are susceptible, actual SAs multiplied by specific debris densities for total load
- Unit 2 bounds Unit 1 with a latent debris load of 113 lb; 200 lb assumed for conservatism, with 15% assumed as latent fiber (30 lb) per NEI 04-07 guidance
- Applying the methodology described in the SE of using a simple sample mean, the estimated mass would be approximately 70 lb as opposed to the 113 lb described above.
- This question relates to Catawba question 7 and McGuire question 9

C7 Please describe the analytical method used to extrapolate the total amount of latent debris in containment. If a statistical method was used, please provide the confidence level of the results.

Response methodology:

- This question is related to Catawba question 6, and the response is provided there.

C8 Please provide the details of the methodology used for the tag and label refinement evaluation. Please provide details of the equipment qualifications and engineering judgments used as basis for reduction of tag and label quantities assumed to fail and reach the sump.

Response methodology:

- This question is related to Catawba question 10, and the response is provided there.

C9 Please provide the technical basis for the assumption of 10-percent erosion of 'fibrous debris in the containment pool. If testing was performed to support this assumption, please demonstrate the similarity of the flow conditions, chemical conditions, and fiberglass material present in the test versus the conditions expected in the Catawba containment pool.

Response methodology:

- Response to this question is based on the Alion erosion testing reports the technical staff is currently reviewing
- Catawba is aware of potential vendor retesting to verify erosion parameters
- The 10% erosion parameter is applied to the non-transported small and large piece fiber component of the total fiber volume in the containment sump pool as generated within the 17D ZOI. See response to question number 4 for the size distribution within the 17D ZOI.
- Since Catawba has a relatively high small piece transport percentage (approximately 45%) and a reduced overall fiber volume (after the fiber removal project), sensitivity studies have demonstrated the small piece erosion percentage is not a key variable in the overall debris quantity expected to transport to the strainer
- This question relates to McGuire 11.

C10 Please provide details of the tags and labels equipment qualifications and engineering judgments used as the basis for reduction of tags and label quantities which are assumed to fail and reach the sump. Specifically, please justify the application of Institute of Electrical and Electronics Engineers (IEEE) Standard 323-1974, "IEEE Standard for Qualifying Class 1 E Equipment for Nuclear Power Generating Stations," in qualifying Electromark® labels for a post-loss-of-coolant-accident (post-LOCA) environment with respect to nondebris transport to the sump strainer.

Response methodology:

- Details regarding tags and labels qualification and engineering judgments used as the basis for quantity reductions were provided in the responses to 3(d)1, 3(d)2, and 3(i)5 of Enclosure 2 of the Catawba GL 2004-02 Supplemental Response dated 2/29/08.
- Reduction assumptions/methodology for the four evaluated regions of containment:
    - Lower Containment: The only area in lower containment outside the Crane Wall and not in the Ice Condenser Lower Plenum is located between the I/C end walls. Plastic tags in this vicinity are generally outside the break ZOIs and are assumed to deform but not become overly pliable (i.e., will not pass through an opening smaller than the tag).
    - Ice Condenser: Tags and labels inside the I/C Lower Plenum will fail and transport. Those located in the Upper Plenum would not be expected to fail immediately during the initial venting of break energy, but eventual detachment possible. Many tags/labels here will fall into the basket array and be trapped by the basket mesh. It was conservatively assumed that 50% of the area is basket array and 50% is open to the Lower Plenum. Any tags/labels that get into the open area are assumed to transport.
    - Elevation 565'+3" (i.e., rooms above the pipe chase): These areas are not subject to sprays or jet impingement. The rooms will eventually flood; low flow velocities are assumed, and only the tags/labels directly above the floor opening (providing ingress/egress) are assumed to transport to the pipe chase.
    - Upper Containment: Majority of tags/labels in upper containment located between the I/C end walls, the Containment Air Return Fan pit, and around the personnel hatch. These tags/labels that detach are expected to fall straight down and not fall into the Refueling Canal. It is conservatively assumed that all tags/labels that reach the fan pit will transport to the Refueling Canal. A 75% reduction of tags/labels falling onto grating located outside the fan pit is taken due to capture. All tags

and labels falling onto the operating floor are conservatively assumed to transport over the three-inch curb into the refueling canal.

- Electromark® labels have been qualified by test for post-accident conditions:
  - Heat Aging – Simulation of long-term exposure to plant ambient conditions at typical ambient temperatures and atmospheric pressure for a period of several years. On the basis of the suggestions and procedures contained in IEEE 117 and IEEE 275, the 10°C rule was utilized to extrapolate an aging temperature to demonstrate a qualified life period by accelerated aging at elevated temperatures.
  - Radiation Aging – At the conclusion of the thermal aging period the samples were inspected for degradation and loss of function, and then exposed to a cobalt-60 source of gamma radiation at a nominal dose rate of 0.5 Mrads per hour until a total accumulated dose of 200 Mrads had been received. The samples were then inspected again for wear and degradation.
  - LOCA simulation – The samples were installed inside a pressure vessel and subjected to an environmental exposure of steam and chemical spray for a period of 30 days in accordance with the suggested IEEE 323-1974 profile. At the conclusion of the exposure the samples were again inspected and compared with the control samples for suitability of function.
- The above Electromark® label testing was conducted under the general guidelines as suggested in IEEE Standard 323-1974
- This response relates to Catawba question 8 and also to McGuire questions 8, 10, and 29

C11 Please provide the results of the array testing conducted at Alion Science and Technology Corporation and the Integrated Prototype Test (IPT) testing conducted at Wyle Laboratories. For the IPT testing, in addition to head loss values, please provide the results as a function of time. Please provide a thorough description of the methodology used to combine the two test results to determine the final head loss for the strainer debris bed. If a correlation was developed to determine head loss, please provide the correlation along with the assumptions and bases used in the development of the correlation.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to McGuire question 12

C12 Please provide information that establishes that vortex testing was conducted at less than or equal to the expected 3.75-inch minimum strainer submergence. The licensee's response to RAI question 38 in Enclosure 1 to the supplemental response sent by letter dated February 28, 2008, and Enclosure 2 of this supplemental response, Section 3(f)(2), state that the strainer modules are submerged by 3.75 inches under limiting sump level conditions. The licensee's response to RAI question 38 states that testing was conducted at a submergence of 3 inches.

Enclosure 2, Section 3(f)(3), states that the testing was conducted with a "few inches" of water coverage above the strainer modules. Separately, Enclosure 2, Section 3(f)(3), states that approach velocities for testing were between 0.01 ftlsec and 0.09 ftlsec, while the expected maximum approach velocity for the plant strainer is 0.045 ftlsec. In order to clarify the conditions under which vortex testing was conducted, please provide the following information:

a. Please provide the basis for the maximum approach velocity value of 0.045 ftlsec.

b. Please discuss how flume velocity was controlled during vortex testing.

c. Please provide a quantitative value for the approach velocity during which any vortices were observed to form.

d. Please provide a quantitative value for the vortex suppressor grating submergence.

e. Please verify that all vortex testing was conducted at less than or equal to 3.75 inches of strainer submergence, with or without a vortex suppressor grating.

f. Please state whether vortex formation occurred during testing and what conditions were present at such times (submergence level, approach velocity and grating installation).

<u>Response methodology:</u>

- Clarifying schematics are provided for both the vortex test condition and the actual McGuire strainer configuration:
    - a For testing purposes, the as-built maximum approach velocity for the top hats closest to the ECCS suction lines was determined to be 0.048 feet per second in Catawba Unit 2, which bounds Unit 1. This approach

velocity does not use the normalized flow distribution approach. Instead, the flow is distributed among the top hat modules such that the internal losses within the strainer top hat assemblies and plenums are pressure balanced. This results in a non-uniform flow distribution, which is used to determine the approach velocities. With an initially clean ECCS sump strainer surface, approach velocities for the top-hat modules closest to the pump suction line are expected to be higher than the predicted Catawba nominal approach velocity (i.e., about 0.021 feet per second) by approximately a factor of two.

b Vortex testing was performed by initially establishing flow at 0.01 feet per second for a time of 10 minutes, without a vortex suppressor installed. Flow was then increased by 0.01 foot per second increments until a vortex was observed. A minimum of 10 minutes was allowed at each flow rate to allow time for a vortex to form. Once an air-entraining vortex was observed, the suppressor was installed. Flow was incrementally increased in 0.01 foot per second increments up to a maximum test approach velocity of 0.09 feet per second, which is approximately twice the maximum expected approach velocity for the Catawba Units.

c Without vortex suppression installed, at approach velocities above 0.04 feet per second and air-entraining vortex was present. With the vortex suppressor installed, vortices were eliminated and only minor surface dimpling remained up to the maximum test approach velocity of 0.09 feet per second (approximately twice the maximum expected Catawba approach velocity).

d The in-plant configuration has the top of the vortex suppressor grating at an elevation of 554'9", which is also the same as the minimum flood level in containment. It should be noted that this minimum flood level is highly conservative as it is calculated based on the break being small enough that no ice melt has occurred, the NC system being water solid, the FWST is at the minimum volume allowed by plant Technical Specifications, and the incore room beneath the reactor is completely flooded. In addition in this configuration, the ECCS flow is significantly less than the full ECCS flow modeled in vortex testing.

e Minimum submergence for the vortex test condition was three inches.

f Vortices were observed at flows of 0.04 feet per second and above without the vortex suppressor installed. With the vortex suppressor installed, no vortices were observed up to flows of approximately 2 times the maximum approach velocity.

- This question relates also to McGuire question 13

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C13 Please provide a response to the question from the NRC Content Guide sent by letter dated November 21, 2007, relating to Enclosure 2 of the supplemental response sent by letter dated February 29, 2008, Section 3(f)(5), regarding the ability of the strainer to accommodate the maximum potential debris volume. This response should apply specifically to the Catawba strainer and not be a generic answer.

Response methodology:

- Volumes of all debris transported to the Catawba strainer are computed:
  - Qualified epoxy coatings = 1.32 ft^3
  - Unqualified epoxy coatings = 2.31 ft^3
  - Unqualified alkyd coatings = 0.11 ft^3
  - Latent dirt/dust = 1.01 ft^3
  - Latent fiber = 12.5 ft^3
  - Total transported released fiber volume* = 100.3 ft^3

    **based on 17D ZOI after fall 2009 fiber removal project*
- Therefore the total debris volume at the Catawba strainer (Unit 1) is 117.6 ft^3
- The total interstitial volume of the limiting Catawba sump strainer (Unit 2) is 513 ft^3, so the complex geometry of the top-hat strainer modules is maintained
- This question relates to McGuire question 14

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C14 Please provide information that verifies that the debris preparation and introduction methods used during the array test and IPT were prototypical or conservative with respect to the transport evaluation for the plant. In general, protocols for fibrous debris preparation result in debris that is coarser than predicted by the plant-specific transport calculation. In addition, the NRC staff has noted that debris introduction frequently results in agglomeration of debris such that it may not transport to the strainer prototypically or create a prototypical debris bed. Both of these issues can result in non-conservative head loss values during testing.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to McGuire question 16

C15 Please provide information on the flow fields in the array test. The NRC staff is concerned that non-prototypical debris distribution may have occurred during testing as a result of stirring of the tank. Stirring can result in the transport of debris that would otherwise not transport, or result in debris being washed from the strainer screen surfaces. Either of these phenomena can result in reduced (non-conservative) head loss values during testing.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to McGuire question 16

C16 Please provide information that verifies that the debris preparation and introduction methods used during the thin bed testing for the top hat strainer design were prototypical with respect to the plant-specific debris generation and transport evaluation for Catawba. Note that for thin bed testing, the NRC staff considers it prototypical or conservative for fine fiber to arrive at the strainer prior to less transportable debris. Overly coarse debris preparation or non-prototypical introduction to the flume may non-conservatively affect the potential for thin bed formation.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to McGuire question 17

C17 Please provide the criteria used to judge that differential pressure-induced effects (e.g., boreholes) did not occur during testing. The existence of pressure-induced effects could invalidate the application of temperature scaling. Please state whether pressure-induced effects were identified and, if so, the resultant effect on the application of temperature scaling.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to McGuire question 18

C18 Please provide the scaling parameters used for calculation of debris quantities and strainer approach velocities used during testing. Please state whether the scaling accounted for strainer areas blocked by miscellaneous debris such as labels and tape.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- The volumes of the coatings surrogates used for all previous prototype testing (Confirmatory Debris Bed Formation Test, 2×3 Array Test, and the Integrated Prototype Test) were adjusted to account for the difference in densities between the surrogates and the predicted post-accident failed coatings debris in the plant. The volume adjustment accounts appropriately for the interstitial capacity of the strainer to address potential issues with uniform loading.

C19 Please discuss the NRC staff's observation that in the IPT the flow was non-prototypically directed at the top hat strainer in a direction parallel to the top hat long axis. Please address whether this non-prototypical flow direction could result in a non-prototypical formation of debris on the top hat strainer.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question also relates to McGuire question 21

C20 Please provide the clean strainer head loss for Catawba Unit 1 (only the clean strainer head loss for Catawba Unit 2 was provided).

Response methodology:

- The Catawba clean strainer head loss (CSHL) for Unit 1 is calculated as 3.21 feet of water at 60F, for the maximum recirculation flow condition.
- The Catawba CSHL for Unit 2 is calculated as 3.50 feet of water at 60F, for the maximum recirculation flow condition.
- This question also relates to McGuire question 22

C21. Please provide the time-dependent results and calculation methodology for determining net positive suction head (NPSH) margin throughout the 30-day mission time.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.

C22. Please provide the basis for the debris introduction information that indicates that no fine fibrous debris would be generated during a loss-of-coolant accident (LOCA). If the assumption of zero fibrous debris generation is in error please provide the amount of fibrous debris generated by the limiting break and justify why, in such a case, the head loss test results would remain valid.

Response methodology:

- This question is related to question 4 and the response is provided there

C23. Please provide the types and amounts of debris added to each test (Array and IPT) and include information on introduction sequence. Please provide relevant test parameters such as temperature, debris introduction times, and flow rate for the Array and IPT tests.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to McGuire question 24

C24. Please provide information on the amounts of debris that settled during testing for each test (IPT, Array, and Thin Bed). Note that Enclosure 1 of supplemental response dated February 29, 2008, stated that near-field settling was not credited during testing. However, the NRC staff observed significant settling during the IPT. Please provide a quantitative evaluation of how this settling affected head losses for each test. Please state whether this settling is prototypical of plant conditions and provide a basis for the conclusion.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to McGuire question 25

C25. The supplemental response stated that the head loss across the Catawba Emergency Core Cooling System Sump strainer (clean strainer head loss plus debris bed head loss) is conservatively predicted to be 5.4 ft at switchover to sump recirculation. However, no explanation was provided as to how this value was derived. It appears that credit was taken for time-dependency in head loss, since the 30-day value is 8.2 ft. Please provide the time dependent results and calculation methodology for determining NPSH margin throughout the 30-day mission time.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to McGuire question 23

C26. Please state whether the containment cleaning actions described in Duke's response to Bulletin 2003-01, sent by letter dated August 7, 2003, will remain in effect at Catawba (in order to assure that debris source assumptions made as part of the GL 2004-02 resolution remain valid). Specifically, please identify the procedures which control the cleanliness actions for containment and any commitments regarding the long-term applicability of these procedures.

Response methodology:

As identified in the Catawba GL 2004-02 Supplemental Response dated 2/29/08, item 3(i)(1), Catawba has implemented programmatic controls to ensure that potential sources of debris that may be introduced into containment will be assessed for adverse effects on the ECCS and Containment Spray recirculation functions.

- Containment Housekeeping / Materiel Condition
    - Extensive containment cleaning is performed during each refueling outage using water spray, vacuuming and hand wiping
    - Localized wash downs are performed as needed and visual inspections are performed on the remaining areas of containment.
    - Foreign material is removed as necessary.
    - Material control procedures require material accountability logs to be maintained in Modes 1 through 4 for items carried into and out of containment. These controls are implemented using administrative procedures.

- Catawba Technical Specification Surveillance Requirement
    - Catawba Technical Specification Surveillance Requirement 3.5.2.8 requires that the ECCS sump be visually inspected to verify there are no restrictions as a result of debris, and no evidence of structural distress or abnormal corrosion present prior to declaring the ECCS sump operable.
    - A visual inspection of containment is performed to ensure no loose material is present which could be transported to the Containment Sump and cause restriction of the ECCS pump suction during accident conditions prior to the transition from Mode 5 to Mode 4 operations.
    - In order to satisfy TS SR 3.6.15.1, the Refueling Canal Drain Valves are verified as locked open and unobstructed prior to entry into Mode 4
    - In order to satisfy TS SR 3.6.15.2, visual verification that no debris is present in the Refueling Canal or Upper Containment that could

obstruct the Refueling Canal Drains is performed once every 92 days

- Catawba Selected Licensee Commitment 16.6.1 ensures that a visual inspection is performed to identify any loose debris inside containment and ensure it is removed prior to establishing containment integrity and following entries made after containment integrity is established.

- This question relates also to McGuire question 28

C27. The revised "Content Guide for Generic Letter 2004-02 Supplemental Responses," sent by letter dated November 21, 2007, Section 3k, requests a summary of structural qualification design margins for the various components of the sump strainer structural assembly. This summary should include interaction ratios and/or design margins for structural members, welds, concrete anchorages, and connection bolts as applicable. Please provide this information.

Response methodology:

- The design input values for the Catawba strainer:

	Design Input	Top-hat module*	Main Structure Excluding Wing Walls/Water Boxes	Structure Including Wing Walls/Water Boxes	Vortex Suppression Rack
	Temperature	300 °F	300 °F	250 °F	250 °F
	Differential Pressure	10 psid	7 psid	7 psid	NA
	Dead Weight	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3	0.29 lb/in^3
	Live Load	-	-	-	50 psf
	Misc. Load (Cable Tray/Conduit)	-	-	-	27 lb/ft (U2) 160 lb (U1)
Seismic	ZPA Frequency	20 Hz	20 Hz	20 Hz	20 Hz
Seismic	Damping	2%	2%	2%	2%
Seismic	Max SSE Horizontal Acc.	0.94 g	0.94 g	0.94 g	0.94 g
Seismic	Max SSE Vertical Acc.	0.63 g	0.63 g	0.63 g	0.63 g

- The response also contains tabulated values of structural design margins and interaction ratios for each component type of the Catawba strainer. A sample table is provided below:

CNC-1144.06-02-0007, Thru Rev 1, Analysis of Sump Strainer Top Hat				
Top Hat Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Top Hat Loading	Bending Stress	1013 psi	4509 psi	
	Hoop Stress	373 psi	4509 psi	Axial stress is insignificant
Top Hat Buckling	Bending Moment Loading	1013 psi	24175 psi	
	Axial Loading	79 psi	33133 psi	
	Circumferential Pressure Loading	373 psi	1253 psi	
3/8" Diameter Studs	Max IR	0.07	1.0	
Top Cover Plate	Bending Stress	2218 psi	16875 psi	
Base Plate	Max Stress	5232 psi	16875 psi	

1/16" Fillet Weld Between Perforated Tube and Bottom Flange	Max Force	115.29 lbs/in	563 lbs/in	Base metal shear allowable - 563 lbs/in; Fillet weld allowable - 928 lbs/in
1/16" Fillet Weld Between Perforated Tube and Cover Plate	Max Force	32.13 lbs/in	563 lbs/in	Base metal shear allowable - 563 lbs/in; Fillet weld allowable - 928 lbs/in

- This question also relates to McGuire question 30

C28. Please describe the basis for concluding that there is no potential of debris blockage at the ice condenser drains and refueling canal drains for accident scenarios where containment spray is necessary.

Response methodology:

- Catawba has implemented the following programmatic controls regarding ice condenser cleanliness to prevent debris blockage at the ice condenser drains prior to an accident:
  - The ice condenser is inspected for foreign material prior to the transition from Mode 5 to Mode 4. Any debris that cannot be removed is evaluated by the Containment Sump Engineer prior to entering Mode 4.
  - In order to fulfill Technical Specification (TS) Surveillance Requirement (SR) 3.6.15.3, ice condenser floor drains are verified as operable once every 18 months during shutdown
- Any debris created during an accident in lower containment would have to be carried by steam into the ice condenser and navigate a torturous path through the ice condenser baskets in order to reach and potentially block the refueling canal or ice condenser floor drains.
- The containment cleanliness activities and surveillances described in response to question 26 ensures debris is not present that would have the potential to become lodged in a refueling canal drain

C29. The NRC staff considers in-vessel downstream effects to not be fully addressed at Catawba, as well as at other pressurized-water reactors. The supplemental response for Catawba refers to the evaluation methods of Section 9 of Topical Report (TR) WCAP-16406-P, Revision 1,"Evaluation of Downstream Sump Debris Effects in Support of GS-191" for in-vessel downstream evaluations and makes reference to a comparison of plant-specific parameters to those evaluated in TR WCAP-16793-NP, Revision 0, "Evaluation of Long Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final Safety Evaluation (SE) for TR WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for Catawba by showing that the licensee's plant conditions are bounded by the final TR WCAP-16793-NP and the conditions and limitations identified in the final NRC staff's SE. The licensee may also resolve this item by demonstrating without reference to TR WCAP-16793 or the NRC staff's SE that in-vessel downstream effects have been addressed at Catawba. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff's SE on TR WCAP-16793. The NRC staff is developing a Regulatory Issue Summary to inform the industry of the NRC staff's expectations and plans regarding resolution of this remaining aspect of GSI-191.

Response methodology:

- Catawba Nuclear Station will address the in-vessel downstream effects issue within 90 days of issuance of the staff's final Safety Evaluation on TR WCAP-16793.
- This question also relates to McGuire question 31

C30. Please discuss why the Integrated Prototype Test (IPT) provided a representative debris bed on the top-hat strainer module for filtering chemical precipitates. The NRC staff observed the debris addition video and concluded that the fibrous debris introduced into the test tank was more agglomerated than what may arrive at the strainer under post-LOCA flow conditions in the plant. Is the amount of bare strainer area observed in the test representative of what is expected to occur with the plant strainer array if a large break LOCA were to occur? The use of chemical effects test results derived from a test which formed a non-prototypically partially clean screen fiber bed would not be appropriate.

Response methodology:

- This question is related to original prototype testing that is being confirmed via separate tests and analysis, using revised protocol and input parameters.
- This question relates also to McGuire question 32