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July 2, 2012

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Duke Energy Carolinas, LLC (Duke Energy)
McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 50-370

Final Responses to NRC Request for Additional Information (RAI) related to Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"

On September 13, 2004, the NRC issued GL 2004-02. The GL requested that all pressurized-water reactor licensees (1) evaluate the adequacy of the emergency sump recirculation function with respect to potentially adverse effects associated with post-accident debris, and (2) implement any plant modifications determined to be necessary.

Duke Energy has been actively engaged in these evaluations, including completion of emergency sump strainer modifications at McGuire. Duke Energy has continued to communicate with the NRC both formally and informally on progress to address remaining issues related to strainer qualification. The Supplemental Responses to GL 2004-02 were formally sent to the NRC by McGuire's submittals dated February 28 and April 30, 2008. From these submittals, the NRC developed plant-specific RAIs that were received by McGuire on November 18, 2008.

Duke Energy discussed the McGuire RAIs with the NRC in a public teleconference on September 1, 2009 in order to clarify the path forward regarding prototype strainer testing and several industry-wide issues affecting credited analytical refinements.

In another teleconference with the NRC on June 9, 2010, Duke Energy agreed to provide plant-specific draft RAI responses by September 30, 2010 to assure clear understanding of methodology prior to formal RAI response submittal. The draft RAI responses were submitted for NRC review on September 30, 2010.

The draft responses were discussed in a follow-up teleconference with the NRC on November 1, 2010. As strainer performance testing was still underway at that time, the formal responses to many of the RAI questions were unfinished pending the test results and documentation. The strainer performance testing was completed in February 2011 and the results certified via report on June 20, 2012.

The purpose of this letter is to provide the formal GL 2004-02 Supplemental Response RAI responses for McGuire Nuclear Station.

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- Attachment 1 provides an overview of the McGuire GL 2004-02 resolution path and identifies any changes made to the draft RAI responses submitted on September 30, 2010.

- Attachment 2 provides the final RAI responses for McGuire.

- Attachment 3 identifies remaining commitments made in support of McGuire GL 2004-02 resolution.

Duke Energy will be working with the NRC Project Manager to arrange a follow-up teleconference to discuss any points of clarification needed on these final RAI responses.

If any questions arise or additional information is needed, please contact P. T. Vu at (980) 875-4302.

Very truly yours,

Regis T. Repko

Regis T. Repko

Attachments

xc (with Attachments):

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Regis T. Repko affirms that he is the person who subscribed his name to the foregoing statement, and that all the matters and facts set forth herein are true and correct to the best of his knowledge.

Regis T. Repko

Regis T. Repko, Vice President, McGuire Nuclear Station

Subscribed and sworn to me: July 2, 2012
Date

Lori C. Gibbs, Notary Public

My commission expires: July 1, 2017
Date

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Attachment 1

Preface to Final McGuire Responses
Generic Letter 2004-02 Supplemental Response
November 18, 2008 NRC Request for Additional Information

July 2, 2012

Preface to Final McGuire Responses
Generic Letter 2004-02 Supplemental Response
November 18, 2008 NRC Request for Additional Information
July 2, 2012

Since the formal submittal of the McGuire Nuclear Station Generic Letter (GL) 2004-02 Supplemental Responses in the spring of 2008 and the receipt of Requests for Additional Information (RAI) from the NRC in the fall of that year, Duke Energy has been actively engaged with the technical staff in resolving questions and concerns related to the Emergency Core Cooling System (ECCS) Sump Strainer design and qualification for the station. This interface has led to specific changes in the original approach addressing GL 2004-02 for McGuire, and also to a clearer understanding of the additional actions required for final resolution. In responding to the RAIs, Duke Energy has incorporated the following differences from the original GL 2004-02 approach:

- McGuire is no longer crediting Zone of Influence (ZOI) refinements for fiberglass insulation associated with 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."
- McGuire is replacing a significant amount of low density fiberglass (LDFG) insulation in specific areas of lower containment with reflective metal insulation (RMI) via the Fiber Insulation Replacement Project (FIRP). The McGuire Unit 2 FIRP scope is already complete and the Unit 1 FIRP scope is in progress.
- McGuire submitted a license amendment request (LAR) to the NRC for ECCS Water Management (WM) modifications, which included revisions to post-accident response that reduce recirculation flow rates through the ECCS Sump Strainers and decrease the predicted volume of transported sump pool debris. The ECCS WM LAR reduces the number of required ECCS trains from four to three (2 trains of Residual Heat Removal (RHR) and one train of Containment Spray (CS), referred to as "three-train flow" throughout this submittal). This LAR was approved; the modifications are complete for McGuire Unit 1 and in progress for Unit 2.
- ECCS Sump Strainer performance for McGuire was confirmed in 2011 via a prototype Chemical Precipitates Head Loss test, which followed the guidance provided in "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Plant-Specific Chemical Effect Evaluations" dated March 2008, in conjunction with the methodology described in WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191."

The attached final RAI responses integrate the differences identified above and represent the current Duke Energy understanding and proposed resolution of remaining open issues related to the McGuire GL 2004-02 Supplemental Responses. McGuire discussed the response methodology for each NRC RAI question during a public teleconference with the technical staff on September 1, 2009 to facilitate final response development. The NRC's comments/clarifications on the RAI questions and proposed response methodology received during the public teleconference, provided they were not altered by the changes identified above, were also incorporated. At the NRC's request, draft RAI responses encompassing the above were submitted for review on September 30, 2010, and a follow-up teleconference conducted on November 1, 2010 to ensure the path to GL 2004-02 closure was understood. With the exception of the then ongoing ECCS Sump Strainer performance testing-related RAI questions, the staff provided additional comments for inclusion in the final RAI responses which have also been incorporated. The testing-related issues have been discussed at length with the staff as they have occurred, and the final disposition of these issues is included herein in the appropriate RAI responses.

ECCS Sump Strainer Performance Testing Chronology

NRC technical staff concerns with the Array Test and the 2007 Integrated Prototype Test (IPT) (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation.

In June of 2009, a Confirmatory Head Loss test series was performed at Wyle Laboratories by Duke Energy using a newly designed flume and conventional debris (i.e., bounding fiber and particulate loads) to address the debris preparation, debris introduction, debris agglomeration/settling and flow field issues identified by the staff regarding the 2007 IPT. NRC staff guidance from March of 2008 as well as input from discussions with the staff were used for the test protocol development for the Confirmatory Head Loss test series. Upon completion of the June 2009 testing, the protocol, debris bed formation and head loss results were discussed with the staff in July 2009, along with photos and videos obtained during the testing. From these conversations, the staff concluded that the methods and protocol being utilized for conventional debris preparation and introduction during the tests met NRC expectations.

In parallel with the Confirmatory Head Loss test series in June 2009, Duke Energy provided a draft white paper to the NRC technical staff entitled "Duke Energy Chemical Effects Testing in Support of GSI-191". This document served as a guide for discussions with the staff on the battery of testing performed by Duke Energy to date in the area of chemical effects, and to address NRC concerns with the effect of potential chemical precipitates. As a result of these discussions, Duke Energy elected to continue head loss testing in the fall of 2009, using the Confirmatory Head Loss test series protocol and test flume along with pre-mixed chemical precipitates in accordance with staff guidance. The fall 2009 testing was identified as the Chemical Precipitates Head Loss test series, which continued into the spring of 2010. The results of this precipitate testing were discussed with the NRC staff in April and May of 2010.

Subsequent to the Chemical Precipitates Head Loss test series, Duke Energy determined that a one-time, long-term test approach utilizing soluble aluminum injection (as opposed to introducing pre-mixed precipitates) would be more representative of the post-LOCA environments predicted in ice condenser containments. Identified as the Confirmatory Integrated Test (CIT), the development of the test protocol followed discussions in June 2010 with the NRC staff, and incorporated previous testing experience with conventional debris preparation, introduction, and transport to facilitate the formation of a uniform debris bed on a prototype strainer array. During the initial phases of the CIT, difficulties were encountered with the test system and the test was abandoned. The difficulties and the plan forward were discussed with the staff in November 2010.

After the CIT was abandoned, Duke Energy determined that the Chemical Precipitates Head Loss test methodology utilized previously would provide a robust long-term design basis position when combined with additional mitigating measures that have been either completed or are underway. These measures include replacing a significant amount of fibrous insulation in Containment with RMI (FIRP modifications), and modifying the plant accident mitigation strategy to include ECCS Water Management methodology. This approach was discussed with the staff in February 2011.

Once the potential effects of these additional mitigating measures were determined, the Chemical Precipitates Head Loss test series was continued with the appropriate refined inputs (reduced ECCS flow and reduced fibrous debris volumes). The testing inputs, methodology and results discussed in this submittal are based on the revised/continued Chemical Precipitates Head Loss test series. The confirmatory testing that took place between the 2007 IPT and the 2011 final testing provided insights on testing methodologies and strainer performance and informed the Chemical Precipitates Head Loss test series, but are not considered tests of record and will not be described further in this submittal.

<u>Changes to the September 30, 2010 McGuire Draft RAI Responses</u>

The following McGuire RAI responses have been modified from the draft versions submitted to and reviewed by the NRC staff. Other than the responses related to the recently completed ECCS Sump Strainer Performance testing, the changes are editorial and clarification-related and result from the enhanced review process associated with the issuance of the formal RAI response. The changes made are identified here for convenience:

RAI questions 1-4: completion date for FIRP modifications clarified.

RAI questions 5-6, 10, 29, and 31: no changes from draft submittal.

RAI question 7: completion date for FIRP modifications clarified, and added Table 7S-2 based on NRC feedback from November 1, 2010 telecon.

RAI question 8: clarification of lower containment area description and added clarifying information regarding ice condenser post-accident environment.

RAI question 9: minor editorial change regarding Unit reference wording.

RAI question 11: minor editorial change regarding Duke Energy reference wording.

RAI questions 12, 15-21, 23-25, and 32: ECCS Sump Strainer performance test related—response completely revised.

RAI question 13: clarification (qualitative) regarding the effect of ECCS Water Management modifications.

RAI question 14: completion date for FIRP modifications clarified, minor (round-off related) refinements to fibrous debris quantities for both pre- and post-ECCS Water Management modification conditions, editorial changes to Table 14S-1, and minor (round-off related) refinements to the limiting total debris volume transported to the ECCS Sump Strainer.

RAI question 22: response revised to qualitatively identify effect of ECCS Water Management modifications.

RAI questions 26-27: clarified date of the McGuire ECCS Sump Strainer Performance test of record.

RAI question 28: Added clarification regarding the capture of previous McGuire commitments.

RAI question 30: Identified the Crossflow Plenum of the ECCS Sump Strainer in Figure 30S-1, and added note regarding the use of faulted allowable loads based on NRC feedback from November 1, 2010 teleconference.

Attachment 2

McGuire Nuclear Station
Generic Letter 2004-02 Supplemental Response
November 18, 2008 NRC Request for Additional Information

Final Responses

July 2, 2012

1. 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.

McGuire Response:

In the McGuire GL 2004-02 Supplemental Response dated February 28, 2008 and the McGuire GL 2004-02 Amended Supplemental Response dated April 30, 2008, the quantity of fibrous debris generated from destroyed fiber insulation and deposited in the ECCS sump pool was determined using the Zones of Influence (ZOIs) described in both the NEI 04-07 Guidance Report (and the associated NRC Safety Evaluation (GR/SE)) and 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," Revision 0. Specifically, the McGuire ECCS Sump Strainers were initially designed using the NEI 04-07 ZOI guidance relating to fiber insulation ZOIs, and the subsequent Integrated Prototype Test (IPT) for chemical effects used WCAP-refined ZOI values.

In the time period since the Supplemental/Amended Supplemental Responses were submitted, McGuire has determined that reliance on the WCAP-16710-P jacketed fiber insulation ZOI refinements is no longer necessary, and therefore the fibrous debris quantities generated from destroyed fiber insulation will be based on the NEI 04-07 GR/SE only. For both jacketed and unjacketed Nukon® fiber insulation types located in the postulated break zones, the ZOI used for quantification of debris is 17D as identified in the GR/SE, Table 3-2. For the Thermal-Wrap® fiber insulation applications within the postulated break zones, the 17D ZOI is also invoked, consistent with the low density fiberglass (LDFG) destruction pressures discussed in the GR/SE, Section II.3.1.1.

This change in approach is primarily due to the implementation of Fiber Insulation Replacement Project (FIRP) modifications, which are scheduled to be completed in 2013. These modifications replace existing fiber insulation on the reactor coolant loop piping (hot legs, cold legs, and crossover legs), the steam generators, and the reactor coolant pumps with reflective metal insulation in both McGuire units. This scope significantly reduces the destroyed fiber insulation load within the postulated 17D break ZOIs.

2. 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>McGuire Response:</u>

As described in the response to RAI question 1, in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008 and the McGuire GL 2004-02 Amended Supplemental Response dated April 30, 2008, the quantity of fibrous debris generated from destroyed fiber insulation and deposited in the ECCS sump pool was determined using the Zones of Influence (ZOIs) described in both the NEI 04-07 Guidance Report (and the associated NRC Safety Evaluation (GR/SE)) and 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," Revision 0. Specifically, the McGuire ECCS Sump Strainers were initially designed using the NEI 04-07 ZOI guidance relating to fiber insulation ZOIs, and the subsequent Integrated Prototype Test (IPT) for chemical effects used WCAP-refined ZOI values.

In the time period since the Supplemental/Amended Supplemental Responses were submitted, McGuire has determined that reliance on the WCAP-16710-P jacketed fiber insulation ZOI refinements is no longer necessary, and therefore the fibrous debris quantities generated from destroyed fiber insulation will be based on the NEI 04-07 GR/SE only. For both jacketed and unjacketed Nukon® fiber insulation types located in the postulated break zones, the ZOI used for quantification of debris is 17D as identified in the GR/SE, Table 3-2. For the Thermal-Wrap® fiber insulation applications within the postulated break zones, the 17D ZOI is also invoked, consistent with the LDFG destruction pressures discussed in the GR/SE, Section II.3.1.1.

This change in approach is primarily due to the implementation of Fiber Insulation Replacement Project (FIRP) modifications, which are scheduled to be completed in 2013. These modifications replace existing fiber insulation on the reactor coolant loop piping (hot legs, cold legs, and crossover legs), the steam generators, and the reactor coolant pumps with reflective metal insulation in both McGuire units. This scope significantly reduces the destroyed fiber insulation load within the postulated 17D break ZOIs.

3. 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.)

McGuire Response:

Unjacketed Nukon® insulation (along with other fiber insulation systems) is present within the McGuire containment break ZOIs.

As discussed in the response to RAI question 1, McGuire is no longer implementing the jacketed fiber insulation refinements identified in WCAP-16710-P. As a result of this, all fiber insulation within the postulated break zones (jacketed or unjacketed) is assumed to have a ZOI of 17D per the NEI 04-07 GR/SE.

This change in approach is primarily due to the implementation of Fiber Insulation Replacement Project (FIRP) modifications, which are scheduled to be completed in 2013. These modifications replace existing fiber insulation on the reactor coolant loop piping (hot legs, cold legs, and crossover legs), the steam generators, and the reactor coolant pumps with reflective metal insulation in both McGuire units. This modification scope significantly reduces the destroyed fiber insulation volume within the postulated 17D break ZOIs.

With the new insulation configuration, jacketed and unjacketed fiber insulation within the assumed 17D ZOI contribute a total volume of 422 ft^3 of fiber to the ECCS sump pool for the limiting break location at McGuire (Unit 2 RC Loop B Hot Leg).

4. 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).

McGuire Response:

As discussed in the response to RAI question 1, McGuire is no longer implementing the jacketed fiber insulation refinements identified in WCAP-16710-P. As a result of this, all fiber insulation within the postulated break zones (jacketed or unjacketed) has a ZOI of 17D per the NEI 04-07 GR/SE.

This change in approach is primarily due to the implementation of Fiber Insulation Replacement Project (FIRP) modifications, which are scheduled to be completed in 2013. These modifications replace existing fiber insulation on the reactor coolant loop piping (hot legs, cold legs, and crossover legs), the steam generators, and the reactor coolant pumps with reflective metal insulation in both McGuire units. This scope significantly reduces the destroyed fiber insulation load within the postulated 17D break ZOIs.

The replacement of the fiber insulation systems in FIRP scope has the same effect from a break location evaluation perspective as any other fiber reduction refinement would; therefore the McGuire break locations were revisited using the post-FIRP insulation configuration to ensure the limiting break was identified.

Post-FIRP break categories/relative ranking did not change; these were documented in McGuire GL 2004-02 Supplemental Response dated February 28, 2008, 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

The top four break locations (all in category 1) identified with the post-FIRP insulation configuration in terms of debris generation are:

- RC Hot Legs
- RC Cold Legs
- RC Crossover Legs
- Pressurizer Surge Line

The limiting break location at McGuire, the Unit 2 RC Loop B Hot Leg, did not change after the post-FIRP insulation configuration was evaluated along with the assumption of a 17D ZOI for fiber insulation. Note that the RC Loop B Hot Leg break is closer to the ECCS Sump Strainer and therefore transports more fibrous debris.

5. 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.

<u>McGuire Response:</u>

McGuire is no longer implementing the jacketed fiber insulation refinements identified in WCAP-16710-P. As a result of this, all fiber insulation within the postulated break zones (jacketed or unjacketed) has a ZOI of 17D per the NEI 04-07 GR/SE.

Reference the response to RAI question 1 of this submittal for further information.

6. 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.

McGuire Response:

McGuire is no longer implementing the jacketed fiber insulation refinements identified in WCAP-16710-P. As a result of this, all fiber insulation within the postulated break zones (jacketed or unjacketed) has a ZOI of 17D per the NEI 04-07 GR/SE.

Reference the response to RAI question 1 of this submittal for further information.

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

McGuire Response:

As discussed in the response to RAI question 1, McGuire is no longer implementing the jacketed fiber insulation refinements (i.e., the 7D ZOI) identified in WCAP-16710-P. As a result of this, all fiber insulation within the postulated break zones (jacketed or unjacketed) has a ZOI of 17D per the NEI 04-07 GR/SE.

This change in approach is primarily due to the implementation of Fiber Insulation Replacement Project (FIRP) modifications, which are scheduled to be completed in 2013. These modifications replace existing fiber insulation on the reactor coolant loop piping (hot legs, cold legs, and crossover legs), the steam generators, and the reactor coolant pumps with reflective metal insulation in both McGuire units. This scope significantly reduces the destroyed fiber insulation load within the postulated 17D break ZOIs.

With the new insulation configuration, destroyed insulation within the assumed 17D ZOI contributes a total of 422 ft^3 of fiber to the ECCS sump pool for the limiting break location at McGuire (Unit 2 RC Loop B Hot Leg).

The size distribution of the destroyed fiber insulation (before and after FIRP modifications) for this limiting break is shown in Table 7S-1 below.

Table 7S-1
McGuire Destroyed LDFG Debris Volumes - Limiting Break Size Distribution

Nukon® and Thermal-Wrap® Low Density Fiberglass (LDFG)	**Pre-FIRP* Fiber Volume Generated (17D ZOI)**	**Post-FIRP Fiber Volume Generated (17D ZOI)**
Fines (constituent fibers)	272.7 ft^3	40.7 ft^3
Small Pieces (<6" on a Side)	891.9 ft^3	81.4 ft^3
Large Pieces (>6" on a Side)	444.9 ft^3	144.7 ft^3
Intact Blankets	476.4 ft^3	155.2 ft^3
Total	2085.9 ft^3	422.0 ft^3

* FIRP = Fiber Insulation Replacement Project

As discussed in the November 1, 2010 telecon between Duke Energy and NRC, this fibrous debris volume distribution is generated from the same three break ZOI band sub-zones as were defined in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008. The three sub-zones are recreated below in Table 7S-2 for convenience.

Table 7S-2
McGuire Destroyed LDFG Debris Distribution
ZOI Bands

SIZE	18.6 psi ZOI (7.0 L/D)	10.0-18.6 psi ZOI (11.9-7.0 L/D)	6.0-10.0 psi ZOI (17.0-11.9 L/D)
Fines (Individual Fibers)	20%	13%	8%
Small Pieces (<6" on a side)	80%	54%	7%
Large Pieces (>6" on a side)	0%	16%	41%
Intact (covered) Blankets	0%	17%	44%

8. 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.

McGuire Response:

The assumptions and engineering judgments used in the McGuire tag and label reduction evaluation performed subsequent to the initial tag and label assessment were provided in the responses to items 3(d)1, 3(d)2 and 3(i)5 of Enclosure 2 of the McGuire GL 2004-02 Supplemental Response dated February 28, 2008.

The tag and label assessment subsequently included only one refinement in the form of a qualified tag reduction. For this reduction, it was assumed that metal tags hung with braided stainless steel connections would either not fail, or would sink and not transport. These robust metal tags are not the same as qualified Electromark® labels, which are discussed later in this response.

The transported tag and label quantifications by area of Containment were reported in Table 3D3-2 of Enclosure 2 of the McGuire GL 2004-02 Supplemental Response dated February 28, 2008. The information in this table is recreated below in Table 8S-1 for convenience.

Table 8S-1

McGuire Refined Miscellaneous Latent Debris Quantities

Type of Debris	Lower Containment (Inside Crane Wall)	Lower Containment (Outside Crane Wall)	Upper Containment	Ice Condenser	Total
Stickers & Labels (ft^2)	64.96	30.34	14.43	8.92	118.65
Plastic Tags w/ Adhesive (ft^2)	33.32	8.79	11.23	8.02	61.36
Plastic Hanging Tags (ft^2)	11.70	4.33	N/A	0.17	16.20
RMI ID Stickers (ft^2)	103.14	32.81	N/A	N/A	135.95
Ice Condenser Debris (ft^2)	N/A	N/A	N/A	15.30	15.30
Total (ft^2)	N/A	N/A	N/A	N/A	347.5

As stated in item 3(i)5, Electromark® labels located outside the Crane Wall in the lower containment at McGuire have been evaluated as capable of withstanding the limiting break, and thus were removed from the quantification of tag and label debris assumed to transport to the ECCS Sump Strainer. Electromark® labels located inside the Crane Wall in lower containment are assumed to fail.

For the purposes of this response, "labels" refers to any thin pliable sticker or marker that is affixed with adhesive. The term "tag" refers to any relatively thick rigid plastic tag or placard that is hung, or affixed with adhesive.

Lower Containment

In an Ice Condenser containment, the areas of the lower containment outside the Crane Wall and not inside the Ice Condenser Lower Plenum or the Pipe Chase are located between the Ice Condenser end walls (approx. 60 degrees of circumference) and in the rooms above the Pipe Chase. Plastic tags in this vicinity are generally outside the break ZOIs and are assumed to deform, but not become overly pliable (i.e., they will not deform enough to pass through an obstruction that has a smaller dimension than the tag).

Ice Condenser Reduction

Tags and labels located within the Lower Plenum of the Ice Condenser (and outside the Crane Wall) are assumed to fail since the break energy is directed into this plenum by design.

Tags and labels located within the Upper Plenum of the Ice Condenser would not be expected to fail immediately during the initial venting of air and steam; however, exposure to the post-LOCA environment and containment spray may lead to eventual detachment even though steam flow is negligible. A minor portion of the tags and labels located in the Upper Plenum of the Ice Condenser are not located above the ice basket array and are located above horizontal surfaces. As these tags and labels fail, they will fall straight down and are not expected to transport further due to containment spray.

It is likely that many of the remaining tags and labels that fail within the Upper Plenum of the Ice Condenser will fall directly into the ice baskets themselves. Given the ice baskets are made of perforated sheet metal with 1" × 1" holes and the bottom of the baskets are covered by a grid and wire mesh, any tags and labels that fall into the ice baskets will not be able to exit. It is conservatively assumed that ice basket openings comprise 50% of the ice basket array cross-sectional area. Tags and labels that do not fall into the ice baskets themselves could fall into the space between the baskets and the lattice frame which provide support for the baskets. While the lattice frame does create a tortuous path for the tags and labels, it is not possible to conservatively estimate an appropriate quantity of labels that would remain within the lattice structure; therefore, no reduction was taken for tags and labels that may fall into this area.

Containment Elevation 738'+3" Reduction

The rooms above the Pipe Chase (i.e., at containment elevation 738'+3") are not subject to jet impingement or containment spray. Initially, the rooms will not be flooded, but as the accident progresses the maximum flood elevation will be reached. Access to the rooms is gained through an opening in the floor from the pipe chase below. Once the rooms are flooded, velocities in the rooms are expected to be very low and tags and labels would not transport to the pipe chase. Only tags and labels directly above the floor opening are assumed to transport to the pipe chase below.

Upper Containment Reductions

The majority of tags and labels within Upper Containment are located between the ends of the Ice Condenser walls, in the Containment Air Return fan pit, and around the personnel hatch. Tags and labels in these areas are subjected only to containment spray; those that detach are expected to fall straight down and there are none that would be expected to fall directly into the Refueling Canal.

It is conservatively assumed that all tags and labels that reach the Containment Air Return fan pit will pass to the lower containment via the fan pit drain. A majority of tags and labels outside the fan pit are located directly above grated platforms. It is judged that many of these labels will be easily captured by the 1" × 4" grating and thus the quantity of labels above the grating is reduced by 75%.

Although highly unlikely, it is conservatively assumed that all tags and labels that detach and fall to the concrete operating floor will be transported over the 3 inch curbing around the Refueling Canal and through the elevated canal drains to lower containment. The quantity of tags and labels overflowing the Refueling Canal curb represents about 50% of the Upper Containment total quantification identified in Table 8S-1.

Qualification of Electromark® Labels

The Electromark® labels located in containment were qualified for the LOCA environment via a comprehensive test program. The purpose of this program was to demonstrate the suitability of application for pressure sensitive markers in being able to remain in position (on equipment or structures) throughout a specified lifetime, including background radiation followed by a simulated LOCA. The safety function demonstrated was that the markers would remain affixed to the equipment or structure without falling off.

This test program was conducted under the general guidelines as suggested in IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." The various phases of the program are outlined as follows:

1) 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.

2) 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 megarads per hour until a total accumulated dose of 200 megarads had been received. The samples were then inspected again for wear and degradation.

3) 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.

9. 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.

McGuire Response:

Latent fiber (i.e., lint) quantities and latent particulate (i.e., dust and dirt) quantities at McGuire were estimated using NEI 02-01 containment walkdown guidance, in combination with the NEI 04-07 Guidance Report (GR) and its companion Safety Evaluation (SE). For McGuire, the Unit 1 latent debris estimates were used to represent both containments, since after inspection/broad sampling it was noted that the Unit 2 containment was sufficiently similar to (and judged to be cleaner than) the Unit 1 containment.

Methodology

The following activities were performed (in accordance with the GR/SE) to quantify the amount of latent debris in containment:

- Estimate horizontal and vertical surface area
- Evaluate resident debris buildup
- Define specific debris densities
- Determine fractional surface area susceptible to debris buildup
- Calculate total quantity and composition of debris

Also in accordance with the GR, containment was segregated into four areas based on the presence of robust barriers and representative surfaces:

- Lower Containment inside the Crane Wall
- Lower Containment Pipe Chase (outside the Crane Wall)
- Upper Containment
- Ice Condenser

Surface types within each of these areas were categorized as (a) Horizontal Floor Surfaces, (b) Horizontal Miscellaneous Surfaces, or (c) Vertical Surfaces. With the sampling surfaces defined, specific areas were chosen in order to obtain their representative online condition.

Sampling media included Masolin cloth and sticky foam. All sampling media was pre-bagged and labeled. Each bag contained a single Masolin cloth and a single sheet of sticky foam (sized approximately 9" × 12"). Each bag was then pre-weighed on a Mettler Toledo PR500D scale, with a tolerance of ± 0.04 gram.

The area was wiped down with a Masolin cloth to pick up fine debris and to consolidate larger particulate debris. Vertical surfaces were wiped from the bottom up to prevent a loss of debris. The sticky foam sheet was then used to pick up any remaining particulate debris. Both the

Masolin cloth and the tacky foam sheet were carefully folded to prevent loss of debris material and placed back in the sample bag. Excess air within the bag was gently forced out to allow the sample to be easily transported and post-weighed. After all sampling was complete the bags were weighed on the same scale. The difference between the pre- and post-weights were then used to calculate the mass of the collected debris.

Sample mass measurements were increased by an offset to account for a number of possible sampling and measurement errors including loss of sample media to the sample surface, air movement above the scale during measurement, and the tolerance of the scale. The error due to air movement and the tolerance of the scale could also act in a conservative direction for some samples (i.e., increase the measured sample mass), therefore the offset applied to these samples further increases the conservatism leading to a higher estimated latent debris loading.

There were 40 individual latent debris samples taken, with the following itemization by surface type:

Horizontal Floor Surfaces: 13 samples

Horizontal Miscellaneous Surfaces: 16 samples

Vertical Surfaces: 11 samples

Once the sample debris mass for each surface type was quantified via scale measurements, the specific debris density for each sampled area was computed by dividing the individual sample masses by their respective sampled surface areas. The sample densities were then grouped into the following sample sets based on common surface type and location, common associated work activities in each area, and cleanup procedures (e.g., similar work activities and cleanup would be expected for the floors in Lower Containment inside the Crane Wall and in the Pipe Chase):

- Horizontal floor surfaces in Lower Containment inside the Crane Wall and in the Pipe Chase
- Horizontal miscellaneous surfaces in Lower Containment inside the Crane Wall and in the Pipe Chase
- Vertical surfaces in Lower Containment inside the Crane Wall and in the Pipe Chase
- Horizontal floor surfaces in Upper Containment and inside the Ice Condenser
- Horizontal miscellaneous surfaces in Upper Containment and inside the Ice Condenser
- Vertical surfaces in Upper Containment and inside the Ice Condenser

A statistical analysis was then performed using the grouped sample densities to provide a conservative assessment of debris buildup over a given surface type. While the GR/SE states that the average of at least three samples for each surface type should be applied to the entire surface, the McGuire analysis goes a step further by determining the 95% confidence interval of the mean (average) debris density. This approach provides margin in the calculation of total latent debris inside the containments. The specific latent debris densities were then multiplied by the appropriate actual surface areas inside the McGuire containment, which were based on reference drawings and information developed from the walkdowns. The total latent debris loads calculated conservatively assume that 100% of the estimated surface areas in containment are susceptible to debris accumulation.

Using this methodology, the extrapolated latent debris mass total for the McGuire Unit 1 containment was determined to be approximately 140 lbs, which bounds Unit 2 as reported in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Enclosure 2, item 3(d)2.

For conservatism, an overall value of 200 lbs was assumed for the total latent debris quantity in each of the McGuire Unit 1 and Unit 2 containments, 30 lbs (15%) of which is considered to be latent fibers per the GR/SE.

10. 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.

McGuire Response:

Please reference the response to RAI question 8 of this submittal for the details regarding the McGuire tag and label refinement evaluation.

11. 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.

<u>McGuire Response:</u>

The quantity of constituent fiber fines transporting to the McGuire strainer due to the erosion of submerged but non-transported pieces of fiber insulation was determined by vendor testing in order to refine the conservative erosion assumptions documented in the NEI 04-07 GR/SE.

The objective of the erosion testing was to quantify any containment pool flow-induced erosion/deterioration that may occur on low-density fiberglass (LDFG) insulation. This was accomplished by subjecting a measured test sample of the LDFG material type to a room-temperature solid water flow in a closed vertical test loop (VTL) apparatus and a horizontal test flume (TF) for durations of up to 72 hours, and quantifying any mass that may have eroded off of or otherwise dislodged from the test sample. These two apparatuses (VTL and TF) were used to compare the different turbulence and energy effects upon the insulation, as well as observing the effects of the orientation of the sample with respect to the water flow. To quantify the fibrous mass loss, the dry weight of the test samples before and after the test was measured and recorded. The testing was conducted on both large and small pieces of LDFG to observe any effects that size or surface area had on the sample's erosion.

Subsequently, a 30-day erosion test in the horizontal flume apparatus was also conducted. Analysis of this test data provided further insight into the nature of the LDFG sample composition and consequently, its erosion characteristics. Primarily, it was observed that during 30 days of flow impingement, the sample did not continuously disintegrate. The fiber insulation samples appeared to yield loosely bound fiber fines early in the test, after which the erosion effects subsided.

<u>Test Inputs</u>

Erosion tests were conducted with LDFG insulation samples in conditions intended to mimic, or be conservative with respect to, the expected post-LOCA plant conditions.

Debris Type and Size:
Both Nukon® and TPI Thermal-Wrap® fiber insulation exist in the break zones of influence in the McGuire containments, and for the purposes of LDFG erosion evaluation can be considered equivalent consistent with the LDFG destruction pressures discussed in the NEI 04-07 GR/SE, Section II.3.1.1. The erosion testing used Nukon® samples with the same bulk density (2.4 lbs/ft^3) as LDFG insulation used in the plant. The Nukon® fiber insulation sheets were cut into 6"×3"×1" rectangles to represent the large pieces, and into 1"×1"×1" squares to represent the small pieces (an extra large piece measuring 6"×6"×1" was also included). Samples were then boiled in tap water for ten minutes to remove the binder, in order to simulate the conditions the fiber insulation would undergo during the blowdown and ECCS sump pool recirculation phases of the predicted post-LOCA response.

Test Environment:
The insulation samples were subjected to a flow erosion environment in both a vertical test loop apparatus and a horizontal flume. Each test consisted of subjecting insulation samples to flow erosion by filling the VTL or TF with tap water and then circulating the water to bound the flow conditions that occur in the ECCS sump pool. The samples were always completely submerged during testing to ensure conservative erosion. The large Nukon® samples were fastened to a screen to impede unnecessary movement. The small Nukon® samples were stabilized by placing them in a wire cage in the flow stream, such that there was no interference with either flow or the release of eroded material.

Flow Velocity:
The erosion tests were performed at a flow velocity that is equal to the incipient tumbling velocity for the specific size. For the LDFG samples tested, the flow velocities were determined to be 0.37 feet per second for the large pieces and 0.12 feet per second for the small pieces. Since the incipient tumbling velocity is the velocity at which the debris would start moving, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being transported to the ECCS sump strainer. Therefore, it is considered the velocity that would produce the most fiber fines from submerged, but not transported, fiber insulation pieces.

Water Temperature and Chemistry:

- Temperature – As discussed previously, the LDFG samples were boiled prior to being subjected to flow impingement testing, to simulate the conditions present during blowdown and recirculation. The actual tests were conducted in the VTL and the TF in room-temperature tap water (i.e., approximately 60°F-80°F). The temperature of the water increased during testing due to continuous pump heating (up to 110°F for longer-duration tests). It was determined that viscosity effects on the erosion rates were insignificant.

- Chemistry – The erosion tests were conducted in tap water and not the buffered or borated water predicted to be present in the containment sump pool post-LOCA. The use of tap water is considered appropriate because the lack of chemicals such as soluble aluminum, boron, or pH buffers will not affect the amount of fibers that would erode from a Nukon® LDFG insulation sample.

Analysis of Erosion Test Data

During the erosion tests, the small Nukon® samples generally eroded more than the large samples, despite the large samples undergoing a higher flow velocity. Small samples eroded more fibrous mass due to their increased surface area exposed to the water flow and their being prepared for the tests by shredding, which produced more fines available for transport. Since the small samples eroded more than the large samples, the test data analysis utilized only the small sample results in order to generate conservative fiber erosion quantities (therefore these higher small piece erosion rates are applied to both size ranges of submerged, non-transported fiber insulation).

The small fiber test samples lost, on average, about 3% to 7% of initial weight for any given test duration, with the raw data range spanning 0% to 20%. Because the LDFG erosion data was not consistent, the data was analyzed and results compared using several different approaches:

1. Assume the 30-day small sample erosion test results represented the most accurate erosion rate.
2. Determine the weight loss per hour rate for all small sample erosion tests, and then extrapolate that weight loss per hour value to 30 days to properly account for the ECCS mission time.
3. Average all of the small sample erosion values regardless of test duration (including root mean square (RMS) error), and assume this value applies for the ECCS mission time.

Application of approaches 1 and 2 above yielded 30-day fiber erosion estimates that appeared to be non-conservative when compared to the majority of the small sample data points.

Since the fiber erosion test results showed wide scatter across all test durations, the assumption was made that fiber erosion is not directly time-dependent, and therefore could be conservatively described by averaging all of the small sample erosion test results to reach an overall erosion value (i.e., approach 3 above). Additionally, as noted previously it was observed that during the 30-day erosion test the samples did not continuously disintegrate. The fiber insulation samples appeared to yield (transport) loosely bound fiber fines early in the test, after which the erosion effects subsided. As such, the overall erosion value calculated from the small sample average is considered applicable to a 30-day mission time.

The calculated average of the small sample fibrous erosion test results was approximately 6% of initial weight, with an error of ±4% as determined by RMS error analysis versus the calculated average. Approach 3, then, determined a conservative estimate of the overall fiber erosion value to be 10% of the initial fiber weight (6% + 4%).

Therefore, the attrition/erosion mechanism that strips away the loose pieces of LDFG via water impingement is conservatively estimated to reduce an initial weight of submerged, non-transported fiber insulation by 10% over the 30-day ECCS mission time.

Subsequent to the preceding series of vendor erosion tests, extensive discussions were held between NRC technical staff, the vendor, and Licensees (including the Duke Energy plants) regarding the testing configuration and analysis methodology. This led NRC to request a confirmatory LDFG erosion test from the vendor to address issues identified with the test flume and erosion sample configuration. The 30-day confirmatory erosion test series was completed by the vendor in 2010 and confirmed a 30-day erosion value of 10% for both large and small piece LDFG.

12. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

Due to the redesign of the strainer tests between 2007 and 2011 as described in the preface of this submittal, the RAI question from the technical staff as written above in response to the 2008 McGuire Generic Letter 2004-02 Supplemental Response dated February 28, 2008 (as amended by submittal dated April 30, 2008) no longer applies in the same manner as it was originally intended. The primary difference is that the strainer head loss result is no longer determined by combining two separate test outcomes; the Chemical Precipitates Head Loss test series was comprehensively designed (with technical staff input) to generate one distinct result to simplify the certification process. To provide fidelity the series consisted of two identical McGuire strainer tests, with the bounding test documented as the test of record. Since this RAI question is clearly focused on identifying the strainer head loss as a function of the ECCS mission time (and information regarding the methodology used to determine it), that will be the approach used to respond to McGuire RAI question 12. This general approach to all of the testing-related RAI questions was discussed and agreed to with the technical staff on the September 1, 2009 public telecon between Duke Energy and NRC.

The ECCS Sump Strainer total head loss following a postulated LBLOCA is shown as a function of ECCS sump pool temperature and approximate ECCS mission time in Table 12S-1 for the bounding McGuire unit.

Table 12S-1

McGuire ECCS Sump Strainer Predicted Post-LOCA Head Loss

ECCS Sump Pool Temperature (°F)	ECCS Mission Time (approx.)	Total ECCS Sump Strainer Head Loss (ft-water)
200	0 min	7.32
190	9 min	7.49
180	25 min	7.67
170	1 hr	7.90
160	16 hr	8.12
140	1.2 days	11.68
120	3.5 days	12.83
100	23 days	14.42
90	>23 days	15.52

Table Notes:

- Values are for the limiting McGuire ECCS Sump Strainer in Unit 1
- Assumes Maximum Safeguards conditions (three-train ECCS flowrate)
- "ECCS Mission Time" begins at swapover to sump recirculation phase

The total ECCS Sump Strainer head loss in the above table is the head loss associated with the clean strainer combined with the predicted debris head loss (conventional and chemical precipitates) as extrapolated from data determined by empirical test.

Methodology

The methodology used to determine the ECCS Sump Strainer head loss at extended sump pool temperatures is based on the results of the Chemical Precipitates Head Loss test series, a series run at steady state temperature for a limited amount of time. As such, translation of the test results to post-accident plant conditions requires the post-processing of specific parameters (i.e., flow rate and pool temperature) in order to conservatively calculate the predicted head loss.

The calculation methodology also assumes that chemical effects (in the McGuire post-accident sump pools, the precipitate is sodium aluminum silicate) on the strainer head loss occur only after the pool temperature cools to approximately 156°F. At pool temperatures above this threshold temperature, the peak conventional debris head loss is applicable. The effect of chemical precipitates on the strainer head loss can be seen in Table 12S-1 at pool temperatures below 160°F. This threshold temperature for precipitates was determined using staff guidance and conservatively predicted aluminum concentrations in the pools; the inclusion of the delayed precipitation approach and the associated temperature threshold in the strainer certification was discussed in a telecon between Duke Energy and NRC staff on March 19, 2012.

The raw strainer head loss results from the Chemical Precipitates Head Loss Test series were post-processed by performing an appropriate and bounding curve fit to the data obtained after all debris had been added and the head loss had stabilized. This generated an expression for the test strainer head loss as a logarithmic function of time, per NRC guidance. After this, the pressure differential and flow data were conservatively corrected to accommodate test instrument uncertainty, and the test head loss trend extended to 30 days. The bounding, corrected test head loss value was then transposed to various sump pool temperatures of interest.

Nine target temperatures (as identified in Table 12S-1) were chosen as representative of the ECCS mission time, and the test condition head loss transposed to each target pool temperature to obtain a predicted post-LOCA ECCS Sump Strainer head loss at that point. The general correlation used to perform this transposition is:

$$\frac{h_{L,2}}{h_{L,1}} = L_{Frac}\frac{\mu_2}{\mu_1}\frac{Q_2}{Q_1} + T_{Frac}\frac{\rho_2}{\rho_1}\left(\frac{Q_2}{Q_1}\right)^2$$

Where:

Q_1	= Test tank flow rate
Q_2	= Target flow rate for the actual plant condition
μ_1 and ρ_1	= Dynamic viscosity and density of water at test tank temperature
μ_2 and ρ_2	= Dynamic viscosity and density of water at target pool temperature
$h_{L,1}$	= Flow head loss from bounding test curve
$h_{L,2}$	= Flow head loss at target flow rate, Q_2 and target pool temperature
T_{Frac}	= Turbulent fraction of the flow
L_{Frac}	= Laminar fraction of the flow

The laminar and turbulent fractions of the flow were determined using flow sweep data, obtained at the end of each run during the Chemical Precipitates Head Loss Test series.

13. 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.

McGuire Response:

Refer to Figures 13S-1 and 13S-2 below for the responses to questions (a) through (g).

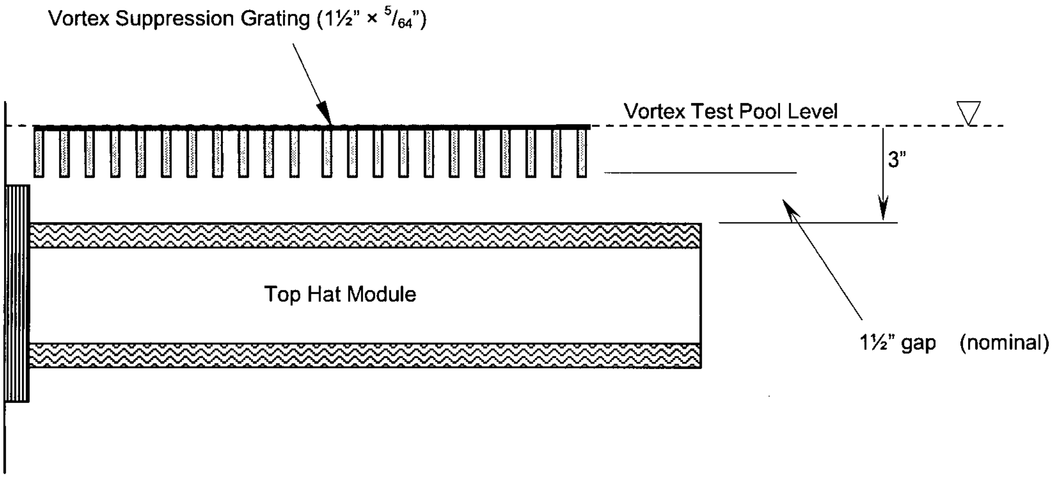

Figure 13S-1: Top Hat Strainer Module Submergence Vortex Test Condition

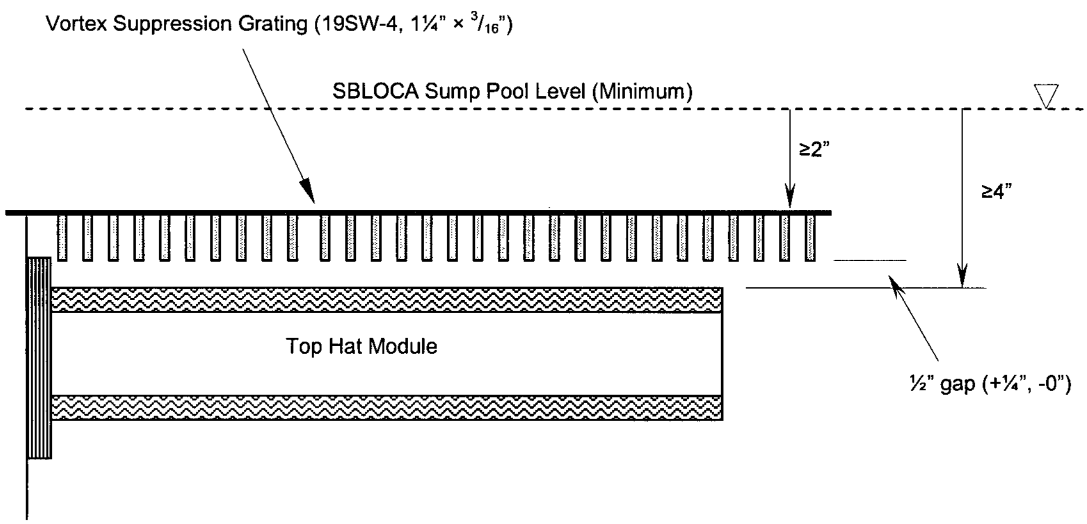

Figure 13S-2: Top Hat Strainer Module Submergence Plant Condition

a. Actual minimum submergence level of the McGuire ECCS Sump Strainer Top Hat modules (pool surface to module perforated plate topmost surface) is ≥ 4 inches, as depicted in Figure 13S-2. The minimum submergence level occurs as a result of the SBLOCA scenario.

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 February 28, 2008, Enclosure 2, item 3(f)3.

c. For vortex testing purposes, the as-built maximum approach velocity for the top hats closest to the ECCS suction lines (assuming four train operation) 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 four-train McGuire nominal approach velocity (i.e., about 0.028 feet per second) by approximately a factor of two.

   It should be noted that MNS submitted a License Amendment Request for the ECCS Water Management Initiative, which has been approved by the NRC. In relation to ECCS recirculation flow, this license amendment allows the Containment Spray system to operate with only one pump. This will decrease the overall recirculation flowrate (and thus the approach velocity) through the ECCS Sump Strainer by approximately 25% compared to four-train operation. Implementations of the associated modifications are scheduled for fall 2012 for Unit 2 and are complete for Unit 1.

d. Vortex suppression testing was performed in two parts; neither portion used walls to model the adjacent top hats or base plates, as the walls could artificially still vortex formation. Water level was set to 3 inches above the topmost surface of the perforated plate of the strainer (reference Figure 13S-1). 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, and then increasing up to 0.06 feet per second, in increments of 0.01 feet per second. Subsequently, additional testing was performed starting at an approach velocity of 0.06 feet per second and then increasing up to 0.09 feet per second, with the same increments and hold times. At approach velocities at and above 0.04 feet per second, an air-entraining vortex was present. When the vortex formed, the vortex suppressor grating was installed in the designated location (i.e., leaving a 1.5-inch gap between topmost surface of the strainer module and the bottom of the vortex suppression grating). Efficacy of the suppressor was demonstrated by elimination of the vortex at all approach velocities up to 0.09 feet per second with only minor surface dimpling remaining.

e. Referencing Figure 13S-1, the submergence level of the strainer top hat module topmost surface (perforated plate) during the vortex suppression testing was fixed at 3 inches. The vortex testing did not vary the submergence for LBLOCA/SBLOCA; the submergence level modeled (3 inches) was a conservative approximation of the minimum expected submergence level (4 inches) following a SBLOCA at McGuire.

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, as shown in Figure 13S-1.

g. Referencing Figure 13S-2, 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.

   With implementation of the approved ECCS Water Management Initiative modifications, the minimum Technical Specification volume for the Refueling Water Storage Tank is being increased and the low-low Refueling Water Storage Tank level (where pumps are transferred to the recirculation mode of ECCS operation) is being reduced. Both of these changes in RWST setpoints directly contribute to increased ECCS sump pool volumes.

14. 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.

McGuire Response:

Note: This response is conservatively based on a four-train ECCS/Containment Spray (CS) flow rate configuration. As noted in the Preface of this submittal, McGuire is implementing ECCS Water Management modifications, which reduce the ECCS recirculation flowrate by 25%.

Guidance issued by the staff dated March 28, 2008 clarified the intent of the Content Guide question regarding the ability of the McGuire ECCS Sump Strainer to accommodate the maximum potential debris volume.

As identified in the GL 2004-02 Supplemental Response dated April 30, 2008, McGuire predicted a total of 231.5 ft^3 of low density fiberglass (LDFG) insulation (fines and small pieces) to be transported to the ECCS sump strainer after a limiting break. Subsequent to that submittal, McGuire determined that replacement of a large portion of the fiber insulation in lower containment (i.e., on the RCS Loops, Steam Generators, and RC Pumps) was necessary, and initiated the Fiber Insulation Replacement Project (FIRP). This project, scheduled to be completed in 2013, results in a bounding transported LDFG insulation volume of approximately 73 ft^3 assuming four-train ECCS/CS recirculation flow (further reduced to approximately 69 ft^3 for three-train ECCS/CS Water Management recirculation flow), a significant reduction in fibrous debris at the ECCS Sump strainers.

The non-LDFG debris quantities expected to transport to the strainer (and their characteristics) were provided in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Enclosure 2, items 3(c)2, 3(d)3, and 3(h)6. Additional margin was also added to the unqualified epoxy coatings debris quantity for chemical effects testing in 2009-2010 as discussed in the response to RAI 26. The appropriate values are provided in Table 14S-1 below for convenience, along with the equivalent volume conversions for each debris type.

Table 14S-1

Non-LDFG Debris Quantities Transported to McGuire ECCS Sump Strainer*

Debris Type	Debris Type Density	Debris Quantity at Strainer	Equivalent Debris Volume at Strainer
Qualified Epoxy Coatings (5D ZOI)	118 lb/ft^3	167.6 lb	1.42 ft^3
Unqualified Epoxy Coatings	94 lb/ft^3	392.2 lb	4.17 ft^3
Unqualified Alkyd Coatings	98 lb/ft^3	15.7 lb	0.16 ft^3
Latent Dirt/Dust	169 lb/ft^3	170 lb	1.01 ft^3
Latent Fiber (lint)	2.4 lb/ft^3	30 lb	12.5 ft^3
Miscellaneous Latent Debris** (tags, labels, etc.)	NA	347.5 ft^2	NA

* Note: Destroyed stainless steel RMI is assumed to not transport to the ECCS Sump Strainer.

** Note: Miscellaneous latent debris is assumed to reduce the strainer flow area for maximizing the approach velocity, but has an insignificant interstitial volume contribution due to the debris being characteristically thin.

Thus, the total volume of debris (LDFG and other) expected to transport to the ECCS sump strainer after a limiting break is approximately 92 ft^3 (the sum of the debris volumes in the above table and the bounding transported LDFG insulation volume total). The total interstitial volume of the limiting McGuire ECCS Sump Strainer (Unit 1) is 346 ft^3.

During accident conditions, the debris bed will initially accumulate non-uniformly on the strainer. The approach velocity will vary across the individual strainer top hats and across the array based on the location of the top hats relative to the recirculation suction piping. Locally, the debris bed will build axially from the top hat base plate out to the free end, up to the maximum debris load. However, since the total transported debris volume (as demonstrated above) is not sufficient to completely fill the strainer interstitial volume, the strainer surface will retain its complex shape (multiple top hat cylinders with flow paths outside and inside the cylinder) and flow area. With no decrease in top hat module flow area, the evaluated approach velocities remain bounding.

15. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

NRC staff guidance from March of 2008 as well as input from discussions with the staff were used for test protocol development. Nukon® fiber utilized for the Chemical Precipitates Head Loss test series was purchased in a heat treated pre-shredded condition. The fiber was then boiled for a minimum of 20 minutes and divided evenly into the required number of 5 gallon buckets such that each bucket contained approximately 0.25 lbm fiber. The buckets were then agitated with a paddle style power mixer to separate the fiberglass into individual strands (fines). The fiber/water mixture was then sampled in a clear pan and inspected over a light source to ensure the mixture was as close to 100% fines as practical. If large or small pieces remained, the mixture was agitated and sampled again until it was deemed acceptable.

After all of the particulate surrogates had been introduced to the test tank, the fiber mixture was then slowly introduced into the test tank on the opposite side of the strainer test array. The main volume of the test tank was equipped with three agitators that were controlled via variable frequency drives in order to keep the tank well mixed and to keep debris from settling.

Prior to testing, a hydraulic shakedown of the test system was performed to ensure acceptable performance. This shakedown was performed without paint surrogate or other particulate debris in the tank so that the fiber transport and potential agglomeration could be observed. During this shakedown, the direction and speed of the agitators were adjusted as well as the height of water in the test tank. The fiber transport and agglomeration issues identified by the technical staff during prior testing were eliminated by tuning the system in this manner.

The debris preparation, introduction, and transport protocol for the Chemical Precipitates Head Loss test series was identical to the protocol used in the 2009 Confirmatory Head Loss test series identified in the Preface of this submittal. Photos and videos of debris preparation, introduction and transport from the 2009 testing series were provided to the staff in July 2009. The staff concluded that the methods and protocol being utilized for conventional debris preparation and introduction during the tests met NRC expectations.

16. Please provide information on the flowfields 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

The test tank used for the Chemical Precipitates Head Loss testing was a custom made tank measuring 4.25 feet × 20 feet. The water depth was controlled at approximately 54 inches. The 6 top hat assemblies, consisting of two 24-inch, two 36-inch and two 45-inch long top hats arranged in a 2 × 3 array, were located at one end of the test tank, opposite the loop return piping end. The spacing of the top hat assemblies (both from the tank bottom and within the array) was similar to the spacing in the installed plant strainer. In addition, baffles were built within the strainer portion of the tank to minimize the area that debris could settle and maximize the debris attracted to the top hat straining surface.

The main test tank volume was equipped with 3 agitators which were driven via variable frequency drive devices that were capable of changing the speed and direction of the agitators. These agitators ensured the water in the test tank remained sufficiently turbulent to prevent particulate and fibrous debris from settling in the main tank volume during the execution of the testing.

A 30-inch vertical divider plate separated the strainer portion of the tank from the main volume and shielded the top hats from the turbulence imposed by the agitators. The baffle plate height was 6.75 inches above the top surface of the strainer top hats and 24 inches below the water surface. With this tank configuration, debris in the test tank can remain agitated and suspended without affecting the morphology of a debris bed on the strainer array.

17. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation.

As identified in the Preface of this submittal, prior to the Chemical Precipitates Head Loss test series performed in February 2011, a series of conventional debris head loss tests were performed in June 2009. A portion of the conventional debris head loss testing was to determine if the McGuire ECCS sump strainer was susceptible to high head losses associated with thin bed formation. In order to accomplish this, all particulate debris (i.e., destroyed coating surrogate and latent dirt surrogate) was introduced into the test tank and allowed to circulate. A small amount of fiber was then introduced into the tank and allowed to circulate. Once sufficient time was allowed for the differential pressure across the strainer to stabilize, another fiber increment was added and again, there was a stabilization period. A borescope was used to determine if the strainer array was completely covered between increments. If a sufficient amount of particulate was filtered out of the tank mixture by the fiber bed prior to the full fiber load being introduced (to the point that tank clarity improved), the test was aborted. The subsequent test then started with the same sequence; however, the initial fiber load was then made equivalent to previous total fiber that had been introduced.

Sensitivity studies were also performed to determine whether the McGuire strainers were susceptible to limiting head losses due to thin bed formation. In these studies, proportional mixtures of both fiber and particulate were introduced into the test tank simultaneously in small increments, or all at once in a bulk addition. The proportional mixture additions prevented the filtering of the particulate prior to complete strainer coverage and also facilitated the building of a more homogeneous debris bed for comparison purposes. Ultimately, it was determined through the thin bed testing that the McGuire ECCS sump strainers are not susceptible to limiting head losses due to thin bed formation when testing with conventional debris. The testing also demonstrated that utilizing a thin bed protocol results in more strainer coverage where the effect may be more problematic upon the addition of chemical precipitates.

The Chemical Precipitates Head Loss testing performed in February of 2011 was designed considering the conventional debris head loss testing described above. Although it had been demonstrated that the McGuire strainers were not limited by conventional debris head losses due to thin bed effects, the thin bed protocol did result in more complete strainer coverage compared to bulk or homogeneous debris addition. Since the thin bed protocol resulted in the highest strainer coverage and generally higher conventional debris head loss, this protocol was used for the Chemical Precipitates Head Loss testing.

Debris preparation as described in the response to RAI question 14 ensured fibrous debris was prepared appropriately with as high a percentage of fines as practical. The test tank design as described in the response to RAI question 15 ensured the prepared debris remained suspended and was transported adequately to the strainer test array. For all testing performed, Performance Contracting Inc. (PCI) dirt mix (silica dioxide) was chosen as the latent dirt surrogate and 800 grit silica carbide was used as the coatings surrogate. The pre-mixed chemical precipitate used for testing was Sodium Aluminum Silicate as prepared following the guidance and protocol outlined by WCAP-16530-NP, "Evaluation of Post- Accident Chemical Effects in Containment Sump Fluids to Support GSI-191."

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

<u>McGuire Response:</u>

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information herein pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the areas of Strainer Head Loss and Vortexing, dated March 2008 identifies concerns with debris bed morphology in the areas of boreholes and flow channeling. In order to accommodate shifts in debris bed morphology as it pertains to temperature/viscosity scaling of test head loss results; it is recommended to perform flow sweeps as part of the testing methodology.

For the tests of record, the protocol dictated that flow sweeps be performed as a final phase of testing after all conventional and chemical precipitate debris was added to the test tank and the strainer array differential pressure stabilized. This flow sweep data was then used to determine the laminar and turbulent fractions used for temperature scaling of the strainer head loss as described in response to RAI question 12 of this submittal.

19. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

During previous testing, small amounts of fiber had been observed to bridge over the non-flowing surfaces of the strainer. It is therefore assumed that tags, labels and other miscellaneous latent debris that transport to the strainer may also overlap the non-flowing areas as well. The strainer area then used to base debris scaling becomes the gross strainer area of the limiting McGuire ECCS Sump Strainer (i.e., smallest surface area, Unit 1) minus an area penalty for tags and labels as discussed in the response to RAI 8 of this submittal and in Enclosure 2 of the McGuire GL 2004-02 Supplemental Response dated February 28, 2008. Approach velocity is scaled based on the same methodology as above with the exception of an additional three percent void fraction penalty at the strainer surface.

McGuire is in the process of implementing the ECCS Water Management initiative on both units. Modifications are complete for Unit 1 and are scheduled for implementation for Unit 2 during the next refueling outage scheduled for fall 2012. Thus, the scaled flow is equivalent to 12,000 gpm representing two Residual Heat Removal pumps and One Containment Spray pump. This flow rate is assumed for the entire 30 day mission time of the ECCS sump strainer and no credit is taken for reducing ECCS flow later in the mission time. It should be noted that the penalties associated with blockage due to tags and labels were not further refined with the adoption of ECCS Water Management. This blockage penalty was originally calculated based on a pre-water management ECCS flow of 16,000 gpm. It is likely there would be less transport of these materials to the strainer with three quarters of the overall flow.

20. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the following information pertains to the Chemical Precipitates Head Loss test series performed in February 2011.

The Chemical Precipitates Head Loss Test was designed in accordance with the March 2008 "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing."

As discussed in the responses to RAI questions 19 and 24 of this submittal, all postulated debris quantities were scaled appropriately for prototype strainer testing. As identified in those responses, the scaling of debris was based on the limiting strainer area (Unit 1) and an applied tag and label penalty. Regarding the use of a failed coatings particulate surrogate in the test, it was understood that the critical parameter for selecting the surrogate material is the volume of the material in the debris mix. The particulate material occupies a certain volume in the fibrous debris space that results in increasing resistance to flow, and therefore higher head loss. Therefore, for the Chemical Precipitates Head Loss Test performed in February 2011, the volume of the failed coatings surrogate material used (800 grit silica carbide) was matched to the volume of the predicted failed coatings particulate. The volume of particulate used in the test can be found in the response to RAI question 24.

21. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information herein pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

Details on debris preparation and transport are provided in the response to RAI question 15 of this submittal. Details on the test tank utilized for ECCS Sump Strainer performance testing are described in detail in the response to RAI question 16 of this submittal.

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

<u>McGuire Response:</u>

For completeness, the clean strainer head loss for both McGuire Units 1 and 2 are provided:

The McGuire Unit 1 clean strainer head loss, based on the installed strainer area and configuration at 60°F, is calculated as 3.55 feet of water for the maximum recirculation flow condition.

The McGuire Unit 2 clean strainer head loss, based on the installed strainer area and configuration at 60°F, is calculated as 3.69 feet of water for the maximum recirculation flow condition.

It should be noted that the clean strainer head loss numbers stated above are lower than values reported in previous submittals. This is based on approval/implementation of a License Amendment Request for the ECCS Water Management Initiative. One aspect of ECCS Water management is to rely on one train of containment spray as opposed to two during the recirculation phase of LOCA mitigation. Thus, overall flow through the strainer is reduced by 25% which in turn reduces the clean strainer head loss. Implementations of the associated modifications are scheduled for fall 2012 for Unit 2 and are complete for Unit 1.

23. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

Due to the redesign of the strainer tests between 2007 and 2011 as described in the preface of this submittal, the RAI question from the staff as written above in response to the 2008 McGuire Generic Letter 2004-02 Supplemental Response dated February 28, 2008 (as amended by submittal dated April 30, 2008) no longer applies in the same manner as it was originally intended. The primary difference is that the strainer head loss result is no longer determined from a combination of two tests; the Chemical Precipitates Head Loss test series was comprehensively designed (with technical staff input) to simplify the certification process. To provide fidelity the series consisted of two identical McGuire strainer tests, with the bounding test documented as the test of record. Since this RAI question is clearly focused on identifying the ECCS recirculation pump NPSH requirements as a function of the mission time (and information regarding the methodology used to determine it), that will be the approach used to respond to McGuire RAI question 23. This general approach to all of the testing-related RAI questions was discussed and agreed to with the technical staff on the September 1, 2009 public telecon between Duke Energy and NRC.

The response to RAI question 12 of this submittal tabulates the predicted post-accident ECCS Sump Strainer head loss as a function of sump pool temperature and approximate ECCS mission time, and explains the calculation methodology used in generating it. Table 23S-1 below duplicates that head loss information, and further identifies the predicted ECCS recirculation pump NPSH margin and the ECCS Sump Strainer structural margin over the ECCS mission time for the limiting McGuire unit.

Table 23S-1

McGuire ECCS Sump Strainer Predicted Post-LOCA Head Loss and Margins

ECCS Sump Pool Temperature (°F)	ECCS Mission time (approx.)	Total ECCS Sump Strainer Head Loss (ft-water)	Limiting ECCS Recirculation Pump $NPSH_R$ Margin (ft-water)	ECCS Sump Strainer Structural Margin (ft-water)
200	0 min	7.32	**3.14**	11.68
190	9 min	7.49	**8.21**	11.51
180	25 min	7.67	12.27	**11.33**
170	1 hr	7.90	15.56	**11.10**
160	16 hr	8.12	18.24	**10.88**
140	1.2 days	11.68	18.98	**7.32**
120	3.5 days	12.83	20.60	**6.17**
100	23 days	14.42	20.73	**4.58**
90	>23 days	15.52	20.22	**3.48**

Table Notes:

- Values are for the limiting McGuire ECCS Sump Strainer in Unit 1
- Limiting ECCS recirculation pump $NPSH_R$ is for Containment Spray
- Assumes Maximum Safeguards conditions (three-train ECCS flowrate)
- Assumes minimum sump pool level exists at swapover to sump recirculation phase
- "ECCS Mission Time" begins at swapover to sump recirculation phase

Note in the above table that, as the sump pool temperature cools, the limiting margin for the McGuire ECCS components shifts from the recirculation pump NPSH to the strainer structural limit (in Table 23S-1, the limiting values are denoted in bold type). This is a result of both the increasing density of the pool liquid at lower temperatures (benefitting available pump NPSH) and the additional increase in head loss below 156°F due to chemical precipitates acting on the conventional strainer debris bed as described in the response to RAI question 12 of this submittal.

Methodology

Calculation of the ECCS recirculation pump NPSH margin and the ECCS Sump Strainer structural margin is a straightforward process once the total strainer head loss is known as a function of pool temperature/mission time. The basic expression for determination of the applicable ECCS recirculation pump NPSH margin at any pool temperature is:

Total NPSH margin =

$(NPSH_A - NPSH_R)$ + *strainer submergence – strainer head loss*

Where:

$NPSH_A$ = available NPSH afforded by ECCS system piping in limiting configuration at predicted ECCS flowrate

$NPSH_R$ = required NPSH at recirculation pump impeller suction centerline at predicted ECCS flowrate

Strainer submergence = minimum predicted sump pool level at swapover to sump recirculation phase (3.4 feet of water at McGuire)

Strainer head loss = total head loss across strainer at three-train ECCS flowrate

Similarly, for the strainer structural margin:

Total structural margin =

Strainer structural limit – strainer head loss

Where:

Strainer structural limit = design limit for loaded strainer at three-train ECCS flowrate

Strainer head loss = total head loss across strainer at three-train ECCS flowrate

For convenience, Table 23S-2 below summarizes the ECCS recirculation pump NPSH requirements and the ECCS Sump Strainer structural limit.

Table 23S-2

McGuire ECCS Recirculation Pump/Sump Strainer Limits

ECCS Component	$NPSH_R$/Limit
Containment Spray Pumps*	≥ 17.5 feet-water $NPSH_R$
Residual Heat Removal Pumps*	≥ 19 feet-water $NPSH_R$
ECCS Sump Strainer Structure**	< 18.5 feet-water total head loss

* $NPSH_R$ at room temperature and predicted ECCS flowrate. No credit is taken for $NPSH_R$ reduction at higher sump pool temperatures.

** Structural limit based on 8 psid maximum differential pressure; also reference response to RAI 30 of this submittal.

24. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information below pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

The scaling of debris is discussed in the response to RAI 19. The chemical precipitate testing was conducted by initially building a conventional debris bed of particulate and fibrous debris as described in the response to RAI 17. The total debris mix is given below in Table 24S-1.

Table 24S-1: Conventional Debris Bed Constituents

Plant Debris	Surrogate	Plant Quantity	Scaled Test Quantity
Latent Dirt	PCI dirt mix	170lbm	6.9lbm
Fibrous Debris (including latent)	Boiled Nukon® Fiber	80.9ft^3	3.27ft^3 (7.86lbm)
Failed Coatings	800 grit Silica Carbide	5.75ft^3	0.232ft^3

The debris bed was built by introducing all particulate debris into the tank and allowing ample time for circulation. The fiber was introduced into the test tank in three equivalent batches. Pauses were incorporated between fiber batches to allow the head loss across the strainer test array to stabilize. The system was then allowed to stabilize a final time prior to introduction of the chemical precipitate.

The pre-prepared chemical precipitate was generated per the guidance contained in WCAP-16530-NP-A, "Evaluation of Post- Accident Chemical Effects in Containment Sump Fluids to Support GSI-191." A total of 1,224 grams of Sodium Aluminum Silicate was prepared and added to the test tank, based on the predicted McGuire ECCS sump pool post-accident concentration. This total was divided into four separate batches and the strainer differential pressure was allowed to stabilize between batch additions.

The flow rate for the testing simulated 12,000 gpm per the ECCS Water Management Initiative modifications (three ECCS/CS trains). The scaled flow in the test tank was 500 gpm. After the final differential pressure stabilization, a series of flow sweeps was performed to gain insights into debris bed behavior and to develop relationships for temperature scaling. The test tank was maintained at 90 degrees F for the duration of all testing with the exception of a temperature sweep as a final step to determine behavior of the debris bed at various temperatures.

25. 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.

McGuire Response:

Near field settling is not credited in the performance evaluation of the McGuire ECCS Sump Strainers.

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information herein pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

Details on debris preparation and transport are provided in the response to RAI question 15 of this submittal. Details on the test tank utilized for ECCS Sump Strainer performance testing are described in detail in the response to RAI question 16 of this submittal.

26. 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?

McGuire Response:

The unqualified coating surface area exposed to post-accident conditions inside the McGuire containments was inspected, quantified, and documented as part of the NEI 02-01 walkdown efforts in support of GSI-191.

As noted in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Enclosure 2, item 3(h)(5), post-accident unqualified epoxy coatings debris quantities were refined based on testing and analysis of original equipment manufacturer (OEM) coatings performed and documented by EPRI. In order to take credit for this refinement, it was assumed that the unqualified epoxy coatings inside the containments at McGuire were similar to the epoxy coatings used in the EPRI testing.

The EPRI program collected samples of many types of unqualified coatings directly from industry, gathering painted electrical components and equipment/structural parts and creating test coupons from them. The coatings sampled included OEM and non-OEM applied epoxies in a wide age range, which are representative of the type existing in the McGuire containments.

The majority of unqualified epoxy coatings inside the McGuire containments are vendor-applied to OEM components and equipment, applied via a controlled method as described in the EPRI report.

There are also specific (limited) situations wherein McGuire maintenance personnel apply remedial coatings as a result of primary containment coating assessments, as detailed in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Enclosure 1, RAI #25. These remedial coatings are manually applied and inspected in accordance with an approved specification and procedure, but remain unqualified coatings for the purposes of the EPRI comparison.

The epoxy-coated test coupons described by the EPRI test report and analysis are therefore appropriately representative of unqualified epoxy coatings in the McGuire containments.

Plant records are maintained for all unqualified coatings in containment in a calculation file. This calculation is periodically reviewed and updated as needed to track any additions of equipment or components that do not have qualified coatings. A cumulative total (in square feet) of the unqualified coatings is kept in this document, which in concert with the GSI-191 walkdown report, serves as a partial basis for the ECCS Sump Strainer performance analysis coatings debris input. The unqualified coatings quantification documented in this calculation does not reflect cumulative reductions in unqualified coating area (e.g., when an area in containment is stripped and re-coated with a qualified system), and also contains other conservative assumptions regarding surface area and inclusion of components with unknown coating characteristics. Also, for the chemical effects testing performed in 2011, additional unqualified epoxy coatings debris margin was included. Therefore, there is an inherent margin in the unqualified coatings value used for GSI-191 evaluation.

27. 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.

<u>McGuire Response:</u>

In the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Table 3E6-1 ("Initial Debris Transport to McGuire ECCS Sump Strainers") represents the <u>initial</u> unqualified epoxy coatings quantity predicted to transport to the ECCS Sump pool after a LBLOCA event. This particulate debris quantity was used to initially size the strainer for design and installation. The unqualified epoxy coatings quantity in this table contains no refinements.

In the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, Table 3H6-2 ("McGuire Unqualified Coatings Characteristics") represents the <u>refined</u> unqualified epoxy coatings quantity predicted to transport to the ECCS Sump pool after a LBLOCA event. The refinement is described in the Table 3H6-2 notes, and further described in the response to RAI question 26 of this submittal.

For the chemical effects strainer testing performed in 2011, an additional quantity of unqualified coatings particulate was added for margin beyond the originally reported value in Table 3E6-1. This additional particulate load, subsequently refined the same way as noted above, increased the total mass of unqualified epoxy coatings debris to 392.2 lbm (from 357.1 lbm).

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

McGuire Response:

As identified in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, 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. The programmatic controls and practices relating to containment cleanliness include:

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. Residual foreign material (i.e., material identified during the inspections and outage-related material) is removed as necessary. Upgrades to existing foreign 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 (SR)

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. When these inspections are performed, major outage work is complete, and any remaining loose material in containment must be logged and tracked in accordance with station procedures for control and accountability. If any debris, damage or deficiency were to be discovered during the inspection, station processes require entry into the corrective action program, with the requisite investigation and implementation of appropriate corrective action prior to the transition from Mode 5 to Mode 4.

Additionally, 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.

The containment cleanliness actions described in Duke Energy's response to Bulletin 2003-01, sent by letter dated August 7, 2003, and in Duke Energy's response to GL 2004-02, sent by letter dated September 1, 2005, are captured by the programmatic controls and practices described above.

29. 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>McGuire Response:</u>

Please reference the response to RAI question 8 of this submittal for details regarding the McGuire tag and label evaluation.

30. 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.

McGuire Response:

As described in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008, the ECCS Sump Strainer is constructed of robust materials and is positioned both inside and outside the crane wall (see Figure 30S-1).

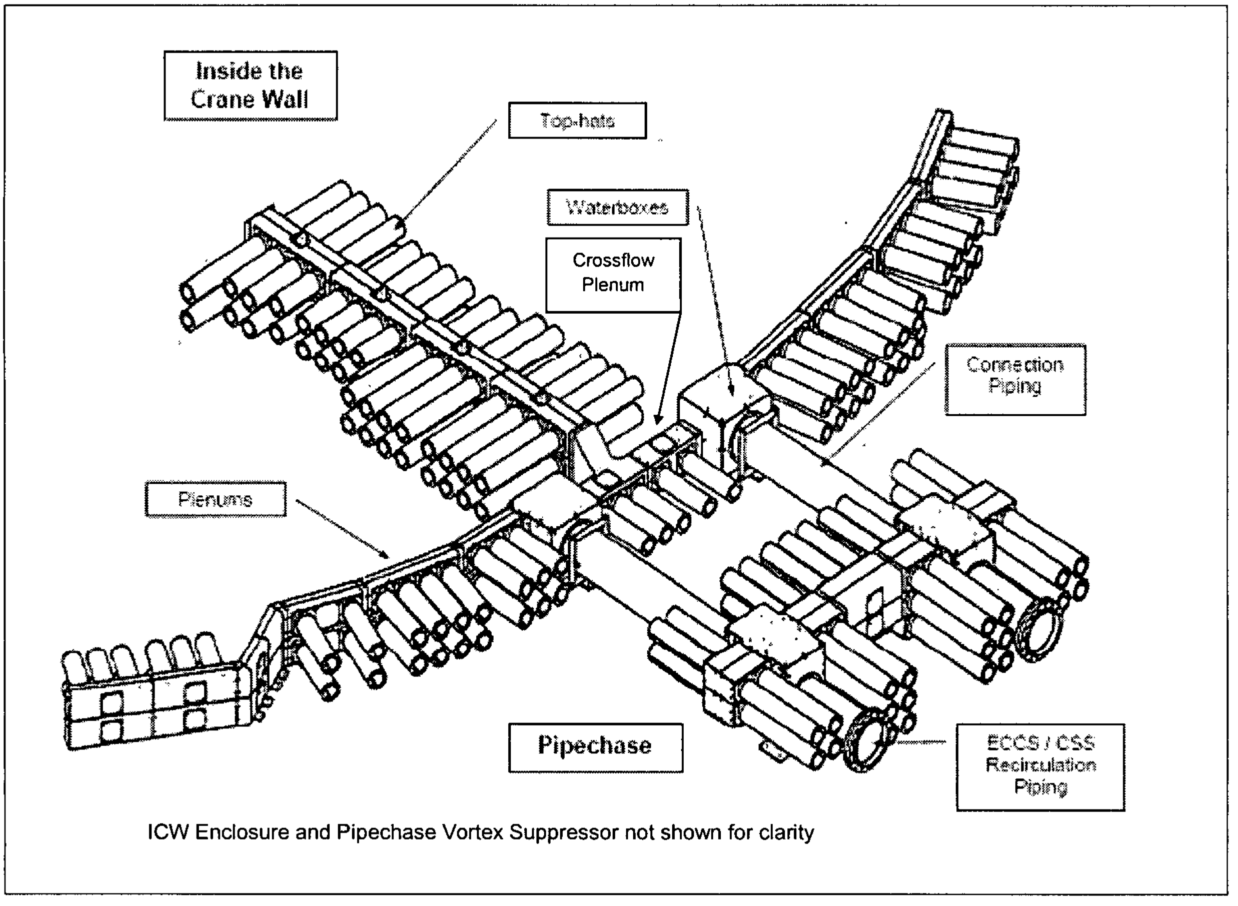

Figure 30S-1: McGuire ECCS Sump Strainer (typical)

Table 30S-1 below shows the design inputs for the McGuire ECCS sump strainer structural calculations, including the Top-hats, the strainer sections Inside the Crane Wall (ICW) and in the Pipechase, the ICW Strainer Enclosure, and the Pipechase Vortex Suppressor. Unit 1 and Unit 2 design input values are identical.

Table 30S-1: Design Inputs/Loads for McGuire ECCS Sump 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)	-	-	80 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

* Bounding top-hat length is 45 inches for structural analysis
** Zero Period Acceleration (ZPA)

Table 30S-2 through Table 30S-6 summarize worst-case interaction ratios (IR) and/or design margins for the various components of the McGuire Unit 1 ECCS Sump Strainer structural assembly including structural members, welds, concrete anchorages, and connection bolts.

The Unit 1 strainer is represented in these tables as five distinct sections: the top-hat strainer modules, the portion of the strainer inside the Crane Wall (ICW), the portion of the strainer outside the Crane Wall (i.e., in the Pipechase), the ICW Enclosure, and the Pipechase Vortex Suppressor.

As discussed on the November 1, 2010 Duke Energy-NRC telecon, structural steel, welds, fasteners, and anchorages in all calculations associated with the McGuire ECCS Sump Strainers were qualified for a combination of dead load, operating load, and seismic load (SSE). The analyses included both hydrodynamic mass and differential pressure; i.e., the strainer components were qualified for faulted loads (Load Cases 5, 6 & 7 as identified in the McGuire GL 2004-02 Supplemental Response dated February 28, 2008). The other load cases (Load Cases 1-4) would have yielded smaller loads and therefore were not considered.

Normal (i.e., not faulted) allowable stresses/loads were initially used to evaluate stress IR as a conservative measure. Exceptions were taken (i.e., faulted allowable used) as noted in the Tables when the IR as compared to the normal allowable was high or exceeded 1.0.

The McGuire Unit 2 ECCS Sump Strainer structural qualification summaries follow those of Unit 1.

Table 30S-2: McGuire Unit 1 ECCS Sump Strainer Top-hat Module Structural Qualification Summary

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	
	Circumferential 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	Base metal shear; Fillet weld allowable - 928 lb/in

Table 30S-3: McGuire Unit 1 ECCS Sump Strainer ICW Structural Qualification Summary

ICW Strainer Structural Frame Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Plate of Tube Module	Max Stress	15302 psi	16875 psi	Strainer Connector Plenum Frame
Member Stress	Max IR	0.90	1.0	Extension Strainer Module (End Module)
Plate Element 3/8" Thick	Max Stress	4097 psi	16875 psi	Main Strainer End Flow Plenum Frame
3/8" Diameter Studs	Max IR	0.82	1.0	Main Strainer Plenum Structural Frame
Anchor Bolts	Max IR	0.90	1.0	Extension Strainer Structure
3/8" Wing Plate	Max IR	0.95	1.0	Extension Strainer Module (End Module)
	Weld IR	0.946	1.0	Using normal allowables (0.83 with faulted allowables)
End Plenum Cover Plate Connection	Load per Angle stud	200 lbs	1546 lbs	
ICW Main Strainer Water Box Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Cover Plate	Max Stress	14212 psi	16875 psi	
3/8" Diameter Stud	Max IR	0.78	1.0	
Member Stress	Max IR	0.64	1.0	
Welds	-	-	-	Full penetration welds - acceptable.
Anchor Bolt	Max IR	0.72	1.0	

Table 30S-4: McGuire Unit 1 ECCS Sump Strainer Pipechase Structural Qualification Summary

Component Description	Measurement	Actual	Allowable	Comments
Pipechase Waterbox (WB) Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Plate on WB	Max IR	0.45	1.0	Bottom of WB
	Max Stress	18068 psi	20250 psi	Fltd. allow. used Side of WB
	Max Bending Stress	14017 psi	16875 psi	Cover plate at end of WB
Member Stress	Max IR	0.8	1.0	
3/8" Plate Element	Max IR	0.62	1.0	
3/8" Diameter Studs	Max IR	0.59	1.0	
1/2" Diameter Studs	Max IR	0.97	1.0	Acceptable via judgment
Welds	Weld Metal Stress Max IR	0.613	1.0	
	Base Metal Shear Max IR	0.94	1.0	Faulted allow. used
Anchor Bolts	Max IR	0.999	1.0	Conservative values utilized; Acceptable via judgment
Plate Stress	Max Stress	14373 psi	16875 psi	
Clip Angle Stress	Max Stress	9531 psi	13500 psi	
Pipechase Connector Plenum Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.255	1.0	
3/8" Plate	Max IR	0.135	1.0	
3/8" Stud	Max Stress IR	0.18	1.0	
	Max Clip IR	0.85	1.0	
Welds	Weld Metal Stress Max IR	0.530	1.0	
	Base Metal Shear Max IR	0.829	1.0	
Anchor Bolt	Max Bolt IR	0.76	1.0	
	Max Plate stress	13488 psi	16875 psi	

Table 30S-5: McGuire Unit 1 ECCS Sump Strainer ICW Enclosure Structural Qualification Summary

ICW Grating Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Stud	Max IR	0.22	1.0	
Overhang Tension on 3/8" Studs	Max Tension	2714 lbs	3954 lbs	
ICW Sides Perforated Plate & Top Solid Plate Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Plate Stress	Max Stress	5237 psi	5949 psi	Perf. Plate; solid plate ok by comparison
Horizontal Differential Pressure toward Grating	Max Stress	705 psi	5949 psi	Perf. Plate; solid plate ok by comparison
ICW Frame 1 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.903	1.0	
3/4" Diameter Bolts/Studs	Max IR	0.49	1.0	
Welds	Max IR - Weld Metal Stress	0.746	1.0	
	Max IR - Base Metal Shear	1.165	1.5	Faulted allowables used in evaluation
South Wall Connection	Bending Stress	3211 psi	17813 psi	
1" Diameter Bolt	Total Shear	5921 lbs	7439 lbs	Base plate connection
3" Diameter Pipe	Axial Compression + Bending IR	0.41	1.0	Base plate connection
ICW Frame 2 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.857	1.0	
3/4" Diameter Bolts/Studs	Max IR	0.78	1.0	Faulted allowables used in evaluation
Welds	Max IR - Weld Metal Stress	0.572	1.0	
	Max IR - Base Metal Shear	0.894	1.0	
1" Diameter Bolt	Max IR	0.45	1.0	Faulted allowables used

				in evaluation
3.5" Pipe	Shear IR	0.23	1.0	Frame component
	Axial Tension + Bending IR	0.26	1.0	
	Axial Comp + Bending IR	0.35	1.0	
Base Plate	Bending Stress IR	0.21	1.0	
1/2" Plate	Bending Stress	2064 psi	14400 psi	
ICW Frame 3 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	1.026	1.36	Faulted allowables used in evaluation
3/4" Diameter Bolts/Studs	Max IR	0.94	1.36	Faulted allowables used in evaluation
3/8" Diameter Bolts	Shear on Bolt	123 lb	474 lb	
Welds	Max IR - Weld Metal Stress	0.499	1.0	
	Max IR - Base Metal Shear	0.780	1.0	
Bracket	Max IR	0.75	1.0	
Bracket Plate	Max IR	0.14	1.0	
1" Diameter Bolt	Max IR	0.62	1.0	Faulted allowables used in evaluation
Base Plate	Max IR	0.61	1.0	
3.5" Pipe	Shear IR	0.08	1.0	Frame component
	Axial Tension + Bending IR	0.20	1.0	
	Axial Comp + Bending IR	0.28	1.0	
ICW Frame 4 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.376	1.0	
3/4" Diameter Bolts/Studs	Max IR	0.83	1.0	
Welds	Max IR - Weld Metal Stress	0.731	1.0	
	Max IR - Base Metal Shear	0.861	1.0	
1" Diameter Bolt	Max IR	0.97	1.0	Faulted allowables used

				in evaluation
3.5" Pipe	Shear IR	0.41	1.0	Frame component
	Axial Tension + Bending IR	0.26	1.0	
	Axial Comp + Bending IR	0.34	1.0	
Base Plate	Bending Stress IR	0.42	1.0	Base Plates on Wall
1/2" Plate at Connection	Bending Stress	1584 psi	14250 psi	
3/8" Bolt	IR (No tension)	0.92	1.0	Acceptable using faulted allowables
3/8" Clip Plate	IR	0.07	1.0	
ICW Frame 5 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.858	1.0	
1/2" Diameter Bolt	Total Shear	4592 lbs	4961 lbs	
3/8" Connection Plate Bracket	Total Stress	10109 psi	14250 psi	
1/2" Connection Plate Bracket	Total Stress	19863 psi	21375 psi	Acceptable using faulted allowables
Welds	Max IR - Weld Metal Stress	0.96	1.0	Member 61
	Max IR - Base Metal Shear	1.49	1.5	Acceptable using faulted allowables
¾" Base Plate	Bending Stress Max IR	0.54	1.0	
	Anchor Bolt Max IR	0.99	1.0	Joint 17
¼" Plate	Bending Stress	15360 psi	17813 psi	
3/8" Diameter Studs	Allowable Tension	480 lbs	1318 lbs	
1" Diameter Bolt	Total Shear	6516 lbs	7439 lbs	Faulted allowables used in evaluation
3" Diameter Piping	Max Shear	4336 psi	9500 psi	
ICW Frame 6 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stress	Max IR	0.807	1.0	
3/4" Diameter Bolt	Total Shear	0.51	1.0	
Welds	Max IR - Weld Metal Stress	0.652	1.0	

	Max IR - Base Metal Shear	0.817	1.0	Faulted allowable
3.5" Pipe	Shear IR	0.43	1.0	Frame component
	Axial Tension + Bending IR	0.27	1.0	
	Axial Comp + Bending IR	0.35	1.0	
½" Base Plate	Bending Stress Max IR	0.49	1.0	
North Wall Connection	Max IR	0.84	1.0	
	Bending Stress	5077 psi	17813 psi	
3/8" Plate	Max Stress	2932 psi	14250 psi	

Table 30S-6: McGuire Unit 1 ECCS Sump Strainer Pipechase Vortex Suppressor Structural Qualification Summary

Pipechase Vortex Suppressor Frame Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stresses	Max IR	0.952	1.0	Faulted load vs. normal allowable
1/2" Diameter Bolts	Max IR	0.60	1.0	
	Support Joint Connection Max IR	0.77	1.0	
3/8" Clip Plate	Max Axial + Bending Stress	6633 psi	17813 psi	
Welds	Max IR - Weld Metal Stress	0.585	1.0	
	Max IR - Base Metal Shear	0.915	1.0	
18" Diameter Cross Connector Pipes and Supports Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Tube Steel 2"x2"x1/4"	Max IR	0.94	1.0	
Anchor Bolts	Max IR	0.98	1.0	Acceptable per engineering judgment
	Plate Stress IR	0.86	1.0	
Welds	Max IR - Weld Metal Stress	0.386	1.0	
	Max IR - Base Metal Shear	0.604	1.0	

Table 30S-7 through Table 30S-11 summarize worst-case IR and/or design margins for the various components of the McGuire Unit 2 ECCS Sump Strainer structural assembly including structural members, welds, concrete anchorages, and connection bolts.

The Unit 2 strainer is represented in these tables as five distinct sections: the top-hat strainer modules, the portion of the strainer ICW, the portion of the strainer outside the Crane Wall (i.e., in the Pipechase), the ICW Enclosure and the Pipechase Vortex Suppressor.

The Unit 2 strainer was built in two stages; the Extension Strainer section inside the Crane Wall and its associated Enclosure structure were added separately in a refueling outage subsequent to the installation of the rest of the Main Strainer and its Enclosure/Vortex Suppressor.

Table 30S-7: McGuire Unit 2 ECCS Sump Strainer Top-hat Module Structural Qualification Summary

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	
	Circumferential 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	Base metal shear; Fillet weld allowable - 928 lb/in

Table 30S-8: McGuire Unit 2 ECCS Sump Strainer ICW Structural Qualification Summary

ICW Strainer Wing Plenums Structural Frame Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Plate of Tube Module	Max Stress	8320 psi	17250 psi	
Member Stresses	Max IR	0.334	1.0	
Plate Element 3/8" Thick Joint	Max Stress	3753 psi	16875 psi	
3/8" Diameter Studs	Max IR	0.98	1.0	Faulted loads utilized w/normal allowable
Anchor Bolts	Max IR	0.97	1.0	Conservative based on top hat sizes utilized (40" vs. 24" actual)
1/2"x3"x3.5" Plate	Bending Stress	6016 psi	16875 psi	
ICW Strainer Extension Plenum Structural Frame Evaluation (incl. Connector and Waterbox)				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Plate of Tube Module	Max Stress	7509 psi	16875 psi	Middle plenum
Member Stresses	Max IR	0.86	1.0	End plenum
Plate Element 3/8" Thick Joint	Max Stress	19680 psi	20250 psi	Faulted allowable
	Max IR	0.97	1.0	Connector plenum
3/8" Diameter Studs	Max IR	0.74	1.0	WB
1/2" Diameter Studs	Max IR	0.66	1.0	End plenum
Anchor Bolts	Max IR	0.97	1.0	Connector plenum
1/2"x5"x3.5" Plate	Bending Stress	13903 psi	16875 psi	End plenum
	Max IR	0.857	1.0	
Weld	Max IR - Weld Metal Stress	0.619	1.0	End plenum; Faulted load; normal allowable
	Max IR - Base Metal Shear	0.968	1.0	End plenum; Faulted load; normal allowable

Table 30S-9: McGuire Unit 2 ECCS Sump Strainer Pipechase Structural Qualification Summary

Pipechase Waterbox (WB) & Plenums Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
3/8" Plate on WB	Max Stress	17040 psi	17813 psi	Plate at top of water box
3/8" Cover Plate	Bending Stress	14615 psi	17813 psi	Plate at end of water box
	Stress on 3/8" angle	4784 psi	17813 psi	
Member Stresses	Max IR	0.763	1.0	Plenum
Plate Element 3/8" Thick	Max Stress	1552 psi	17813 psi	
	Max IR	0.864	1.0	
3/8" Diameter Studs	Max IR	0.71	1.0	
1/2" Diameter Studs	Member Max IR	0.89	1.0	
	Joint Max IR	0.91	1.0	
Welds	Max IR - Weld Metal Stress	0.875	1.0	
	Max IR - Base Metal Shear	1.367	1.5	Faulted allowables
Anchor Bolts	Max IR	0.65	1.0	
1/2" Diameter Wedge Bolts	Max IR	0.38	1.0	
1/4" Diameter Wedge Bolts	Max IR	0.60	1.0	
3/4" Plate Stress	Max Stress	17724 psi	21375 psi	Faulted allowables
Clip Angles	Force	416 lbs/in	2784 lbs/in	Allowable for 3/16" weld
Pipechase Connector Plenum Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stresses	Max IR	0.135	1.0	
Plate Element 3/8" Thick	Max Stress	556 psi	16875 psi	
	Max IR	0.135	1.0	
3/8" Diameter Studs	Max IR	0.18	1.0	
Welds	Max IR - Weld Metal Stress	0.452	1.0	
	Max IR - Base Metal Shear	0.559	1.0	
Anchor Bolts	Max IR	0.86	1.0	
	Max Plate Stress	12480 psi	16875 psi	

Table 30S-10: McGuire Unit 2 ECCS Sump Strainer ICW Enclosure Structural Qualification Summary

ICW Grating Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
1/4" Diameter U-Bolt	Horizontal Load	184 lbs	5472 lbs	Per panel basis
1/4" Tap Screw Capacity	Horizontal Load	108 lbs	2792 lbs	Per panel basis
3/8" diameter stud	Tension	413 lbs	1604 lbs	
	Shear	220 lbs	578 lbs	
Angle 3"x1-1/4"x1/4"	Bending Stress	14400 psi	17813 psi	
Angle 3"x3"x1/4"	Bending Stress	15356 psi	21375 psi	
ICW Perforated Plate/Solid Plate Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Solid Plate	Max Stress	3479 psi	21375 psi	
	Max Overhang stress	18000 psi	21375 psi	
Perforated Plate	Max Stress	2619 psi	7139 psi	
	Max Overhang stress	5380 psi	7139 psi	
Hydrodynamic Pressure Toward Grating	Max Stress	705 psi	7139 psi	
ICW Frame 1 Evaluation (Frame 2 Evaluation encompassed in this evaluation)				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stresses	Max IR	0.507	1.0	Faulted allowables used in evaluation
Weld Stresses	Weld Metal Stress	0.589	1.0	
	Base Metal Shear	0.921	1.0	
Anchor Bolt Stress	Max IR	0.56	1.0	
Base Plate	Max stress	12028 psi	21375 psi	
Tube steel to Base Plate Connection	Shear Stress	4321 psi	8494 psi	
Bearing of 1" Bolt	Bearing Stress	13568 psi	21375 psi	
ICW Frame 3 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member stress	Max IR	0.566	1.0	Faulted allowables used in evaluation
Welds	Max IR	0.78	1.0	
Anchor Bolts	Max IR	0.45	1.0	
Base Plate	Max Stress	6158 psi	21375 psi	

Tube steel to Base Plate Connection	Shear Stress	-	-	Acceptable by comparison with Frame 1
ICW Frame 4 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member stress	Max IR	0.871	1.0	Faulted allowables used in evaluation
Welds	Weld Metal Stress	0.797	1.0	
	Base Metal Shear	1.247	1.5	Faulted allowables used in evaluation
Anchor Bolts	Max IR	0.54	1.0	
Base Plate	Max Stress	11000 psi	21375 psi	
Bearing of 1" Bolt	Bearing Stress	14773 psi	21375 psi	On 3" pipe
2" Piping	Bending Stress	6426 psi	14250 psi	
ICW Frame 5 Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member stress	Max IR	0.618	1.0	Faulted allowables used in evaluation
Welds	Weld Metal Stress	0.76	1.0	
	Base Metal Shear	1.18	1.33	Faulted allowables used in evaluation
Anchor Bolts	Max IR	0.73	1.0	
Base Plate	Max Stress	2955 psi	21375 psi	
1" Bolt - Connection of Tube steel to Base Plates	Shear Stress	3972 psi	12741 psi	
Bearing of 1" Bolt	Bearing Stress	9704 psi	21375 psi	On tube steel
3" Piping	Tensile Stress	782 psi	21375 psi	
ICW Enclosure Miscellaneous Evaluations				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Horizontal Beams Supporting Grating	Frame 1(2) IR	0.424	1.0	Faulted allowables used in evaluation
	Frame 3 IR	0.768	1.0	Faulted allowables used in evaluation

	Frame 4 IR	0.848	1.0	Normal allowables used
	Frame 5(6) IR	0.411	1.0	Faulted allowables used in evaluation
Reactions	Max IR	0.88	1.0	
Welds	Weld stress	14233 psi	14250 psi	
Diagonal Bracing of Frames	Shear Stress	5869 psi	12741 psi	
	Bearing Stress	12885 psi	21375 psi	
Plate and Tube Steel to Support Grating	Bending Stress	7311 psi	20250 psi	
	Weld Force	2823 lbs/in	3375 lbs/in	
Field Splices	3/4" Diameter Bolt Max IR	0.23	1.0	Horizontal frame
	Max plate stress	17784 psi	20250 psi	Vertical posts
ICW Extension Strainer Structural Frame				
Member stress	Max IR	0.811	1.0	
Welds	Weld Metal Stress	0.691	1.0	
	Base Metal Shear	1.289	1.5	Faulted allowables used in evaluation
3"x3"x1/4" angle	Shear stress	13970 psi	14250 psi	Torsion
Anchor Bolts	Max IR	0.78	1.0	
Base Plate	Max Stress	5525 psi	14250 psi	
1" Bolt - Connection of Tube steel to Base Plates	Shear force	5858 lb	7852 lb	Faulted allowable
3" Piping	Shear Stress	3214 psi	9500 psi	
	Compression/Bending IR	0.54	1.0	

Table 30S-11: McGuire Unit 2 ECCS Sump Strainer Pipechase Vortex Suppressor Structural Qualification Summary

Pipechase Vortex Suppressor Structural Frame Analysis				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Member Stresses	Max IR	1.235	1.5	Faulted allowables used in evaluation
1/2" Diameter Bolts	Max IR	0.95	1.0	Clip plate evaluation - ok via engineering judgment
3/8"x2" Clip Plate	Clip Plate Bending + Axial Stress	14333 psi	17813 psi	
½" Plate Stress	Max stress	13795 psi	17813 psi	West Side Vortex Suppressor Frame
½"x4½"x 8" plate	Max stress	16481 psi	23550 psi	West Side Vortex Suppressor Frame
Welds	Max IR - Weld Metal Stress	0.759	1.0	
	Max IR - Base Metal Shear	0.98	1.0	Faulted allowables used in evaluation
18" Diameter Pipes and Support Evaluation				
Component Description	**Measurement**	**Actual**	**Allowable**	**Comments**
Tube Steel 2"x2"x1/4"	Max IR	0.65	1.0	
Lug 1"x1"x3"	Load per Lug	263 lb	-	Insignificant loads; welds okay
Anchor Bolts	Max IR	0.79	1.0	
	Plate Stress IR	0.62	1.0	
Welds	Max IR - Weld Metal Stress	0.347	1.0	
	Max IR - Base Metal Shear	0.480	1.0	

31. 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.

McGuire Response:

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.

32. 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.

McGuire Response:

NRC technical staff concerns with the Array Test and the Integrated Prototype Test (debris preparation, debris introduction, debris agglomeration, flow fields, bare strainer area and chemical effects) were discussed at the public meeting convened on November 24, 2008 in Washington, D.C. It was determined that resolution of the issues raised by the staff at that meeting would require further testing and evaluation. As stated previously in this submittal, the information herein pertains to the Chemical Precipitates Head Loss test series performed in February 2011, which is the test of record for the McGuire ECCS Sump Strainers.

McGuire has not attempted to predict or characterize the amount of bare strainer that could exist post-LOCA. The thin bed testing protocol (as detailed in RAI 17 of this submittal) was used during the Chemical Precipitates Head Loss testing in accordance with the "NRCs Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Strainer Head Loss and Vortexing", March 2008, in order to promote strainer coverage and increased head losses.

The preparation and introduction of debris is discussed in the responses to RAI questions 15 and 17 of this submittal. Test tank design and transport of debris in the test tank is discussed in the response to RAI question 16 of this submittal.

Attachment 3

McGuire Nuclear Station
Generic Letter 2004-02 Supplemental Response
November 18, 2008 NRC Request for Additional Information

Commitments

July 2, 2012

McGuire Nuclear Station
Generic Letter 2004-02 Supplemental Response
November 18, 2008 NRC RAI
Final Response

Commit. #	RAI Resp.#	Commitment	Due Date
1	1, 2, 3, 4, 7, and 14	Fiber Insulation Replacement Project modifications are scheduled to be completed.	Spring 2013
2	13, 19, and 22	ECCS Water Management Initiative modifications for Unit 2 are scheduled to be implemented.	Fall 2012
3	31	McGuire will address the in-vessel downstream effects issue.	Within 90 days of issuance of the staff's final Safety Evaluation on TR WCAP-16793.