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April 6, 2010

U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

ATTENTION: Document Control Desk

SUBJECT: **R.E. Ginna Nuclear Power Plant**
Docket No. 50-244

Request For Additional Information Regarding Generic Letter 2004-02

REFERENCES:
(a) Letter from John Carlin (Ginna LLC) to Document Control Desk (NRC) dated February 29, 2008, Supplementary Response to Generic Letter 2004-002, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"
(b) Letter from John Carlin (Ginna LLC) to Document Control Desk (NRC) dated July 25, 2008, Second Supplemental Response to NRC Generic Letter 2004-002, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"
(c) Letter from John Carlin (Ginna LLC) to Document Control Desk (NRC) dated June 2, 2009, Third Supplemental Response to NRC Generic Letter 2004-002, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"
(d) NRC Generic Letter 2004-02: ""Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"
(e) Letter from Douglas Pickett (NRC) to John Carlin (LLC), dated December 4, 2009, Request for Additional Information Re: Generic Letter 2004-02 (TAC No. MC 4687)

By letters dated February 29, 2009 (Reference a), July 25, 2008 (Reference b), and June 2, 2009 (Reference c), R.E. Ginna Nuclear Power Plant LLC (Ginna LLC) provided supplemental responses to Generic Letter 2004-02: ""Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors", dated September 13, 2004 (Reference d).

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NRR

WPCNRC-1002293

Reference (e) requested additional information to our supplemental responses noted above. Attachment (1) contains our response to this request. Attachment (2) provides the regulatory commitments associated with this submittal.

If there are any questions or if additional information is required, please contact Mr. Thomas Harding at (585) 771-5219 or at Thomas.HardingJr@cengllc.com

Very truly yours,

John Carlin

STATE OF NEW YORK:
: TO WIT:
COUNTY OF WAYNE:

I, John Carlin, being duly sworn, state that I am Vice President, R.E. Ginna Nuclear Power Plant, LLC (Ginna LLC), and that I am duly authorized to execute and file this request on behalf of Ginna LLC. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other Ginna LLC employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Subscribed and sworn before me, a Notary Public in and for the State of New York and County of Wayne, this day of April, 2010.

WITNESS my Hand and Notarial Seal:

Sharon L Miller
Notary Public

SHARON L. MILLER
Notary Public, State of New York
Registration No. 01MI6017755
Monroe County
Commission Expires December 21, 2010

My Commission Expires:

12-21-10
Date

Attachment (1): Ginna LLC Response to Request for Additional Information Regarding GL 2004-02, Dated December 4, 2009

Attachment (2): List of Regulatory Commitments

CC: S.J. Collins, NRC
D.V. Pickett, NRC
Resident Inspector, NRC (Ginna)
P.D. Eddy, NYSDPS
A.L. Peterson, NYSERDA

ATTACHMENT 1

Ginna LLC Response to Request for Additional Information
Regarding GL 2004-02, Dated December 4, 2009

1 RAI RESPONSES

1.1 RAI Question #1

The staff requested that the licensee provide a comparison of the banding, jacketing, and manufacturing processes for the calcium silicate insulation installed at Ginna with the corresponding properties for the material used for destruction testing. The licensee's response provided sufficient information to address the aspect of this question associated with the insulation manufacturing processes for the plant and test materials. However, the staff considers the following additional information necessary regarding the jacketing and banding:

a. A comparison of the type banding used at Ginna with that used for the Ontario Power Generation testing (e.g., band thickness and/or nominal failure strength), factoring in the larger allowable band spacing at Ginna as compared to the tested configuration.

b. A basis for concluding that the 0.01"-thick stainless steel jacketing installed on piping at Ginna is more robust than the 0.016"-thick aluminum jacket used for the Ontario Power Generation (OPG) testing.

Response to Part A

Ginna will install stainless steel banding on all calcium silicate (Cal-Sil) insulation within the zone of influence of any limiting break location that meets or exceeds that installed on the test specimen used in the Ontario Power Generation testing. The banding will be 0.020-inch thick by 0.50-inch wide stainless steel circumferential bands, or better, spaced at 6-inches (maximum). The installation of the banding on the calcium silicate insulation will be completed no later than the Ginna 2012 refueling outage.

Response to Part B

The main function of the jacketing is to protect the underlying Cal-Sil from direct jet impingement. The failure mode during the OPG testing was shearing of the aluminum jacket adjacent to the banding. Aluminum and stainless steel jacketing thickness on the order of 0.01 inches will provide considerable protection of the Cal-Sil from the effects of direct jet impingement. The Ginna stainless steel jacketing is Type 301, annealed (UNS S30100) [12]. The tensile strength of Type 301 stainless steel is 75 ksi, and the yield strength is 30 ksi [10]. The aluminum jacketing used in the OPG testing was Aluminum 1100 [11]. The tensile strength of Aluminum 1100 is 13 ksi, and the yield strength is 5 ksi [10]. A comparison of the tensile strengths per unit width shows that the stainless steel jacketing, used at Ginna, is over three times as strong as the aluminum jacketing, used during the OPG testing, (75 ksi * 0.010 in = 750 lbs/in vs. 13 ksi * 0.016 in = 208 lbs/in). Therefore, it is reasonable to conclude that the stainless steel jacket at Ginna is equivalent or better than the strength of the slightly thicker aluminum jacket used in the OPG tests.

1.2 RAI Question #3.1

Based on the information provided in the June 2, 2009, supplemental response, it appeared that 3% of small pieces and 37% of large pieces of fibrous debris were assumed to be trapped on gratings during the blowdown phase. Please clarify whether the grating credited with this debris capture is located below postulated break locations, and provide a technical basis (e.g., specific tests from which data was applied) to justify the assumed capture fractions.

Response

There was no credit taken for debris remaining captured on grating below the postulated break locations as there is no grating underneath the break location. The configuration at Ginna is such that the break location is below the grating (on the crossover leg), but the majority of the insulation that could be potentially blown off of the steam generator is above the grating. Thus, no debris held up on grating was credited with being captured below the break location. A cutaway view of a steam generator compartment at Ginna is shown below in Figure 1.2.1.

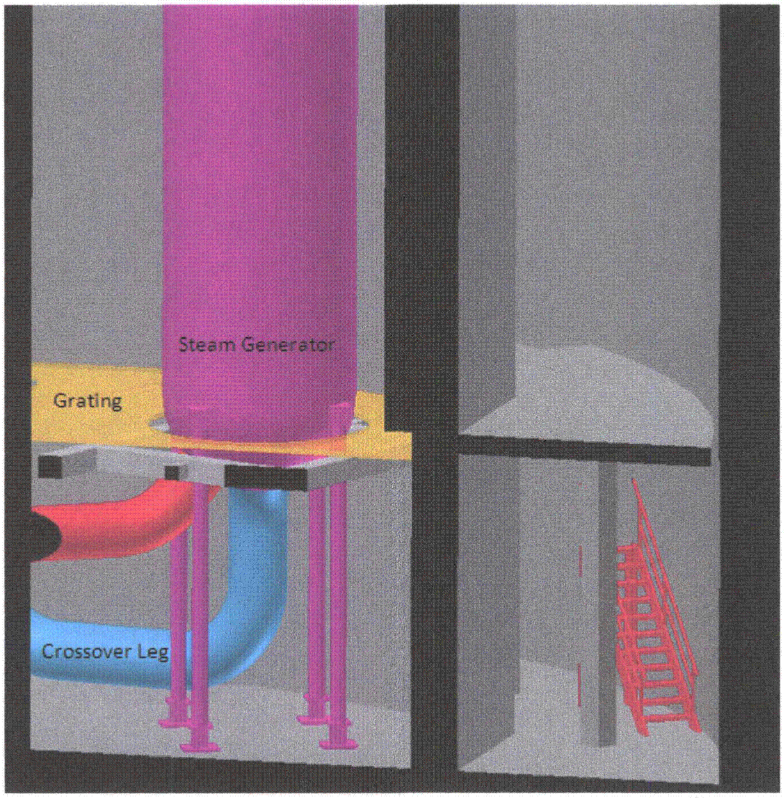


Figure 1.2.1 – Ginna Steam Generator and Grating Configuration

Using the ratio of upper to lower containment volumes, it was determined that 89% of the small piece debris would be blown toward upper containment [5]. Of the 89% blown upward, some of the debris would be trapped by structures and grating and some would be trapped as the blowdown flow makes significant bends.

The results of the drywell debris transport study (DDTS) [1] blowdown testing showed that in a wetted, highly congested area, approximately 10% of small fiberglass debris would be trapped by miscellaneous structures, and approximately 25% would be trapped by grating. Also, 17% of small fiberglass debris was shown to be captured at 90° turns in a flow path. Although 90° turns might not have to be negotiated by debris blown to upper containment at Ginna, significant bends would have to be made. It was conservatively estimated that 5% of the small fiberglass debris blown upward would be trapped due to changes in flow direction. Figure 1.2.2 shows the grating platforms in the steam generator compartments.

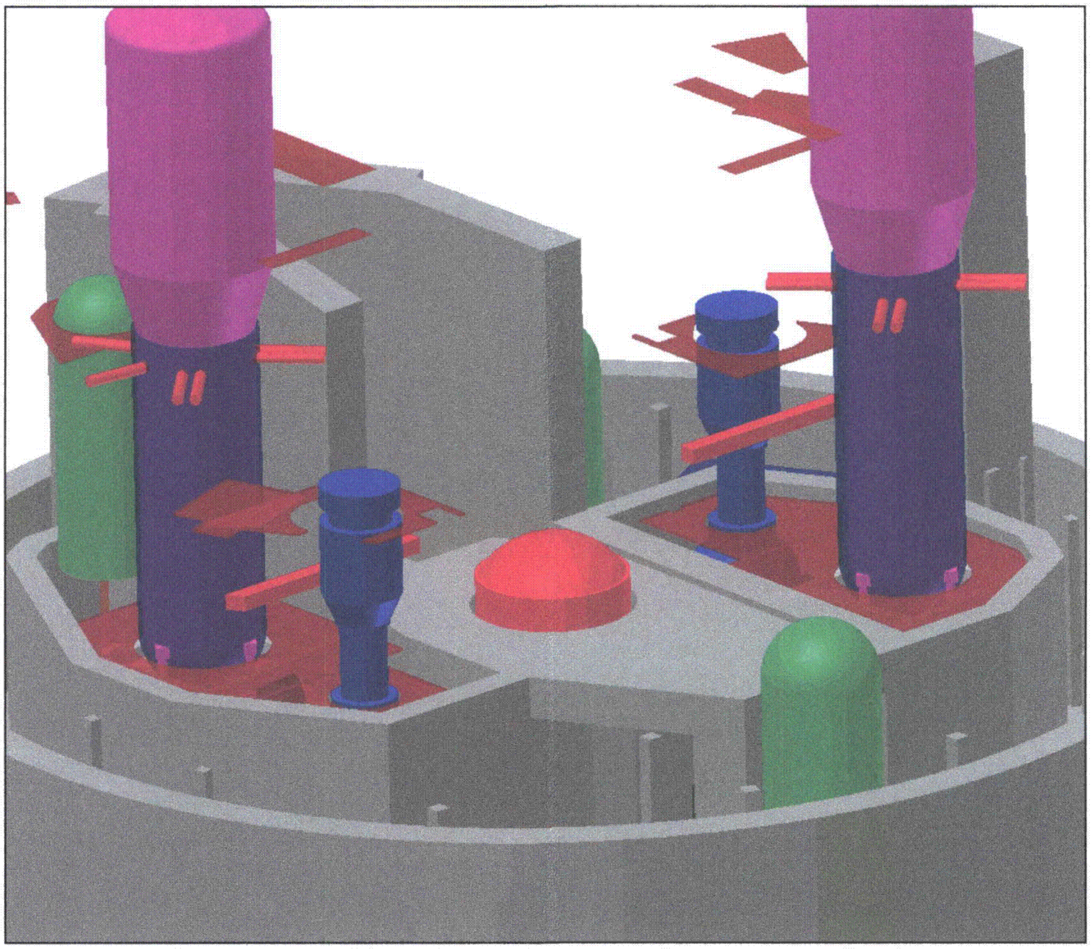


Figure 1.2.2 – Ginna Steam Generator Compartment Grating

There is no significant grating at the top of the SG compartments at Ginna. Based on this, the percentage of small piece fibrous debris that would be blown to upper containment can be calculated as shown below:

$$\%_{SMALLUPPER} = (0.89) \times (1.00 - 0.05) \times (1.00 - 0.10) = 76\%$$

As shown in Figure 1.2.2, grated platforms exist low in the steam generator compartments at Ginna covering a large portion of the compartment area. In the transport analysis, the grating was conservatively assumed to only cover 50% of the compartment. The grating would capture some of the small and large debris not blown to upper containment. All of the debris not transported to upper containment was conservatively assumed to be blown toward the floor (in reality some of the debris would be lodged in structures around the compartment). Based on this, the percentage of small piece fibrous debris that would be blown to lower containment was calculated as shown below:

$$\%_{SMALLLOWER} = (1 - 0.76) \times [1.00 - (0.25 \times 0.50)] = 21\%$$

Thus, the amount of small fiber that would remain captured on structures and grating during blowdown was calculated to be:

$$\%_{SMALLCAPTURED} = (1.00 - 0.76 - 0.21) = 3\%$$

It's possible that a small amount of the captured fiber could be washed down by containment sprays during the brief duration that the sprays are in operation. However, less than 55% of the grating near the base of the steam generator compartment (where debris retention was credited) is exposed to sprays as shown in Figure 1.2.3. Since it was very conservatively assumed that the grating covers only 50% of the compartment area when it actually covers close to 100% of the area, any washdown that occurs due to sprays is more than compensated by the conservatism. For example, if the full 100% grating coverage was credited, the percentage of small fiberglass debris captured would be doubled to 6%. Based on drywell debris transport study testing, washdown of small fiberglass due to containment sprays is likely less than 50%. However, even if 100% of the small fiberglass exposed to sprays on the grating is washed down, the retention of small fiberglass on grating in the steam generator compartment would still be approximately 3%. Therefore, the retention fraction that was credited is conservative.

The large fiberglass debris would be blown toward upper containment in a manner similar to the small fiberglass debris. However, since this debris would be more likely to be held up on structures than the small pieces, it was estimated that only 25% would be blown to upper containment. Note that this is a conservative estimate since most of the large pieces of fiberglass are generated from the insulation on the steam generators directly above the break, and this debris would essentially have a straight path to upper containment.

Again, grated platforms exist low in the steam generator compartments at Ginna covering approximately 50% of the compartment area, thus, the percentage of large piece fibrous debris that would be blown to lower containment can be calculated as shown below:

$$\%_{LARGELOWER} = (1 - 0.25) \times [1.00 - 0.50)] = 38\%$$

Thus, the amount of large fiber that would remain captured on structures and grating during blowdown was calculated to be:

$$\%_{LARGECAPTURED} = (1.00 - 0.25 - 0.38) = 37\%$$

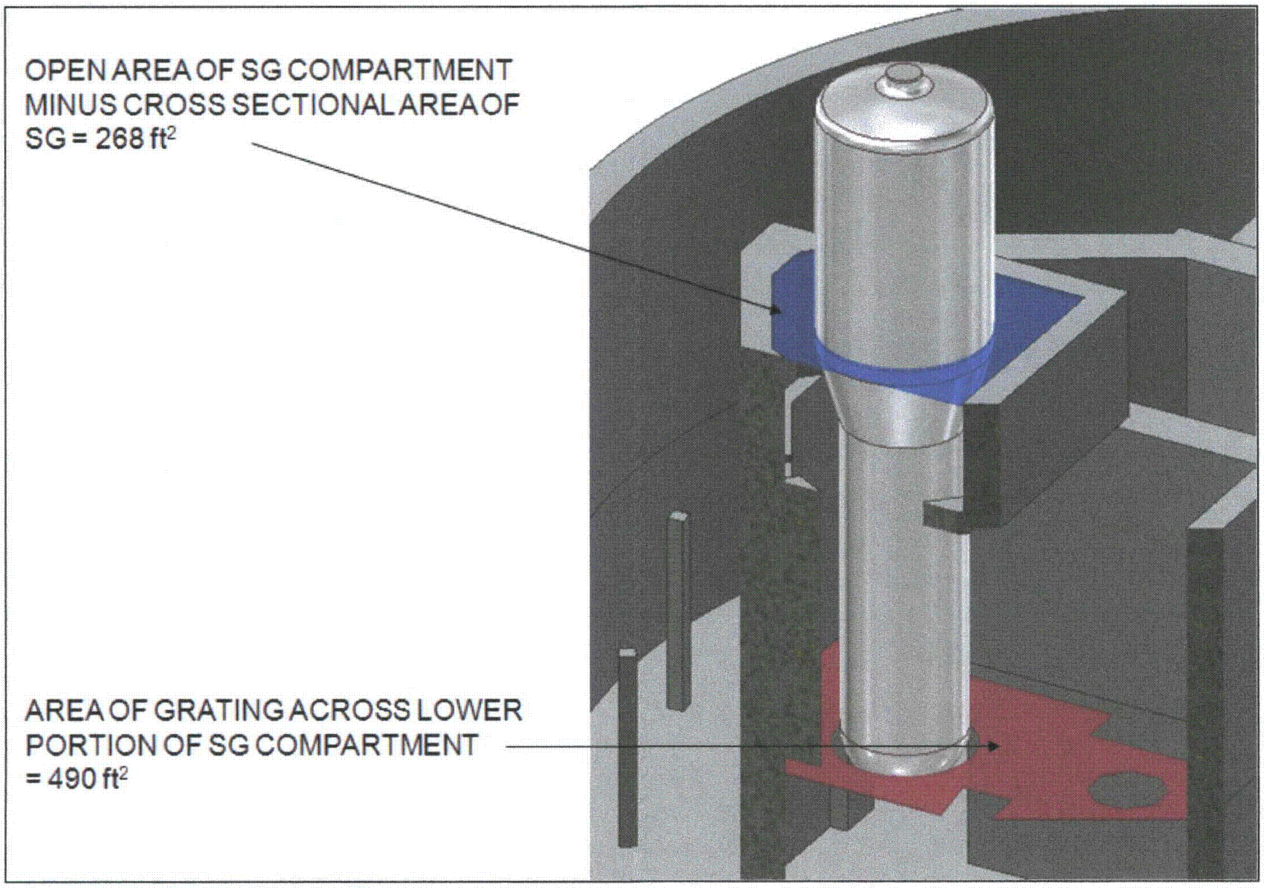


Figure 1.2.3 – Ginna steam generator compartment spray and grating areas

1.3 RAI Question #3.2

The June 2, 2009, supplemental response stated that 5% of the small fiberglass debris blown upward would be trapped due to changes in flow direction. It appeared to the staff that much of this debris considered to be trapped due to inertial capture may be only temporarily held up against vertical surfaces or the underside of horizontal surfaces. As such, it was not clear that the debris would remain trapped for the 30-day sump mission time. Please discuss whether this debris that was assumed to be trapped due to a change in flow direction is assumed to remain trapped for the 30-day sump mission time. If a 30-day holdup cannot be justified, please discuss the manner in which the subsequent potential transport of some or all of this debris to the strainers is considered. Please provide a technical basis to justify the assumptions made.

Response

The 5% of small fiberglass debris that is blown upward and trapped due to changes in flow direction was not assumed to be retained for the full 30 day sump mission time [5]. As discussed in Section 1.2, all debris that is not blown to upper containment was conservatively assumed to be blown toward lower containment with a small portion of small piece debris held up on grating. This is conservative since a large fraction of the debris that was assumed to be blown through grating, would actually be trapped on structures above the grating, and may or may not fall off the structures onto the grating. Also, the retention fraction for debris falling on grating would be much higher than the retention fraction for debris blown through grating by the LOCA blast.

1.4 RAI Question #3.3a and 3.3b

The June 2, 2009, supplemental response described the methodology used to determine transport of small fibrous debris pieces on the operating deck level. Based on this methodology, the licensee calculated 0% transport on the upper level of the operating deck, and 40% transport on the lower level of the operating deck. The staff considered several aspects of the licensee's methodology to be unacceptable, including the following:

a) The use of a single transport metric for all small pieces (which range in size from pieces larger than fines to pieces up to 4 inches in size) does not appear to be sufficient to lead to realistic transport percentages, particularly for the upper operating deck.
b) The methodology assumed that the small pieces of fibrous debris would be saturated with water. The basis for this assumption is unclear, given that the fraction of small pieces of fiber that was fragmented and blown to the upper containment would have been impacted with a two-phase jet that had largely flashed to steam before contacting the insulation. Furthermore, the water on the operating deck would largely be spray drainage at cooler temperatures, which does not rapidly penetrate insulation debris due to its viscosity. In addition, on the upper level, the debris pieces would not be fully submerged. Accounting for trapped air in small pieces of fibrous insulation would lead to increased tumbling transport versus the licensee's evaluation, and also to the consideration of the potential for transport via floatation, which did not appear to have been evaluated due to the assumption of the debris being water saturated.

Response to Part A

The transport calculations are based on a four size distribution of fiber debris developed based on the methodology described in the SER to NEI-04-07 [3]. The definition of the fiber four size distribution used in the transport calculations are:

1. Fines – defined as NUREG/CR-6224 size Category 1 through 3
2. Small pieces – defined as pieces ranging in size from approximately 1 inch to 6 inches
3. Large pieces – defined as pieces ranging in size larger than 6 inches
4. Jacketed intact pieces – defined as mostly intact large pieces of debris that have retained their silicone impregnated jackets

The percentages of the debris size distribution were based on conservative interpretation of the available size distribution data. This conservative interpretation of the debris sizes from the debris generation testing ensures that the 4 size distribution is conservatively skewed towards smaller and more transportable debris.

The transport metric used for small pieces is based on the smallest size of the small pieces, i.e. approximately 1 inch size pieces, even though there are significant quantities of debris larger than 1 inch in the size category of "small pieces". Therefore there are significant conservatisms in the debris transport on the operating deck.

Response to Part B

Extensive studies have been performed as to the sequence of events following a double ended guillotine break. One of the most recent studies was performed by Los Alamos National Laboratory (LANL) as part of their GSI-191 support documented in NUREG/CR-6770 [2]. Page 53 of the LANL report provides that following description of the thermal hydraulic scenario following a large break:

> "The RCS blowdown following an LLOCA occurs over a period of 30 s, during which time the vessel pressure drops from 2000 psia to near atmospheric pressure. During this time, the reactor pressure vessel thermodynamic conditions undergo a rapid change. Initially, the break flow is subcooled at the break plane and flashes as it expands into the containment. Within 2 s, the vessel pressure drops below 2000 psi and the flow in the pipes and the vessel becomes saturated. Thereafter, the break flow quality is equal to or higher than 10%. On the other hand, the void fraction increases to approximately 1.0, clearly indicating that the water content would be dispersed in the vapor continuum in the form of small droplets."

This LANL description suggests that the fluid from a break would be in the form of small droplets that would wet the insulation as it was destroyed. The large break LOCA accident progression scenario is illustrated in Figure 12 of the LANL report. The portion illustrating the first few seconds of the accident sequence associated with debris generation is reproduced in Figure 1.4.1.

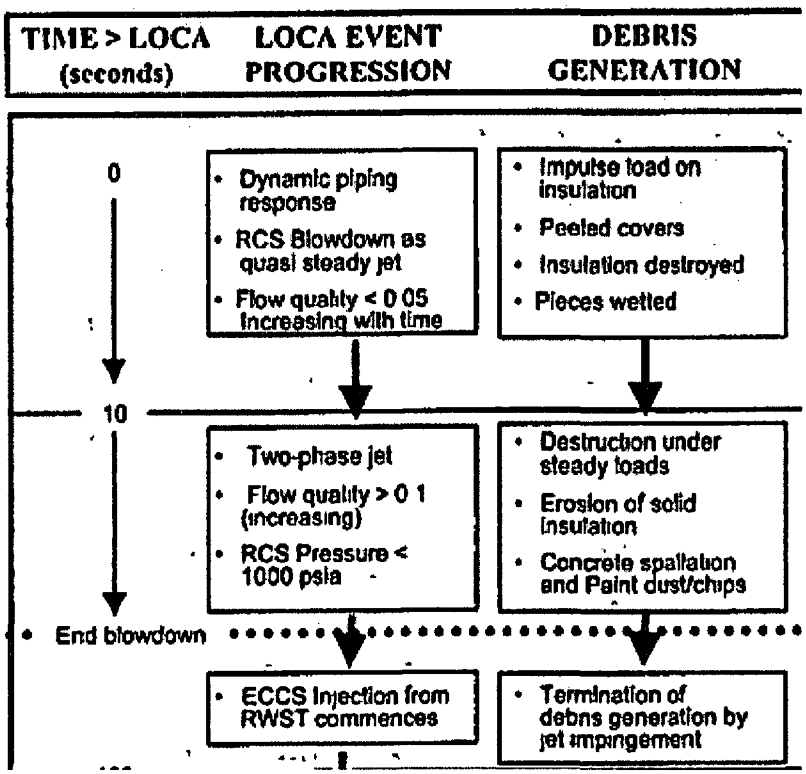


Figure 1.4.1 – LANL LBLOCA Progression Excerpt

Also note that although containment sprays only operate for approximately 1 hour after SIAS [4], the containment sprays would quickly saturate the small pieces of fiberglass blown to upper containment.

With the combination of the initial wetting by the break jet and the effects of the spray flow, it is reasonable to conclude that insulation in upper containment would be water saturated.

1.5 Additional RAI Question #3.3a and 3.3b

In addition (to previous Section 1.4), several aspects of the methodology are not sufficiently clear, including the following:

a. The basis for assuming a weir model with uniform radial flow across the operating deck elevation was not stated. From the information provided, it is not clear whether the geometric location of the stairways and hatches, as well as the location of any flow obstacles that may be present, are consistent with this model. Also, the significant amount of debris assumed to reach the operating deck and settle out (e.g., it appeared from the information provided that well over 100 ft^3 of small pieces of fiber alone could settle out on the operating deck level) could result in channeled flowpaths at higher velocities. It is not clear to the staff that the simplified flow approximations used by the licensee are sufficient to determine the behavior of the gradually varying open channel flow across the operating deck.

b. It is unclear that the derivation of partially submerged transport metrics from submerged transport metrics is valid. In addition to the concerns identified above, submerged, tumbling transport would seemingly be associated with a static coefficient of friction, whereas partially submerged transport would seemingly be associated with a dynamic coefficient of friction. Without benchmarking, the staff believes there is significant uncertainty associated with the licensee's transport metrics that cannot be accounted for.

Please provide additional justification, or else modify the approach used to determine the transport percentages across the operating deck, in response to the issues noted above.

Response to Part A

Since the spray flow would be distributed essentially uniformly across the operating deck, the spray flow would accumulate across the entire floor and subsequently approach the openings in a radial manner. Although the accumulation of pieces of fiberglass on the operating deck floor could have a localized impact on flow, these pieces would tend to inhibit the transport of other pieces since the pieces would agglomerate together into larger less transportable groups.

Response to Part B

It's correct that the submerged tumbling velocity is associated with a static coefficient of friction since the 0.12 ft/s value is the incipient tumbling velocity (i.e. the velocity required to start moving the piece of fiberglass). However, the tumbling velocity for a partially submerged piece of fiberglass would also be associated with the static coefficient of friction, since the velocity required to first cause a piece of fiberglass to move (whether it is submerged or not) is dependent on the static coefficient of friction. The dynamic coefficient of friction would be applicable for a piece of fiberglass that is already moving along the floor.

RAI 3.3 Response Summary

As discussed in the above responses, there are a number of conservatisms in the analysis used to credit retention of small fiberglass debris in upper containment, and a large amount of this debris would not be transported down to the containment recirculation pool. However, in the interest of expediting resolution of the NRC's concerns, the debris transport analysis will be revised to remove credit for any small fiberglass debris retention in upper containment. This approach will significantly increase the overall conservatism in the debris transport analysis.

1.6 RAI Question #3.4

Based upon the information presented in the June 2, 2009, supplemental response, the staff did not have confidence that the licensee had adequately addressed several items associated with post-loss of coolant accident (LOCA) debris erosion.

a. Please discuss any testing used to justify the assumption of 10% fibrous debris erosion in the containment pool, including a description of the test facility, the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fibrous material present in the erosion tests to the analogous conditions applicable to the plant condition. Please also identify the duration of the erosion tests and how the results were scaled to the plant condition.
b. The licensee's June 2, 2009, supplemental response indicates that a significant quantity of fibrous debris is predicted to settle out on the operating deck. The response further indicates that the flow velocities will be quite high across the operating deck, with average flows in the range of 0.5 – 1.9 ft/s. Although the supplemental responses indicate that spray operation will be terminated prior to recirculation, based upon these high flow rates and erosion test results at much lower velocities that appear to demonstrate that loose fibers can be rapidly released from pieces of fiberglass (i.e., promptly upon exposure to the flow stream), it appears that neglect of erosion is non-conservative for this debris even during the relatively short duration of containment spray operation.
c. Although erosion of debris retained on gratings resulting from the impact of containment spray droplets is typically not a major effect, it was not clear to the staff that erosion of retained debris due to break flow could be neglected for Ginna. In particular, the June 2, 2009, supplemental response appears to indicate that retention of fibrous debris on gratings below the break location is credited. Please discuss how erosion of debris due to break flow, which can be a major effect, was evaluated.

Response to Part A

To resolve this concern, Ginna is participating in the current Alion fiberglass erosion test program. The NRC has been involved in the testing as it has progressed, and is intimately familiar with the details of the testing. Acceptance of the Alion fiberglass erosion test report by the NRC is pending.

Response to Part B

The highest velocity where debris was credited to settle on the operating deck floor is on the 278'-4" elevation where the pieces would be only partially submerged, and the maximum velocity is approximately 0.5 ft/s. No pieces were credited to settle in higher velocity regions on the 274'-6" elevation of the operating deck.

Containment spray flow is terminated upon switchover to recirculation (57.56 minutes after SIAS [4]). This would result in the retained debris being subject to the velocities described above for less than one hour. The SER states in Appendix 6 [3] that for the pilot plant "about 1 percent of the small and large piece debris that the sprays directly impacted was considered to have eroded. This amount of erosion was considered to be conservative because the DDTS concluded that the erosion was less than 1 percent."

Using the conservative erosion fraction of 1% from the SER for the debris located in upper containment would result in an overall 0.3% increased transport fraction for small pieces of fiber and a 0.2% increase for large pieces. These potential increases are extremely small and have no practical impact upon overall transport fractions. The impact would likely be smaller than stated above as the 1% erosion fraction is being applied to all debris located in upper containment, when it is likely that at least some portion of the debris would not be directly impacted by containment spray. Also, the debris that is partially submerged would not have flow moving past the top, upper sides, or bottoms of the pieces of fiberglass. Given the small surface area exposed to flow, and the short duration of the containment spray operation, it is reasonable to conclude that erosion is negligible.

As discussed in the RAI 3.3 response summary, the debris transport analysis will be revised to remove credit for any small fiberglass debris retention in upper containment. This is being done in the interest of expediting resolution of the NRC's concerns. This approach will significantly increase the overall conservatism in the debris transport analysis.

Response to Part C

All debris subject to break flow was assumed to erode and transport to the post LOCA pool. As discussed in Section 1.2, there was no credit taken for debris remaining captured on grating below the postulated break locations as there is no grating underneath the break location. The configuration at Ginna is such that the break location is below the grating, but the majority of the insulation that could be potentially blown off of a steam generator is above the grating. Thus, no debris held up on grating was credited with being captured below the break location.

1.7 RAI Question #3.5

The June 2, 2009, supplemental response indicates that the head loss testing performed for Ginna resulted in more than half the debris added to each test settling onto the test flume floor. It appeared that a significant part of this settled debris was composed of large pieces of fibrous debris, and potentially other types of erodible debris as well (e.g., small pieces of fiber and calcium silicate). Please address the following points associated with the settled debris in the test flume.

a. Based on the information in the supplemental response, the staff did not consider the head loss test flume flow conditions as being representative of the plant from a debris transport perspective. Furthermore, the staff noted that, while the transport analysis suggests that a significant portion of the transported large pieces of fibrous debris seemed to be Temp-Mat that transported via floatation, the supplemental response describes the large fibrous debris pieces as being soaked with water prior to the test, which would prevent floatation under the test conditions. Particularly given that the transport analysis for the plant flow conditions took significant credit for settlement of fine debris, it was not clear to the staff why large debris pieces soaked with water under the flow conditions in the test flume would have been considered potentially transportable. In light of this information, please provide a basis for considering the behavior observed in the test flume to be representative of the plant condition.

b. A significant quantity of debris settled during the design basis head loss tests. Based on the response, it is not clear that erosion of this settled debris was accounted for in the analysis. Please describe how erosion of debris that settled in the test flume was accounted for in the analysis, or provide a basis for neglecting the erosion of a potential significant fraction of the debris added to the test flume.

Response to Part A

Debris Generation and Debris Transport Analyses [5 and 6] determined the debris types, quantities, characteristics, and size distribution of debris that would transport to the location of the sump strainers in containment. During head loss testing, the quantity of debris determined to transport to the sump strainer was scaled down based on the ratio of strainer surface area used in the test loop and the surface area of the strainer installed in containment. The debris was added to the test loop in a way to maximize the impact on the test strainer. Debris was added in small batches to minimize agglomeration and settling. Between batches, any debris that had settled on the bottom of the test loop was re-suspended via a hand drill powered propeller. Care was taken to ensure that re-suspending the debris did not cause any disruption of the debris bed on the surface of the strainer. Hence, the procedure used maximized the quantity of debris that entered the strainer pockets, and therefore maximized the strainer head loss.

The quantity of large pieces of Temp-Mat transported to the sump strainer was determined, via the Debris Transport Analysis [5]. The analysis conservatively assumed that more dense fibrous insulation, such as Temp-Mat, would float for an extended period of time, as compared to less dense fibrous insulation, such as Thermal Wrap [5]. Transport to the sump strainer is maximized by assuming that the Temp-Mat floats in the recirculation pool of containment. However, if allowed to float during strainer head loss testing, the Temp-Mat would never approach the face of the strainer, since the test flume water depth was maintained approximately 7" above the top of the strainer (comparable to the minimum recirculation pool depth). By soaking the large pieces of Temp-Mat, prior to placing them in the test loop, allows for them to be submerged, which more easily allows for them to impact the strainer. The treatment of Temp-Mat in the transport analysis and the strainer head loss testing is considered to be conservative.

During strainer head loss testing, the large pieces of Temp-Mat accumulated on the bottom of the test loop in front of the strainer. The debris that settled was repeatedly agitated by a hand drill powered propeller to re-suspend the debris and allow it to enter the strainer pockets. The large pieces of Temp-Mat measured approximately 6" x 6". The openings of the strainer pockets are 3.130" x 2.772". Therefore, unless a large piece becomes folded on to itself two times, the large pieces will never enter the strainer pockets. The most detrimental impact of the large pieces of Temp-Mat is if they were to be held parallel to the face of the strainer pocket opening, thereby blocking multiple strainer pockets. By periodically agitating the debris that had settled on the test loop bottom, gave the large pieces of Temp-Mat every opportunity to affix itself to the strainer face. However, with a strainer fluid approach velocity of 0.31 in/s, there is insufficient dynamic force to hold the large pieces of Temp-Mat against the face of the strainer. As a result, it falls to the bottom of the test loop, at the face of the strainer, and forms a debris pile. This pile of debris in front of the test loop strainer extended out from the face of the strainer approximately 3 feet and ramped up to cover the face of the bottom third of the strainer pockets. Due to the unique configuration of the CCI strainer pocket design and the very low approach velocities, it is believed that accumulation of debris at the face of the strainer is prototypical.

Response to Part B

As a result of the debris addition to the test loop, a debris pile was formed in front of the face of the test strainer. This is primarily a result of the unique design of the CCI strainer. The strainer is constructed of multiple pockets with 3.130" x 2.772"openings. As a result, the majority of the large debris cannot enter the pockets. The debris pile that was formed in front of the test strainer was composed primarily of large pieces of Temp-Mat and Thermal Wrap, which blocked the lower portion of the test strainer pockets. The debris pile extended out from the face of the strainer approximately 3 ft. The debris pile acts as a large filter in front of the face of the lower portion of strainer pockets, increasing the effective depth of the debris loading, thereby serving to restrict flow through the lower strainer pockets. The majority of any erosion or breakdown of debris in the debris pile would be contained within the debris pile. The effects of any debris erosion at the boundary between the debris pile and the face of the strainer pockets is minimized by the resultant reduction in flow through the debris pile. Erosion of the top surface of the debris pile could result in increased transport of fiber fines and particulate in the strainer pockets not blocked by the debris pile. Erosion of the debris, determined to be transported to the sump strainer, was not separately accounted for in the strainer head loss testing, i.e., additional quantities of fiber fines and Cal-Sil particulate were not added to the test loop specifically for this purpose.

The results of the strainer head loss testing is reflective of any erosion of the debris pile that takes place during sump pool recirculation. Once the debris pile was formed in front of the test strainer, the testing continued for approximately 5 days. The strainer head loss over the 5 days of continual test loop recirculation did not show any appreciable increase in head loss. The strainer head loss varied by no more than 2 to 3 mbar over that entire period. It is reasonable to conclude that any erosion of debris in the debris pile has minimal effect on strainer head loss. Furthermore, as discussed below (RAI 14 and 14.2), the RHR pump NPSH margin increases at a substantially greater rate than does the strainer head loss, later into the event, as the recirculation fluid temperature decreases. Therefore, it is reasonable to conclude that the potential for additional adverse effects due to continued erosion beyond Day 5, will be more than offset by the increasing NPSH margin.

The above information reflects strainer head loss testing performed to date. As a result of the responses to RAI 3.3, Ginna will revise the debris transport analysis and re-perform strainer head loss testing. This will likely cause the details of the above response to change. In the re-performance of the strainer head loss testing, 10% erosion of the debris, determined to be transported to the sump strainer that does not become part of the strainer debris bed, will be applied to account for any potential for erosion of the debris pile in front of the face of the strainer.

1.8 RAI Question #3.6

The June 2, 2009, supplemental response stated that any debris washed to the refueling cavity would be held up in the refueling cavity or reactor cavity rather than reaching an active portion of the containment pool. Please clarify whether filling of the inactive volumes prior to the termination of the containment sprays could occur for any post-LOCA scenarios, resulting in a portion of the debris assumed to wash to the inactive volumes reaching the active containment pool instead.

Response

There are two inactive cavities at Ginna. The first is the lower portions of the refueling canal which are only filled by containment spray. The second is the inactive Sump A (the reactor cavity), which is filled via spray flow running down the reactor vessel and by the pool filling. However, the pool does not communicate with Sump A (or the recirculation sump, Sump B) until the pool has reached a height of 6". The only means of filling the inactive cavities until this point is via containment spray landing in the refueling canal.

The maximum pool recirculation flow rate was determined to be 2,167 gpm (2,286 gpm minus 119 gpm pump recirculation flow) based on flow rates of 1 RHR pump, 2 SI pumps, 2 deluge lines, and 1 sump line [4]. The debris transport calculation [5] determined that the 6" pool volume is 3,094 ft^3 (23,144 gallons).

The maximum volume of spray flow that would be delivered over the 57.56 minutes that the containment spray pumps are running would be 133,172 gallons, which yields an average flow rate of 2,314 gpm [4]. The refueling canal area was calculated to be 1,194 ft^2 (see Figure 1.8.1) and the cross sectional area of containment was calculated to be 8,669 ft^2 [4].

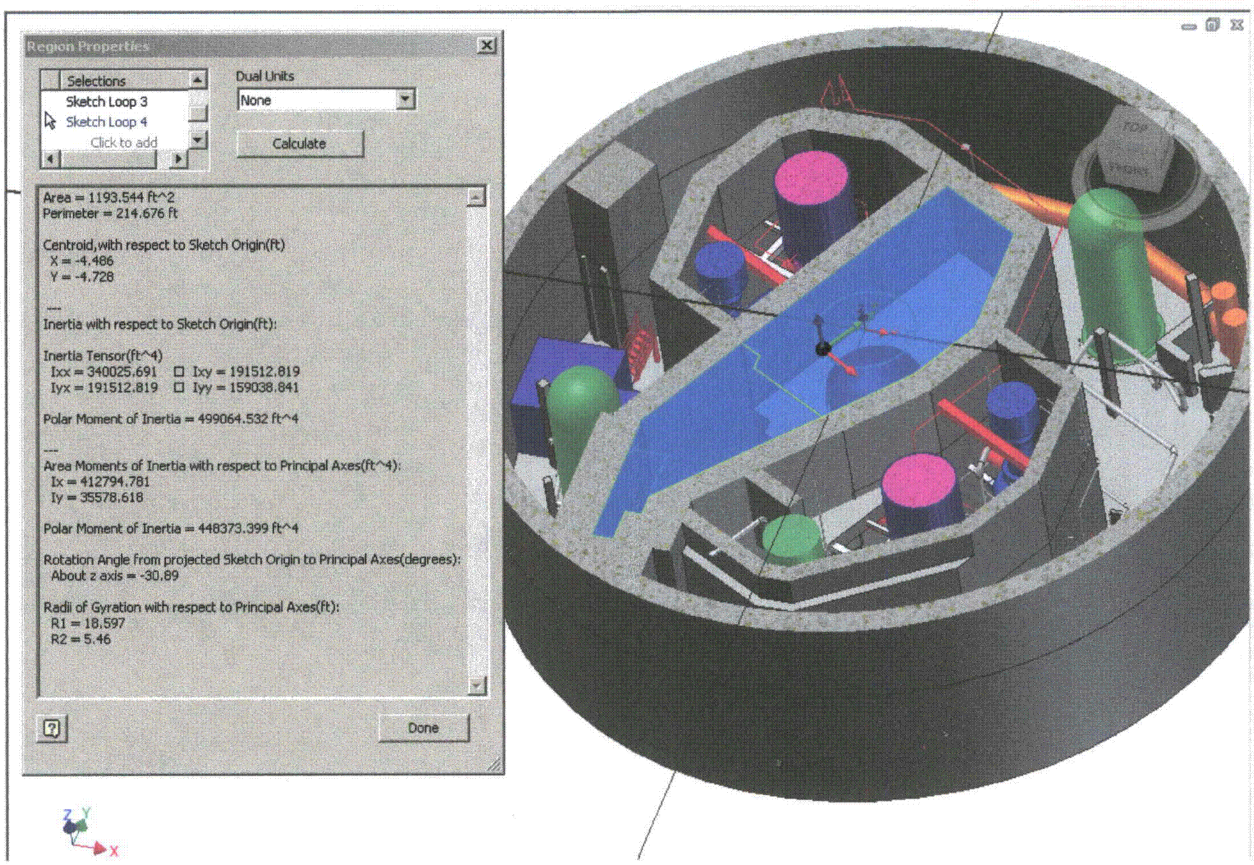


Figure 1.8.1 – Reactor cavity area

Thus, the flow rate contribution of the sprays to the active pool is calculated to be:

$$Q_{ACTIVEPOOL} = [(8{,}669\ ft^2 - 1{,}194\ ft^2) / 8{,}669\ ft^2] \times 2{,}314\ gpm = 1{,}995\ gpm$$

The remaining containment spray flow rate of (2,314 gpm – 1,995 gpm) 319 gpm would be delivered to the refueling canal. The refueling canal is divided into levels as shown below in Figure 1.8.2. Level 1 is the highest level around the reactor vessel head, level 2 lies below level 1, and level 3 below level 2. All of the debris and water landing on level 1 has the potential to either wash down the side of the reactor (to Sump A), or down to level 2. Any spray flow arriving in level 2 or 3 remains trapped in place (an inactive cavity).

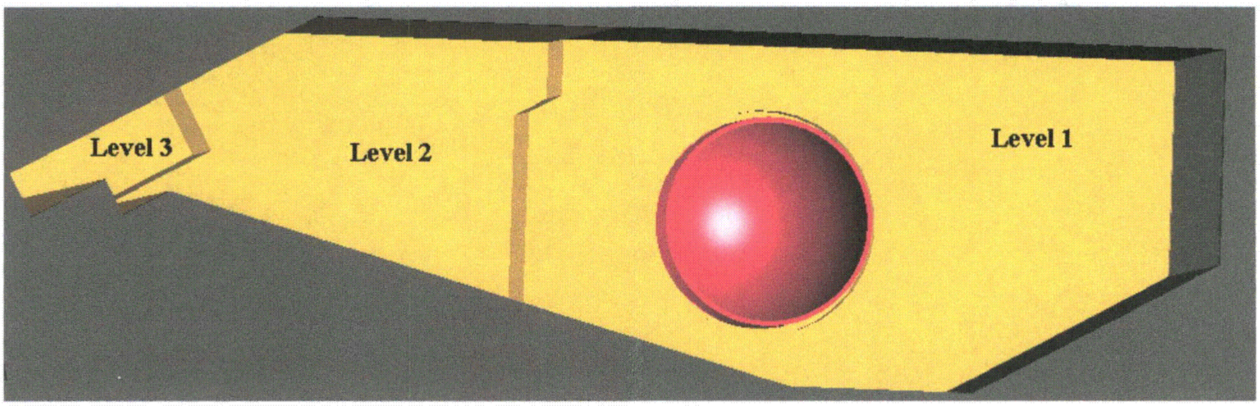


Figure 1.8.2 – Reactor cavity levels

Level 1 has a total area of 787 ft^2 (Figure 1.8.3) out of the total refueling canal area of 1,194 ft^2.

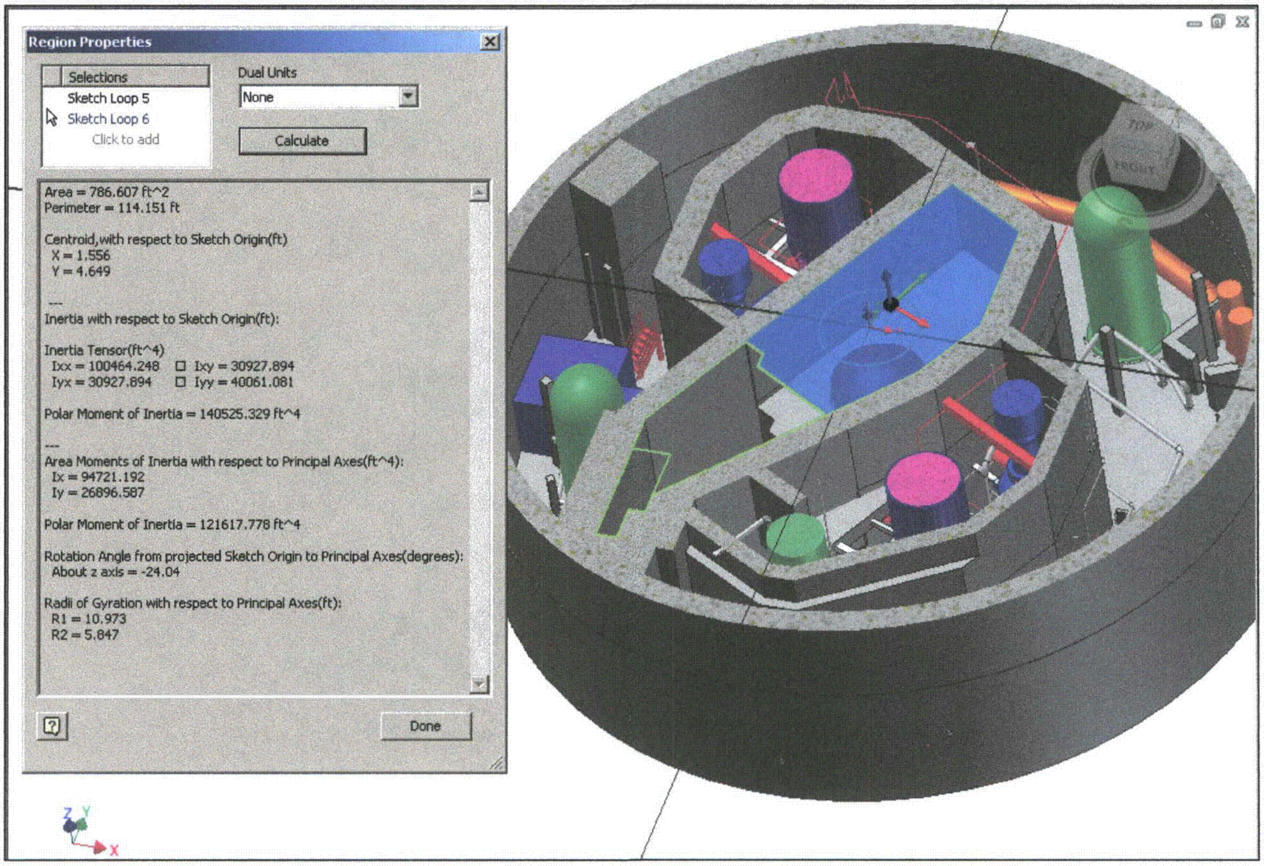


Figure 1.8.3 – Reactor Cavity Level 1

The water and debris in level 1 of the refueling canal has two locations that it can flow to. It can flow down the side of the reactor vessel (which has a total perimeter of 44 ft, Figure 1.8.4) to Sump A or past the reactor vessel down to level 2 (which has a perimeter of 39 ft, Figure 1.8.5) as shown in Figure 1.8.2.

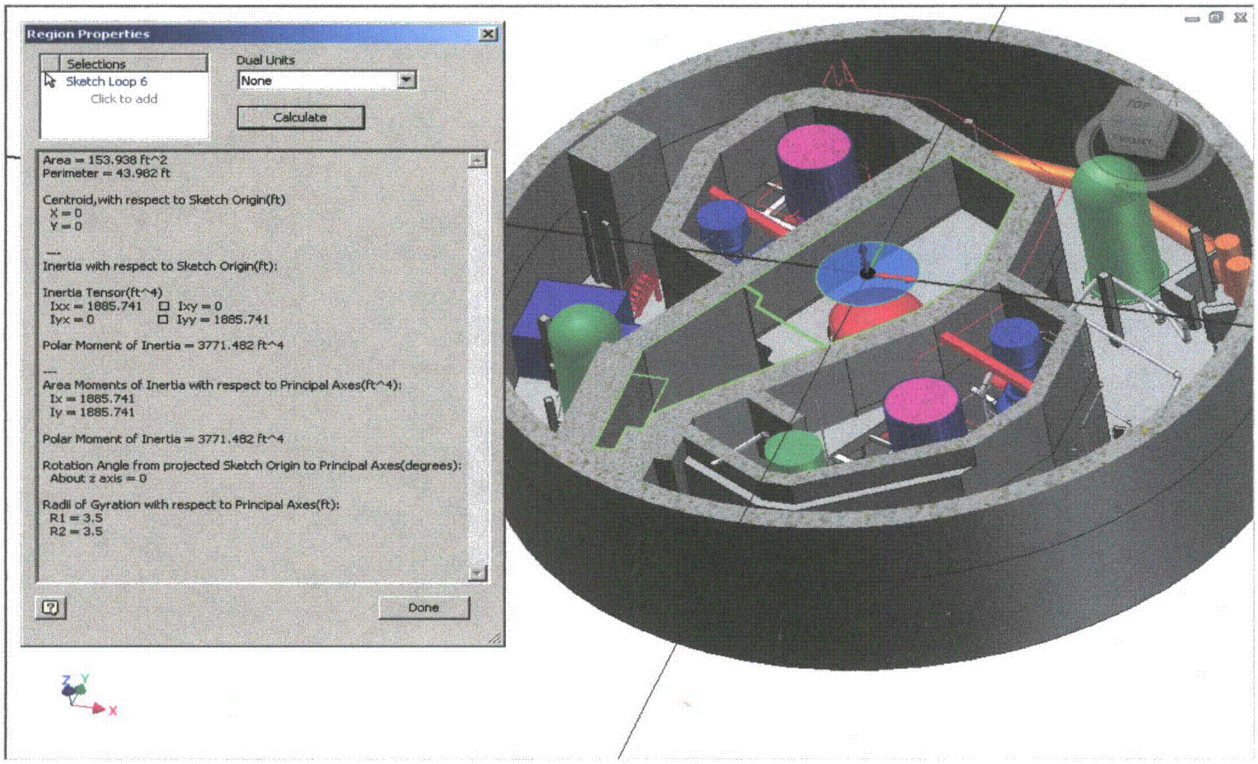


Figure 1.8.4 – Reactor head perimeter

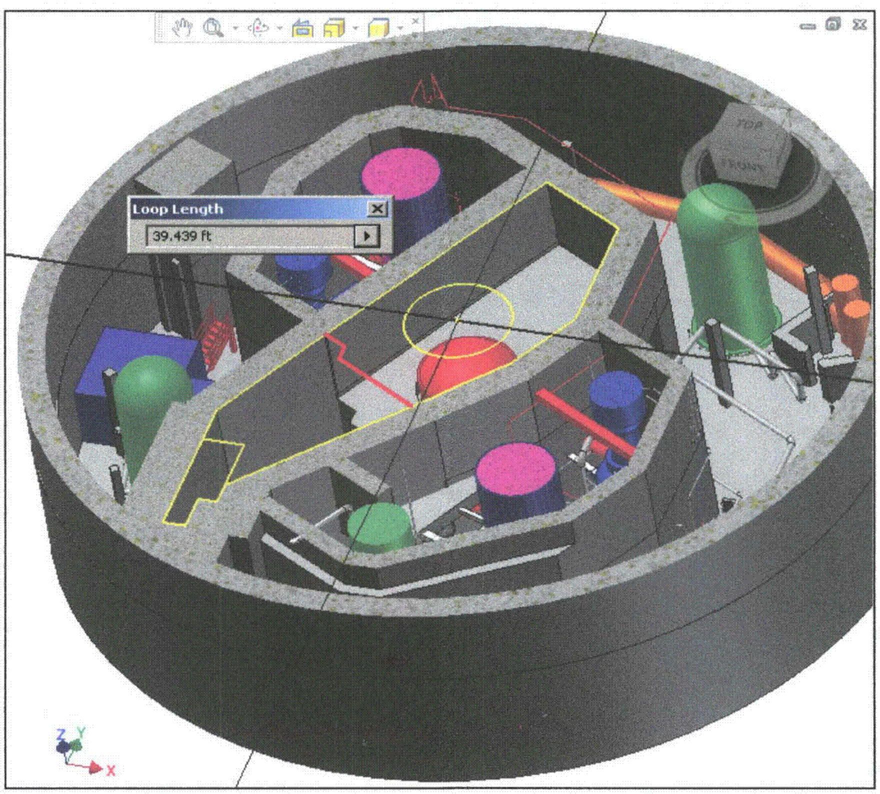


Figure 1.8.5 – Level 1 to Level 2 "wall" length

Using a ratio of perimeters [44 ft / (44 ft + 39 ft)], 53% would travel down the sides of the reactor vessel to Sump A and 47% would travel down to level 2 of the refueling canal.

With this flow split determined, the split of refueling canal spray flow can be split between the inactive cavity (Sump A) and the inactive portion of the refueling canal. The flow to Sump A can be calculated as follows:

$$(787 \text{ ft}^2 / 1{,}194 \text{ ft}^2) \times 53\% \times 319 \text{ gpm} = 111 \text{ gpm}$$

The remaining 208 gpm (319 gpm - 111 gpm) of the spray flow to the refueling canal would travel to the inactive portion of the refueling canal.

With the flow rate from the pool and refueling canal to Sump A and the flow rate from the refueling canal to the inactive portion of the refueling canal known, the fill rate over time can be determined.

The total flow rate to the active pool is (2,167 gpm + 1,995 gpm) 4,162 gpm. This yields a 6" active pool fill time of (23,144 gal / 4,162 gpm) 5.6 minutes.

While the active pool is filling, the spray flow would contribute 622 gallons (111 gpm x 5.6 min) to Sump A and 1,165 gpm (208 gpm x 5.6 min) to the inactive refueling cavity.

At the 5.6 minute mark, the pool would begin to fill Sump A and the recirculation sump (Sump B) while the refueling canal portion of the containment sprays would continue to fill Sump A and the inactive refueling canal. Sump A has a total volume of 6,020 ft^3 (45,033 gallons) and the recirculation sump (Sump B) has a volume of 992 ft^3 (7,421 gallons) [4]. Both would be filled at the same time by the pool flow as they both have a 6" curb.

The recirculation sump would be filled by the pool in [7,421 gal / (4,162 gpm / 2)] 3.6 minutes. During this time frame, Sump A would have been filled with [((4,162 gpm / 2) + 111 gpm) x 3.6 min)] 7,891 gallons of water and the inactive portion of the refueling canal would have been filled with (208 gpm x 3.6 min) 749 gallons of water.

To summarize briefly; after 9.2 minutes (5.6 min + 3.6 min), the inactive portion of the refueling canal would contain (208 gpm x 9.2 min) 1,914 gallons of spray water, Sump A would contain (7,891 gal + 622 gal) 8,513 gal and Sump B would be completely filled.

Sump A would have a remaining free volume of (45,033 gal – 8,513 gal) 36,520 gallons. This volume would take [36,520 gal / (111 gpm + 4,162 gpm)] 8.5 minutes to fill, for a total time of 17.7 minutes (8.5 min + 9.2 min). Up to this point, Sump A would contain [((4,162 gal / 2) x 3.6 min) + (4,162 gal x 8.5 min)] 42,869 gallons of water from the containment pool and (17.7 min x 111 gpm) 1,965 gallons from the refueling canal. Also during this time, the inactive portion of the refueling canal would contain a total of [1,914 gal + (8.5 min x 208 gpm)] 3,682 gallons of water. Up to the 17.7 minute mark, any debris that carried into Sump A, either from the refueling canal or from the pool fill, would be trapped in the Sump.

Over the next (57.56 min – 17.7 min) 39.9 minutes, the inactive portion of the refueling canal would fill with (39.9 min x 208 gpm) 8,299 gallons of water, for a total holdup of (8,299 gal + 3,682 gal) 11,981 gallons.

Also over the next 39.9 minutes, a total of (111 gpm x 39.9 min) 4,429 gallons of water would travel down the sides of the reactor vessel into Sump A and "push" water through the cavity into the pool. Large and small piece debris within the cavity would have already settled to the floor and this extremely low flow rate (111 gpm) would not be high enough to pull this settled debris off the reactor cavity floor and out into the active pool. However, the transport of fines should be evaluated.

Table 1.8.1 shows the blowdown fraction of the various debris types to upper containment. This was the bounding case as it had the greatest quantity of Cal-Sil/asbestos and fiberglass.

Table 1.8.1 – Blowdown fractions of debris to upper containment

Debris Type	Fines
Cal-Sil with Asbestos	89%
Temp-Mat	89%
Thermal-Wrap	89%
Phenolic Paint (inside ZOI)	89%
IOZ Paint (inside ZOI)	89%

As previously calculated, 319 gpm of the 2,314 gpm of spray flow (14%) goes directly into the refueling canal. Since the debris blown to upper containment was assumed to be spread across containment at the operating deck elevation, 14% of the fine debris was also assumed to land in the refueling canal. Table 1.8.2 tabulates the quantity of debris that would transport to the refueling canal.

Table 1.8.2 – Quantity of debris in the refueling canal

Debris Type	Fines
Cal-Sil with Asbestos	89% x 14%
Temp-Mat	89% x 14%
Thermal-Wrap	89% x 14%
Phenolic Paint (inside ZOI)	89% x 14%
IOZ Paint (inside ZOI)	89% x 14%

The debris in the refueling canal could land on one of three levels (see Figure 1.8.2). Debris landing on level 1 could either wash down the reactor vessel toward inactive Sump A or to the inactive portion of the refueling canal. Note that no debris is conservatively assumed to remain on the level 1 floor. Debris landing on level 2 or level 3 would remain in the inactive refueling cavity. The fraction of water and debris that would wash down to the Sump A inactive cavity was previously calculated to be 111 gpm out of 319 gpm, or 35%. The quantity of debris blown to the refueling canal that would be washed down to the Sump A inactive cavity is shown below in Table 1.8.3.

Table 1.8.3 – Fraction of debris in the refueling canal washed to Sump A

Debris Type	Fines
Cal-Sil with Asbestos	89% x 14% x 35%
Temp-Mat	89% x 14% x 35%
Thermal-Wrap	89% x 14% x 35%
Phenolic Paint (inside ZOI)	89% x 14% x 35%
IOZ Paint (inside ZOI)	89% x 14% x 35%

In a similar manner, the transport fraction for fines in lower containment transported to inactive cavities is shown below in Table 1.8.4.

Table 1.8.4 – Fraction of debris in lower containment washed to Sump A

Debris Type	Fines
Cal-Sil with Asbestos	11% x 42%
Temp-Mat	11% x 42%
Thermal-Wrap	11% x 42%
Phenolic Paint (inside ZOI)	11% x 42%
IOZ Paint (inside ZOI)	11% x 42%

Again, Sump A has a free volume of 45,033 gal. After the Sump A had filled, a total of (111 gpm x 39.9 min) 4,429 gallons of water was previously calculated to travel down the sides of the reactor vessel into Sump A and "push" water through the cavity into the pool.

Since the fine debris would transport from the refueling canal with the initial flow of spray water, the water entering the reactor cavity after it has filled would be essentially clean. Although it would take some time, the fine debris would tend to settle to the bottom of the reactor cavity. Note that the bottom of the reactor cavity is approximately 26 ft. below the containment elevation [9]. Given the low flow rate and the large volume of the reactor cavity, most of the cavity would be unaffected as water drains down the sides of the reactor vessel and flows to the containment pool through Sump A. Therefore, it is reasonable to assume that a negligible quantity of debris would wash out of the reactor cavity into the pool.

However, even if the fines are conservatively assumed to remain in uniform suspension in the reactor cavity, the increase in the overall transport fraction would be very small. The following calculation shows the fraction of fine debris washed out of the reactor cavity based on this assumption, and Table 1.8.5 shows that the overall fines transport fraction would increase by less than 1%.

$$F = 1 - e \wedge (-V_{Water} / V_{Cavity})$$
$$F = 1 - e \wedge (-4{,}429 / 45{,}033) = 9\%$$

Table 1.8.5 – Maximum fraction of debris from Sump A back to active pool

Debris Type	Fines
Cal-Sil with Asbestos	9% * (89% x 14% x 35% + 11% x 42%) = 0.8%
Temp-Mat	9% * (89% x 14% x 35% + 11% x 42%) = 0.8%
Thermal-Wrap	9% * (89% x 14% x 35% + 11% x 42%) = 0.8%
Phenolic Paint (inside ZOI)	9% * (89% x 14% x 35% + 11% x 42%) = 0.8%
IOZ Paint (inside ZOI)	9% * (89% x 14% x 35% + 11% x 42%) = 0.8%

To ensure conservatism, the debris transport calculation will be revised to incorporate the potential for 0.8% of the fine debris to wash out of the reactor cavity and transport to the ECCS sump strainer.

1.9 RAI Question #3.7

The June 2, 2009, supplemental response discusses crediting the settlement of fine debris (fiberglass and inorganic zinc fines). It appears that values in a range of approximately 7–59% of the total quantities of fine fiberglass and zinc powder were assumed to settle during recirculation for certain cases, although the supplemental response does not explicitly quantify the credit taken. Please state the quantities of fine debris assumed to settle onto the containment floor or other areas of containment. In addition, technical justification is needed regarding the following points: (1) lack of experimental benchmarking of analytically derived turbulent kinetic energy metrics; (2) uncertainties in the predictive capabilities of turbulent kinetic energy models in computational fluid dynamics codes, particularly at the low turbulent kinetic energy levels necessary to suspend individual fibers and 10-micron particulate; (3) the basis for analytical prediction of settling velocities in quiescent and non-quiescent water due to the specification of shape factors and drag coefficients for irregularly shaped debris; and (4) the basis for the theoretical correlation of the terminal settling velocity to turbulent kinetic energy that underlies the methodology for fine debris settling. Please address these points to demonstrate that the credit taken for fine debris settling is technically justified.

Response

The credit for fine debris settling in the recirculation pool is shown in Table 1.9.1 for a break in Compartment B. The settling values are equal to 100% minus the recirculation transport fractions for these debris types [5]. The only credit taken for fines settling was Temp-Mat and Thermal-Wrap fibers, and IOZ coatings debris. The transport fractions for a Compartment B break are relatively low due to the fact that the break location is in the vicinity of the sump strainer. Since there are no containment sprays in operation during recirculation, the rest of the pool is essentially stagnant.

Table 1.9.1 – Fraction of fine debris settling in recirculation pool for a Compartment B break

Debris Type	Recirculation Pool Fines Settling Fraction
Cal-Sil with Asbestos	0%
Temp-Mat	73%
Thermal-Wrap	73%
Phenolic Paint (inside ZOI)	0%
IOZ Paint (inside ZOI)	58%
IOZ Paint (outside ZOI)	58%
Dirt/Dust	0%
Latent Fiber	0%

Response to Part 1

The analytically derived transport metric for TKE required to suspend debris is based on the definition of TKE:

$$TKE = \frac{1}{2}\overline{u_i u_i}$$ Equation 1

$$TKE = \frac{1}{2}\overline{u^2} = \frac{1}{2}\left(\overline{u_1^2 + u_2^2 + u_3^2}\right)$$ Equation 2

where:

- the over-bar denotes time averaging,
- u_i (a vector) is the fluctuating part of velocity (as opposed to the mean part),
- $u_i u_i$ is a vector inner product,
- u_1 and u_2 are taken to be the horizontal components of the velocity fluctuation,
- u_3 is taken to be the vertical component of the velocity fluctuation

Since the horizontal velocity fluctuations would have no effect on debris settling, only the vertical velocity fluctuations, u_3, would affect whether debris is kept in suspension or settles to the floor. Since there is no reason to suspect that velocity fluctuations in a containment pool are greater in one direction than another, Equation 2 can be simplified and related to the debris settling velocity, V_T, as follows:

$$TKE = \frac{1}{2}3 \cdot u_3^2 = \frac{3}{2}V_T^2$$ Equation 3

This is a conservative estimate of the TKE required to keep debris in suspension since it neglects the fact that only the upward velocity fluctuations will inhibit settling whereas the downward fluctuations would enhance settling. Although there is very little data available on the turbulence required to keep debris in suspension, NEI 04-07 provides one TKE metric that is not calculated based on the setting velocity for ¼" × ¼" clumps of fiberglass. The reported minimum TKE required to keep the clumps of fiber in suspension is 0.14 ft^2/s^2 (see Table 4-2 of NEI 04-07) [8]. Plugging the reported settling velocity of 0.175 ft/s [8] into Equation 3 yields a calculated TKE of 0.046 ft^2/s^2, which is less than $1/3^{rd}$ of the measured value.

Response to Part 2

Uncertainties in the capabilities of CFD software to accurately predict low levels of turbulent kinetic energy is a valid concern since it is challenging to accurately model turbulence. However, this was taken into consideration in the Ginna debris transport analysis. The regions where fine debris were assumed to settle were conservatively selected within the bounds of the low TKE regions rather than using the exact boundary defined by the TKE metric. The recirculation pool at Ginna is different from most PWRs, since containment sprays are secured at the beginning of recirculation. Since the containment sprays are not active, regions of the pool that are outside the path from the break location to the sump strainers are essentially stagnant, which provides a good opportunity for fine debris to settle to the floor.

Response to Part 3

The shape factor is an important factor in determining the settling velocity for fine debris. The settling velocity used in the Ginna debris transport calculation for fiberglass fines was taken from NUREG/CR-6808. The settling velocity for particulate debris was calculated based on a spherical shape factor. Although particles would not necessarily be perfectly spherical, the assumed size for the particulate (10 microns for coatings and 5 microns for Cal-Sil) is based on a conservatively small characterization of this debris. Since the size has a much greater affect on settling than non-uniformities in the shape, the settling velocity that is calculated based on Stokes' Law is a reasonably conservative method. Note also that the settling velocity was calculated at 120°F, and the viscosity of water is lower at higher temperatures, the particulate debris would be even more likely to settle at the beginning of recirculation when the pool is much hotter.

Response to Part 4

See response to Part 1.

Due to the difficulty in performing the benchmark testing suggested in this RAI, and the limited time available to accomplish this testing, Ginna will revise the debris transport analysis to remove credit for any fine debris settling in the recirculation pool.

RAI 3.7 Response Summary

As discussed in the above responses, it is expected that a significant quantity of fine fiberglass and coatings debris would settle in quiescent regions of the recirculation pool. However, in the interest of expediting resolution of the NRC's concerns, the debris transport analysis will be revised to remove credit for any fine debris settling in the recirculation pool. This approach will significantly increase the overall conservatism in the debris transport analysis.

1.10 RAI Question #3.8

It appeared from the June 2, 2009, supplemental response that the same debris transport metrics used for Thermal Wrap may have been applied to Temp-Mat as well. Please confirm this statement or provide the transport metrics used for Temp-Mat.

Response

All Temp-Mat large and small pieces in the active recirculation pool were assumed to float and therefore transport in unity (100%). The only transport metric that was the same for Temp-Mat and Thermal-Wrap was the TKE required to keep individual Temp-Mat and Thermal-Wrap fibers in suspension [5].

1.11 RAI Question #14

The clean strainer head loss calculation was apparently conducted at 195 °F. It is likely that the clean strainer head loss at lower temperatures would be higher. The licensee should verify that the head loss evaluation considers the potential for higher clean strainer head loss later in the event when the sump temperature is likely to be colder.

The round 2 review also identified a number of new issues. The staff identified the following additional issues that should be answered in order to assure that the licensee's head loss evaluation was conducted conservatively:

1. The licensee should perform a deaeration evaluation to ensure that any gasses liberated from the sump fluid as it passes through the debris bed are considered. If deaeration occurs, the effects on net positive suction head (NPSH) required should be evaluated as described in Regulatory Guide 1.82, Rev. 3, Appendix A.

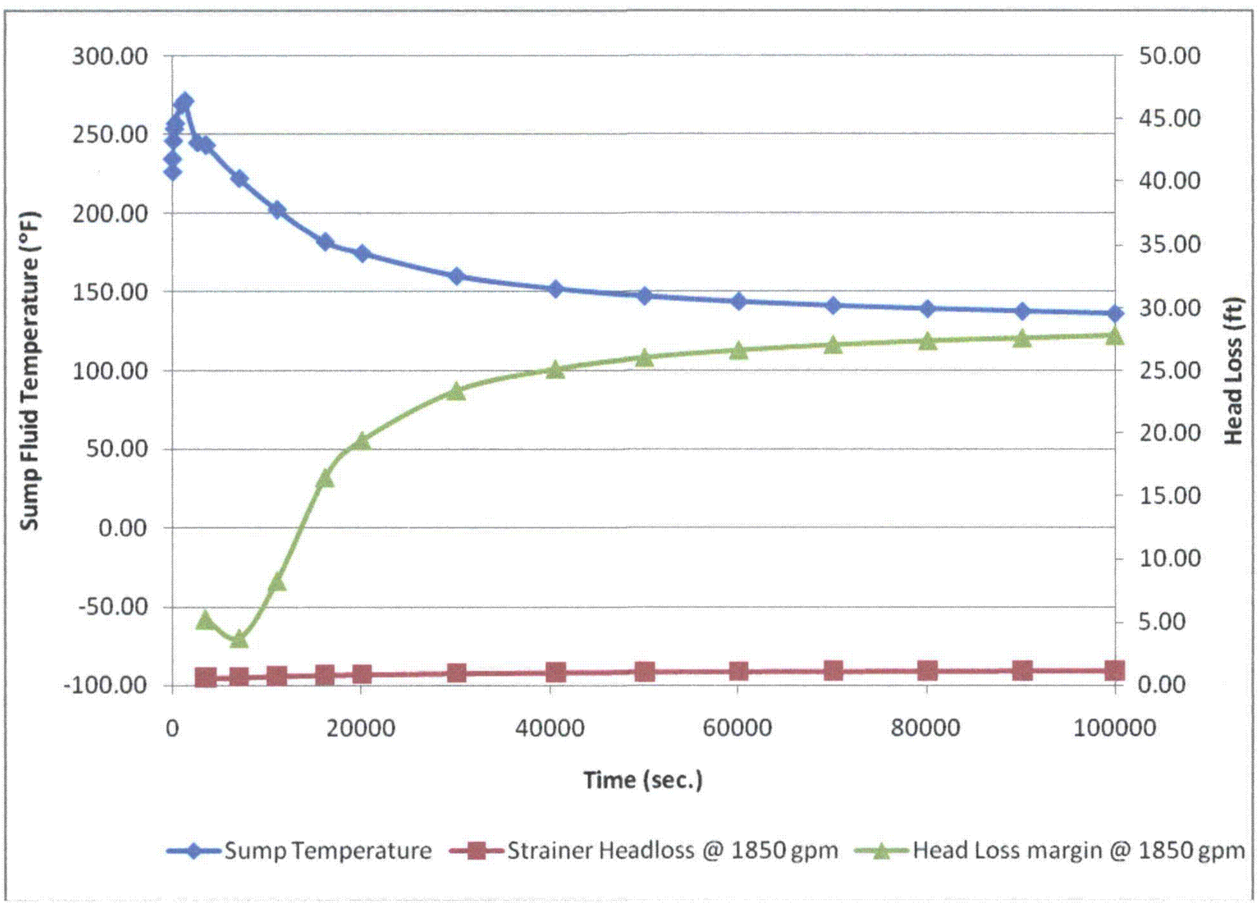
2. The supplemental response provided a debris head loss value stated to be 0.99 feet when corrected to a "minimum sump temperature" of 195 °F. It was not clear what head loss value was applied at colder sump temperatures that would occur later in the event or whether the value was corrected further for hotter conditions. The staff did not understand what was meant by "minimum sump temperature" as used in this context. The licensee should either calculate the head loss at the minimum sump temperature predicted for the event and apply this value to the NPSH margin calculation, or provide a time/temperature dependent NPSH margin evaluation that justifies that adequate NPSH margin is available for all pumps taking suction from the containment sump for the plant's potential range of post-LOCA conditions.

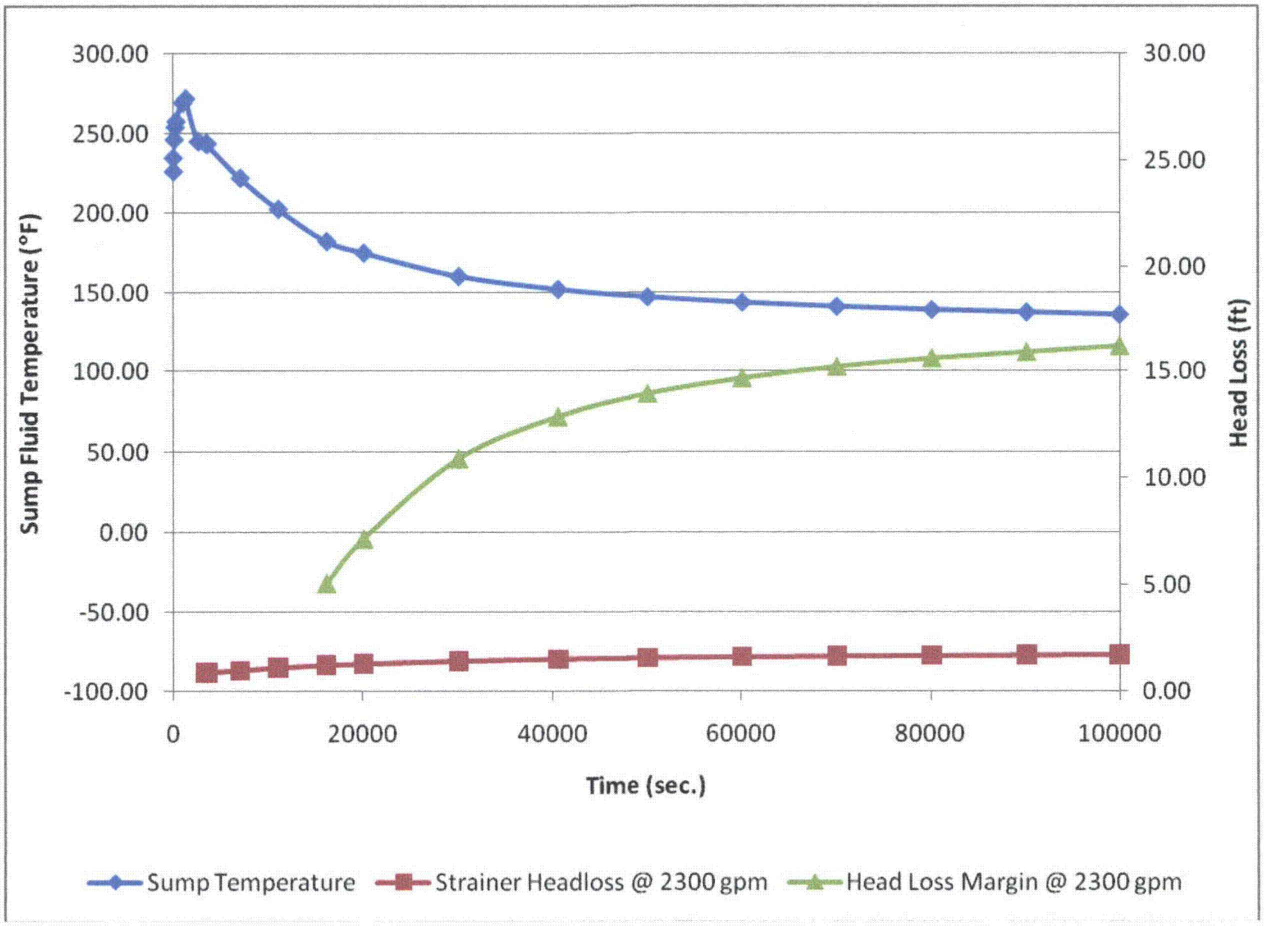
3. The supplemental response stated that calcium silicate (Cal-Sil) dust and zinc dust were used as a surrogate for Cal-Sil. Approximately 20% by weight of the Cal-Sil was replaced with zinc. The supplemental response did not provide the reason for the partial substitution of Cal-Sil with zinc. The substitution was potentially non-conservative from a head loss testing perspective because Cal-Sil has been shown to be particularly detrimental to strainer head loss. In addition, the zinc powder is likely more dense than Cal-Sil powder. A substitution based on mass without correction for

the density difference would result in a reduced volume of debris during the head loss test. Volume is a more important factor than mass when considering debris bed characteristics.

Response to RAI Question #14

The clean strainer head loss was determined through head loss testing. It was determined to be 0 mbar at the scaled equivalent of 2300 gpm and approximately 65 °F [7]. The sump strainer connecting ducts and channel head loss was determined by calculation to be 3.91 mbar (0.131 ft) at the scaled equivalent of 2300 gpm and 195 °F [7]. The following sump strainer head loss curves, as a function of sump fluid temperature, for two flow rates, include the clean strainer head loss, the head loss due to full debris load, and the head loss due to connecting ducts and channels. The two flow rates depicted bound the large break and small break sump recirculation flow cases (1850 gpm), and the long term recirculation to prevent boron precipitation (2300 gpm). Overlaid on each curve is the RHR pump NPSH margin for that case. As shown below, the rate of increase in NPSH margin is greater than the increase in strainer head loss, as sump fluid temperature decreases. This results in greater NPSH margin later in the event.





The above information reflects strainer head loss testing performed to date. As a result of the responses to RAIs 3.3 and 3.7, Ginna will revise the debris transport analysis and re-perform strainer head loss testing. This will likely cause the details of the above response to change. Once the re-performance of strainer head loss testing is complete, an updated response will be provided.

Response to 14.1

A deaeration calculation of the Ginna sump recirculation pool fluid was performed to ensure that the quantity of dissolved air in the fluid, when released as a result of the pressure drop across the sump strainer, does not adversely affect the ECCS pump performance. The deaeration calculation was performed at a strainer head loss nearly twice the current strainer head loss. It also assumes the most conservative design inputs with respect to containment recirculation pool level and temperature, and containment pressure and temperature. It does not credit the affects of the delayed onset of chemical precipitant formation on strainer head loss. The calculation determines the average void fraction along the depth of the strainer face for a wide range of temperatures. The calculation determined that the largest void fraction downstream of the sump strainer is 0.08%. This value is below the 3% void fraction limit identified in Attachment V-I of Appendix V of the SER on NEI-04-07, and is below the 2% void fraction identified in RG 1.82. Since the void fraction is very small, its impact on pump performance is insignificant. This is supported by conclusions drawn in NUREG/CR-2792 and RG 1.82. Both documents state that a void fraction less than 2% would result in negligible degradation of pump performance.

Both NUREG/CR-2792 and RG 1.82 specify the use of an arbitrary relationship for increasing $NPSH_R$ for void fractions less than 2%. The relationship, ($NPSH_{air/water} = NPSH_{water} (1 + 0.5 AF)$, where AF is the air volume fraction in percent), applies a substantial $NPSH_R$ penalty and is recognized as a conservative application to ensure the pumps operate as designed. However, ANSI/HI publications state that small amounts of entrained air would not result in significant increases in $NPSH_R$. The level of void fraction at which impacts to $NPSH_R$ become significant is not defined. Examination of the impact that the $NPSH_R$ penalty would have on the Ginna RHR pumps' $NPSH_R$ indicate that it would be insignificant. The deaeration calculation determined that the void fraction downstream of the sump strainer ranges from 0.007 to 0.08%, depending on fluid temperature. The largest void fractions occur at lower temperatures. The increase in void fractions, as temperature decreases, coincides with increasing pump NPSH margin. For example, at the most limiting conditions (i.e., SBLOCA at 212 °F), with respect to NPSH margin, the NPSH penalty would account for a 3/8" increase in $NPSH_R$. Given the conservative nature of the NPSH penalty, as well as, the conservatisms applied in the calculation of the void fractions, this is deemed insignificant. At lower temperatures, where NPSH margin is significantly greater, the relative impact on $NPSH_R$ is less.

Response to 14.2

The sump strainer head loss of 0.99 ft (29.7 mbar) is the head loss due to the clean strainer and full debris load, including chemical effects, at 195 °F. It does not include the added head loss from the sump strainer internal connecting ducts and channels. The head loss due to sump strainer internal connecting ducts and channels results is an additional 0.131 ft of head loss at 195 °F.

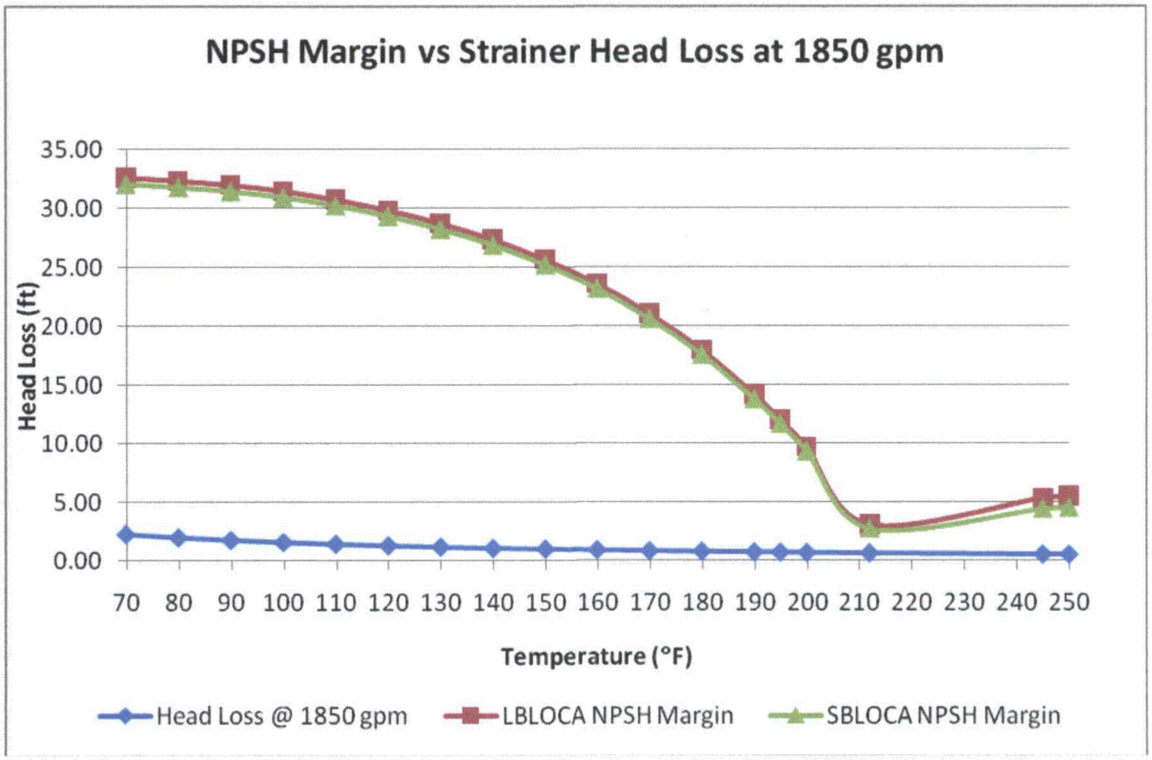
The sump strainer procurement specification required the testing of the sump strainers at bounding conditions, reflective of the large break and small break sump recirculation flow cases (1850 gpm at 245 °F), and the long term recirculation to prevent boron precipitation (2300 gpm at 195 °F). The long term recirculation at the higher flow rate is not required until approximately 4.5 hours into the event, when sump fluid temperature is less than 195 °F (182.35 °F). Therefore, the lowest temperature at which the test results were to be evaluated for direct comparison to the ECCS pump NPSH calculation is 195 °F. Hence, the sump strainer head loss was corrected to the "minimum sump temperature" of 195 °F, per the specification.

The sump strainer full debris head loss, as a function of recirculation pool temperature, is provided below for the two bounding flow rates. Overlaid on each curve is the RHR pump NPSH margin for that case. As shown, the most limiting condition with respect to RHR pump NPSH margin is at higher temperatures. For the bounding small and large break cases, at a bounding flow rate of 1850 gpm, the worst case NPSH margin is 2.74 ft. The corresponding strainer head loss is 0.68 ft. Similarly, for the bounding long term recirculation case, at the bounding flow rate of 2300 gpm and 182.35 °F, the NPSH margin is 5.09 ft. The corresponding sump strainer head loss is 1.16 ft. A temperature of 182.35 °F bounds the sump fluid temperature 4.5 hours into the event, when long term recirculation to prevent boron precipitation starts.

The above information reflects strainer head loss testing performed to date. As a result of the responses to RAIs 3.3 and 3.7, Ginna will revise the debris transport analysis and re-perform strainer head loss testing. This will likely cause the details of the above response to change. Once the re-performance of strainer head loss testing is complete, an updated response will be provided.

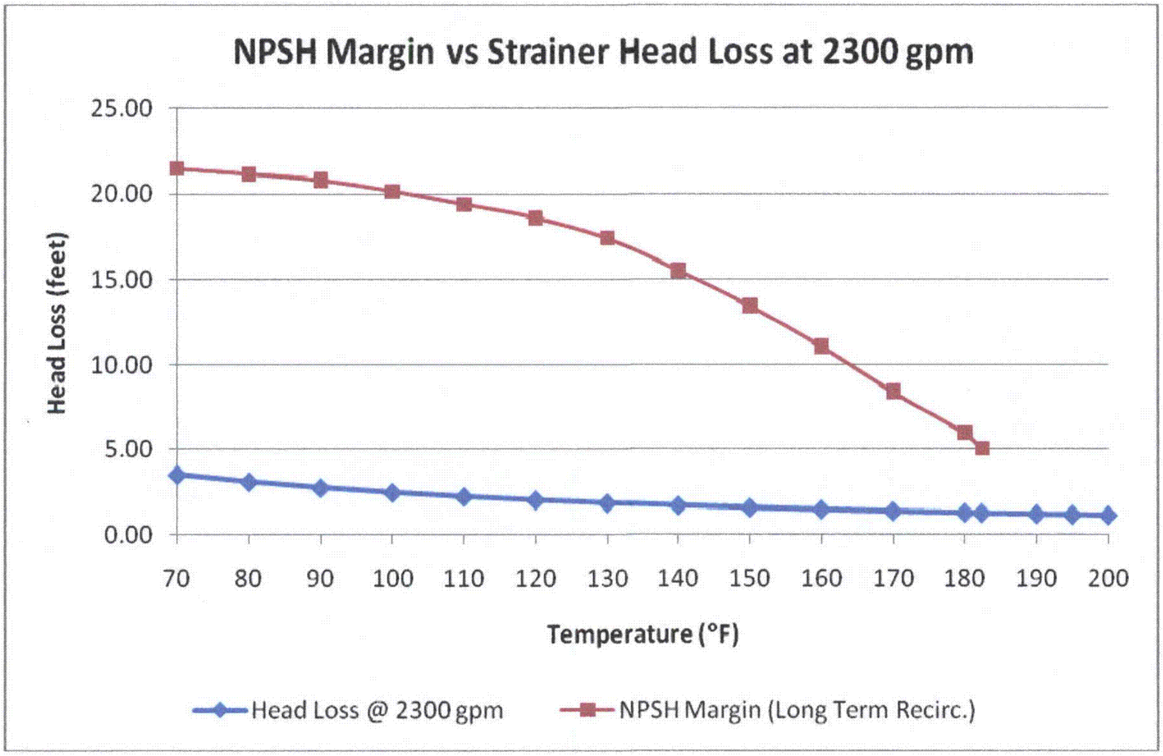
NPSH Margin vs Strainer Head loss at 1850 gpm

T	Dynamic Viscosity	Debris Headloss	Channel Headloss	Total Headloss	Total Headloss	Density	Total Headloss	LBLOCA NPSH (Margin)	SBLOCA NPSH (Margin)
°F	lbm/ft-s	mbar	mbar	mbar	psi	lbm/ft3	ft		
68	6.73E-04	61.59	8.11	69.71	1.01	62.32	2.34	32.58	32.08
70	6.55E-04	59.95	7.90	67.85	0.98	62.31	2.27	32.54	32.03
80	5.76E-04	52.72	6.95	59.67	0.87	62.22	2.00	32.26	31.75
90	5.12E-04	46.80	6.17	52.97	0.77	62.12	1.78	31.90	31.40
100	4.58E-04	41.89	5.52	47.41	0.69	62.00	1.60	31.39	30.90
110	4.13E-04	37.76	4.97	42.74	0.62	61.86	1.44	30.66	30.20
120	3.75E-04	34.26	4.51	38.78	0.56	61.71	1.31	29.76	29.30
130	3.42E-04	31.27	4.12	35.39	0.51	61.55	1.20	28.66	28.22
140	3.14E-04	28.68	3.78	32.46	0.47	61.38	1.10	27.3	26.87
150	2.89E-04	26.43	3.48	29.91	0.43	61.19	1.02	25.61	25.19
160	2.67E-04	24.46	3.22	27.68	0.40	61.00	0.95	23.56	23.15
170	2.48E-04	22.72	2.99	25.72	0.37	60.79	0.88	21.01	20.61
180	2.32E-04	21.19	2.79	23.98	0.35	60.57	0.83	17.93	17.54
190	2.17E-04	19.83	2.61	22.44	0.33	60.34	0.78	14.18	13.8
195	2.10E-04	19.20	2.53	21.73	0.32	60.23	0.75	12.03	11.66
200	2.03E-04	18.61	2.45	21.06	0.31	60.11	0.73	9.67	9.31
212	1.89E-04	17.31	2.28	19.60	0.28	59.81	0.68	3.10	2.74
245	1.58E-04	14.47	1.91	16.38	0.24	58.94	0.58	5.36	4.43
250	1.54E-04	14.12	1.86	15.98	0.23	58.80	0.57	5.48	4.55


NPSH Margin vs Strainer Head Loss at 1850 gpm
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Head Loss (ft)
70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250
Temperature (°F)
Head Loss @ 1850 gpm
LBLOCA NPSH Margin
SBLOCA NPSH Margin

NPSH Margin vs Strainer Head loss at 2300 gpm

	T °F	Dynamic Viscosity lbm/ft-s	Debris Headloss mbar	Channel Headloss mbar	Total Headloss mbar	Total Headloss psi	Density lbm/ft3	Total Headloss ft	NPSH Margin ft
Test	68	6.73E-04	95.20	12.54	107.74	1.56	62.32	3.61	21.48
Data	195	2.10E-04	29.68	3.91	33.59	0.49	60.23	1.16	
	70	6.55E-04	92.67	12.21	104.87	1.52	62.31	3.52	21.43
	80	5.76E-04	81.49	10.73	92.22	1.34	62.22	3.10	21.13
	90	5.12E-04	72.34	9.53	81.87	1.19	62.12	2.75	20.78
	100	4.58E-04	64.75	8.53	73.28	1.06	62.00	2.47	20.15
	110	4.13E-04	58.37	7.69	66.06	0.96	61.86	2.23	19.38
	120	3.75E-04	52.96	6.98	59.94	0.87	61.71	2.03	18.60
	130	3.42E-04	48.33	6.37	54.69	0.79	61.55	1.86	17.41
	140	3.14E-04	44.33	5.84	50.17	0.73	61.38	1.71	15.55
	150	2.89E-04	40.85	5.38	46.23	0.67	61.19	1.58	13.47
	160	2.67E-04	37.80	4.98	42.78	0.62	61.00	1.46	11.07
	170	2.48E-04	35.12	4.63	39.75	0.58	60.79	1.37	8.43
	180	2.32E-04	32.76	4.31	37.07	0.54	60.57	1.28	6.00
	182.35	2.28E-04	32.24	4.25	36.48	0.53	60.51	1.26	5.09
	190	2.17E-04	30.65	4.04	34.68	0.50	60.34	1.20	
	195	2.10E-04	29.68	3.91	33.59	0.49	60.23	1.16	
	200	2.03E-04	28.77	3.79	32.56	0.47	60.11	1.13	


NPSH Margin vs Strainer Head Loss at 2300 gpm
Head Loss (feet)
25.00
20.00
15.00
10.00
5.00
0.00
70
80
90
100
110
120
130
140
150
160
170
180
190
200
Temperature (°F)
Head Loss @ 2300 gpm
NPSH Margin (Long Term Recirc.)

Response to 14.3

Sump strainer head loss testing with full debris load, including chemical effects, was completed in March 2008. Since then, debris transport analysis refinements have resulted in Cal-Sil fines transported to the sump strainer increasing, exceeding the quantity used during strainer head loss testing. Since the quantity of zinc dust used during testing, as a surrogate for inorganic zinc (IOZ) fines was conservatively taken as four times that required to account for IOZ, a portion of the excess zinc dust is being credited as a surrogate for the required quantity of Cal-Sil. This was done to preclude the need to undergo additional testing, where it is felt that the resulting head loss would be the same.

The quantity of zinc dust required to serve as a surrogate for Cal-Sil is determined by proportioning the quantity of required Cal-Sil by the ratio of their densities (223 lb/ft^3 / 144 lb/ft^3). As a result, there is more excess zinc dust used in the head loss testing than is required to serve as a surrogate for Cal-Sil.

As a result of the responses to RAIs 3.3 and 3.7, Ginna will revise the debris transport analysis and re-perform strainer head loss testing. The strainer head loss testing to be performed will use the appropriate quantity of Cal-Sil fines, without crediting a zinc dust surrogate.

1.12 RAI Question #25

The staff requested additional information to support crediting the injection of the accumulators for all break scenarios, including small-break LOCAs. The licensee responded that the potential non-conservatism of assuming accumulator injection for some small-break LOCAs for which injection may not occur (or may not fully occur) is offset by the lack of credit taken for reactor coolant system (RCS) leakage. The staff did not consider this response to be adequate, because there could be small-break LOCAs for which the accumulators may not inject (or may not fully inject), during which flow from the emergency core cooling system (ECCS) would result in refilling the RCS to an extent that could make the licensee's assumption non-conservative. Therefore, please provide a basis for concluding that, for all small-break LOCAs (including breaks at elevated locations such as the pressurizer), the water level in containment will be prototypical or conservative with respect to its importance to strainer submergence, deaeration, and vortexing.

Response

The sump recirculation pool minimum level calculation was revised to address potential non-conservatisms associated with differences in the affects of various LOCA break sizes. The sump recirculation pool minimum level, for each break size, was determined by summing the volume of the various water sources, consistent with the break size, and the volume of containment internal structures; subtracting the volume of the various water hold-ups; and dividing the difference by the surface area of the containment basement floor.

For the large break LOCA, the minimum sump recirculation pool level was determined to be 3.80 ft. The water sources and containment structures included in this calculation are: RWST (88% to 15%), RCS volume (conservatively taken as that lost from the system for a small break), accumulator volume, and concrete walls and structures. The water hold-ups included in this calculation are the volume of the reactor cavity (Sump A), the containment sump (Sump B), the refueling cavity, voided piping in the containment spray and RHR systems, moisture in the containment atmosphere, and condensation on containment surfaces.

For the small to intermediate break LOCAs (≥ 2"), in which containment spray is initiated, the minimum sump recirculation pool level was determined to be 3.39 ft. Breaks of 2", 3" and 4" at the most elevated location, the top of the pressurizer, were analyzed in detail at several key events in the post-accident recovery. The breaks were analyzed: 1) at the start of sump recirculation, 2) when operators would be depressurizing the RCS (if applicable), 3) when the RCS is refilled with water, and 4) when the RCS is refilled and depressurized. The water sources and containment structures included in this calculation are: RWST (88% to 15%), RCS volume, and concrete walls and structures. The water hold-ups included in this calculation are the volume of the reactor cavity (Sump A), the containment sump (Sump B), the refueling cavity, voided piping in the containment spray and RHR systems, moisture in the containment atmosphere, condensation on containment surfaces, and the amount of refilled RCS volume (from the RWST and/or accumulators). The RCS water shrink associated with the cooling and depressurization of the RCS was considered in the refilling of the RCS volume. The most limiting break, which yields the minimum sump recirculation level, was determined to be the 3" break at the point in time after the RCS had completely refilled.

Additional conservatisms in determining the minimum sump recirculation pool level for the limiting break case (3"), beyond that prescribed in NEI 04-07, section 6.4.7.1, include instrument uncertainty in calculating the RWST and accumulator volumes that would contribute to the sump recirculation pool level, include the use of minimum Technical Specification volumes for RWST and accumulators, and do not include the NaOH tank volume.

For the small break LOCA (< 2"), in which containment spray does not initiate, the minimum sump recirculation pool level was determined to be 3.40 ft. The water sources and containment structures included in this calculation are: RWST (88% to 15%), and concrete walls and structures. The water hold-ups included in this calculation are the volume of the reactor cavity (Sump A), the containment sump (Sump B), voided piping in the RHR systems, moisture in the containment atmosphere, condensation on containment surfaces, and the refill volume in RCS.

Therefore, the conservative, minimum containment recirculation pool level, which bounds all break sizes, is 3.39 ft. This value was used in pump NPSH calculations, flashing and vortexing calculations, and deaeration calculations.

2 REFERENCES

1) D.V. Rao, et al., "Drywell Debris Transport Study: Experimental Work", NUREG/CR-6369, Volume 2, September 1999.

2) NUREG/CR-6770, "Thermal-Hydraulic Response of PWR Reactor Coolant System & Containments to Selected Accident Sequences", August 2002.

3) NRC Safety Evaluation Report, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report 'Pressurized Water Reactor Sump Performance Evaluation Methodology'", Revision 0, December 2004.

4) Calculation DA-ME-2005-085, "NPSH for ECCS Pumps During Injection and Sump Recirculation", Revision 2, December 6, 2007.

5) Calculation ALION-CAL-GINNA-4376-03, "Ginna GSI-191 Debris Transport Calculation", Revision 2, May 28, 2009.

6) Calculation ALION-CAL-CONS-3237-02, "Ginna Reactor Building GSI-191 Debris Generation Calculation," Rev. 2

7) 3SA-096.077, "Head Loss Calculation Including Chemical Effects," Rev. 2

8) NEI PWR Sump Performance Task Force Report NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology", Revision 0, December 2004.

9) Drawing 33013-2132, "Plant Arrangement Reactor Containment Structure Section "2-2", Revision 1, October 31, 1991.

10) Marks' Standard Handbook for Mechanical Engineers, 10th Edition, (Tables 6.2.16 and 6.4.2).

11) "Jet Impact Tests—Preliminary Results and Their Applications," N-REP-34320-10000-R00, April 2001.

12) Rochester Gas and Electric Corporation Technical Specification SP-5401, August 22, 1967.

ATTACHMENT 2

List of Regulatory Commitments

ATTACHMENT 2

List of Regulatory Commitments

The following table identified those actions committed to in this document by Ginna LLC. Any other statements in this submittal are provided for informational purposes and are not considered to be regulatory commitments. Direct questions regarding these commitments to Mr. Thomas Harding at (585) 771-5219 or Thomas.HardingJr@cengllc.com

COMMITMENT	COMPLETION DATE
Stainless steel banding will be installed on all calcium silicate (Cal-Sil) insulation within the zone of influence of any limiting break location that meets or exceeds that installed on the test specimen used in the Ontario Power Generation testing. Installation will be completed by the end of the 2012 refueling outage.	November 30, 2012
The debris transport analysis will be revised to: ▪ Remove credit for any small fiberglass debris retention in upper containment ▪ Incorporate the potential for 0.8% fine debris to wash out of the reactor cavity and transport to the ECCS sump strainer ▪ Remove credit for any fine debris settling in the recirculation pool.	July 30, 2010
The strainer head loss testing will be re-performed to: ▪ Include 10% erosion of the debris, determined to be transported to the sump strainer that does not become part of the strainer debris bed, to account for any potential for erosion of the debris pile in front of the face of the strainer ▪ Use appropriate quantity of Cal-Sil fines, without crediting a zinc dust surrogate.	September 30, 2010
An updated response to the NRC will be provided based on the revision of the debris transport analysis and re-performance of the strainer head loss testing.	October 29, 2010