**UNITED STATES**
**NUCLEAR REGULATORY COMMISSION**
**WASHINGTON, D.C. 20555-0001**

August 25, 2009

LICENSEE: INDIANA MICHIGAN POWER COMPANY

FACILITY: DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

SUBJECT: SUMMARY OF AUGUST 12, 2009, CATEGORY 1 PUBLIC MEETING VIA CONFERENCE CALL TO DISCUSS RESPONSES TO GENERIC LETTER 2004-02 REQUESTS FOR ADDITIONAL INFORMATION (TAC NOS. MC4679 AND MC4680)

On August 12, 2009, a Category 1 public meeting was held via conference call between representatives of Indiana Michigan Power Company (the licensee) and the U.S. Nuclear Regulatory Commission (NRC) staff from NRC Headquarters, One White Flint North, 11555 Rockville Pike, Rockville, Maryland. The purpose of the meeting was for the NRC staff to provide the licensee information regarding the proposed response to requests for additional information (RAI) associated with Generic Letter (GL) 2004-02,“ (Agencywide Documents Access and Management System (ADAMS) Accession No. ML091490421).

A list of attendees is provided in Enclosure 1.

The licensee provided draft RAI responses for the meeting (see Enclosure 2).

The meeting was held to allow the NRC staff to inform the licensee which proposed RAI responses appeared adequate, and which responses were either insufficient (i.e., require further explanation or additional detail) or failed to fully address the staff's concern. The licensee and NRC staff discussed the proposed RAI responses. The results of the discussion are provided below.

(1) Questions 28 through 35 are related to VUEZ testing. The licensee is not using VUEZ testing in addressing GL 2004-02; therefore, no response to these questions is required.

(2) The NRC staff determined that the licensee's responses to the following RAIs were adequate, in that the staff did not foresee any significant concerns:

Question 1.a)
Question 1.b)
Question 2.b)
Question 4
Question 7.b)
Question 8
Question 9
Question 10
Question 11
Question 12
Question 15
Question 16.a)
Question 16.c)
Question 18
Question 19.a)
Question 19.b)
Question 20
Question 23.a)
Question 25.a)
Question 25.c)
Question 25.d)

(3) The NRC staff determined that the following RAIs require further staff review prior to having further discussion:

Question 2.a)
Question 3
Question 5
Question 6
Question 21

(4) The licensee will provide additional information to either address specific NRC staff concerns or enhance its response:

Question 6.c): The staff requested the licensee to modify response to better address expected flow distributions in the plant.

Question 7: The licensee stated that the response will be substantially revised and presented in a different format. Also, the licensee stated it will provide a summary of testing and results, including a plot with the short-term test results extrapolated to 30 days.

Question 8: Although the staff considers the response to not be of significant concern, the licensee will provide additional clarification.

Questions 22 and 23.b): The staff does not believe the alkyds argument to be adequate. This is not considered of significant concern, but the licensee was advised to better document its position.

Question 24: The staff stated that more information is required. Specifically, provide a stronger basis for why water level will be lower and/or whether there will be continuous outflow. The argument should demonstrate that there will be no credible flow path for debris through the break and into the vessel.

Question 25.b): The licensee will provide additional information and/or detail showing that the break would be bounded for water level and debris generation.

Question 26: Although the staff considers the response to not be of significant concern, the licensee will provide additional pH information.

Question 27: Although the staff considers the response to not be of significant concern since the chemical additions involved greater than 100 percent of the predicted plant-specific load, the licensee will provide additional information.

(5) The NRC staff informed the licensee that it still had some significant concerns with the following RAI responses:

Question 2.c): The staff does not agree with the application of GDC-4, and requested the use of a different analytical argument.

Questions 5, 6.a), 6.b), 6 (closing paragraph), 13, 14, 16.b), 17 and 21: The staff noted that the complexity of the testing and evaluations resulting from the unique containment design and determining the flow distribution to the main and remote strainers. Since the flow distribution is difficult to represent, additional margins and conservatisms are required. The staff stated that too many unknowns still exist, that there remains some concern whether the current testing methodology is bounding, and that it is difficult to balance the non-conservatisms against the conservatisms. The staff concluded that the resolution of these concerns may be difficult without additional testing and will require further discussion.

Prior to concluding the meeting, it was agreed that an additional conference call will be held to discuss items (3), (4), and (5), above, and to determine if the proposed responses adequately address the staff's concerns or that additional information is still required. This meeting will be held on August 26, 2009.

Members of the public were not in attendance at this meeting.

Please direct any inquiries to me at 301-415-3049, or Terry.Beltz@nrc.gov.

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Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-315 and 50-316

Enclosures:
1. List of Attendees
2. Draft Responses to NRC Requests for Additional Information

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# LIST OF ATTENDEES

## AUGUST 12, 2009, TELECONFERENCE WITH INDIANA MICHIGAN POWER COMPANY TO DISCUSS REQUESTS FOR ADDITIONAL INFORMATION ASSOCIATED WITH GENERIC LETTER 2004-02 FOR THE DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

### NRC

Michael Scott
John Lehning
Matt Yoder
Steve Smith
Paul Klein
Terry Beltz

### Indiana Michigan Power Company

Michael Scarpello
Joe Waters
Paul Leonard

William Knous *
Tim Sande *

* Alion Science & Technology

Enclosure 1

# Enclosure 2

Draft Responses to NRC
Requests for Additional Information

# DRAFT
# Response to June 18, 2009 Request for Additional Information (RAI) To Support August 12, 2009 Teleconference Between Nuclear Regulatory Commission (NRC) And D. C. Cook Nuclear Plant (CNP)

This document contains the following information:

- Attachment 1: Overview of the Alternate Evaluation Methodology Utilized by CNP
- Attachment 2: Proposed Responses to the RAIs
- Attachment 3: Margins and Conservatisms Evaluation
- Attachment 4: Figures and Photographs Supporting RAI Responses
- Attachment 5: Table Summarizing the Strainer Testing Performed and Results

**Draft**
**Attachment 1**

## Alternate Evaluation Methodology Approach Utilized by CNP for Resolution of GSI-191

As first identified in I&M's August 31, 2005 response to GL 2004-02, the planned approach to be taken for resolution of the GSI-191 issue was to utilize the NEI 04-07 Chapter 6 guidance and allowances. To this end, the following approach was utilized.

- As provided in Chapter 6, alternative mitigative strategies can be utilized for the Region II Double Ended Guillotine Break (DEGB), while the Region I Debris Generation Break Size (DGBS) must fully rely on the design basis approach for mitigation of the event.

- As part of the design solution, redundant safety related, RG 1.97 qualified water level instruments were installed inside the CNP containment recirculation sump enclosure. Since CNP utilizes a fully vented recirculation sump, the level instruments provide early warning of excessive head loss across the strainer prior to challenging the operation of the Emergency Core Cooling (ECCS) and Containment Spray (CTS) systems. These water level instruments provide indication and annunciation within the main control room to alert the operators of the excessive head loss condition. The main control room operators are then procedurally driven to stop an operating CTS pump to restore water level inside the recirculation sump. The challenge to operation of these systems in not as a function of Net Positive Suction Head (NPSH) but rather the potential for significant air entrainment as a result of vortexing or voiding at the ECCS and CTS suctions from the recirculation sump.

- Debris generation analyses were performed for both the DEGB and DGBS to determine the worst break location for each type of break.

- Since the 14 inch diameter equivalent pipe break for the DGBS will result in essentially the same ECCS injection into the Reactor Coolant System (RCS), a single debris transport analysis was performed that was common to both of the break sizes.

- Debris only strainer head loss and chemical effects head loss testing was performed for each of the two break sizes, as reported in the February 29, 2008 supplemental response to GL 2004-02. The total head loss results for both break sizes, with the conservatively applied increase factors, remained below the allowable head loss for each of these break sizes. For the DEGB, the factored head loss was approximately 0.13 ft below the allowable head loss of 2.8 ft. I&M believed it would be prudent to credit the alternative mitigative strategies for this break.

- The following has been excerpted from the February 29, 2008 supplemental response to GL 2004-02 (Pages 311 and 312):
  - Alternate Evaluation Methodology

    As described in the responses to Information Items 3.f and 3.o, I&M performed testing for both a DEGB and a DGBS. The purpose of performing testing for the two different break sizes was to support use of the alternate evaluation provisions of Chapter 6 of the GR and SER. The testing determined the overall system head loss for the DEGB to be approximately 0.13 ft $H_2O$ less than the allowable strainer head loss of 2.8 ft $H_2O$. As was described in References 11, 12, and 14, the strategy for mitigating an excessively high head loss would be to reduce flow through the strainers. In accordance with EOPs, operators would accomplish this by securing a CTS pump, and if necessary, securing an RHR pump. Based on the testing results, a reduction in flow equivalent to securing a CTS pump would result in a decrease in head loss across the strainers of approximately 38% (3.f.4, Figure 3f4-21 and 3.g.7). This would provide approximately 1.14 ft $H_2O$ margin to the established vortex limit of 601 ft 6 in.

As described in the response to Information Item 3.g.7, the assumed single failure for containment minimum sump water inventory is one of the two CEQ fans. A single failure of a CEQ fan is limiting for minimum containment minimum sump water inventory because it would result in less flow through the ice bed, which would result in less ice melt. A single failure of a CEQ fan is also limiting with respect to strainer head loss. If the single failure component was one of the operating ECCS or CTS pumps rather than one of the CEQ fans, the reduction in head loss that was described in the previous paragraph would result. The limiting single failure for CNP, as described in the UFSAR (Section 14.3.1.2), is the loss of an entire train of ECCS and CTS. With only a single train operating following a DEGB LOCA, the head loss across the strainers would be approximately 66% less than the full flow head loss. A further reduction in flow by the operators would not be required since strainer head loss would be well below the allowable head loss.

The CNP licensing basis for single failure criteria (UFSAR Sections 1.4.7 – Criterion 41, 6.2.1, 6.2.3, Table 6.2-6, and Table 6.2-7) requires assumption of an active failure during the injection phase, or an active or passive failure during the recirculation phase. In the unlikely event that the operating pump that corresponds to the pump that was stopped to reduce head loss failed, the pump that had been secured could be restarted to restore the function. Since the CNP licensing basis does not require assumption of multiple failures, a failure of an operating pump following a failure of a CEQ fan would be considered to be a beyond design basis condition.

If strainer head loss exceeded the allowable head loss, indicator lights and an audible annunciator would actuate in the control room. The operators would respond to the condition by securing a CTS pump, as described above. Since the predicted maximum head loss is slightly less than the maximum allowable head loss, and will occur several hours following the event, as described in the response to Information Item 3.f.4, this condition will develop slowly. This will provide the operators with a significant quantity of time to respond to the condition.

As described in the response to Information Item 3.f.3, the established vortex limit was conservatively determined assuming the potential vortex formation would be in the same chamber of the recirculation sump as the pump suction pipes. The vortex elevation determined, 601 ft 6 in, implies that the vortex would form in the vent pipe in the rear chamber of the recirculation sump. Since there is no flow through the vent pipe, the potential for a vortex to form is significantly reduced. As described in Reference 31, the maximum vortex that did form in the front section of the scaled recirculation sump test configuration did not introduce air bubbles into the flow stream.

Given these analysis and testing results, it is reasonable to assume that the water level inside the recirculation sump would have to drop to a substantially lower level to result in significant air entrainment to the suctions of the RHR and CTS pumps. Based on the limited potential for development of significant air entrainment, and the slowly developing head loss, it is reasonable to assume that the operators would have greater than thirty minutes to recognize and take action to reduce head loss across the recirculation sump strainers.

In summary, the proposed mitigation strategy of securing a CTS pump, and if necessary, an RHR pump, to ensure continued core and containment cooling following a DEGB LOCA with an excessive recirculation sump strainer head loss, is considered to be in accordance with the requirements of the GR and SER.

- As part of mitigative strategy developed within the EOPs, the operators have demonstrated through training on the simulator that they can recognize and respond to an excessive head loss condition. The EOPs include a fold-out page and continuous action steps to remind the operators of the need to monitor recirculation sump level indication whenever the plant has been placed in a recirculation lineup. Since the predicted maximum factored head loss for the DEGB is slightly below the conservatively determined maximum allowable head loss, it is not expected that CNP would have to utilize the mitigative strategies following a LOCA that exceeds the size of the DGBS. I&M believes that at the time that the maximum head loss would be expected to occur following the LOCA, the change in head loss would be occurring very slowly, allowing the operators ample time to take action to reduce head loss by securing one of the CTS pumps. This assumes that CTS had not been previously secured, which is expected to occur at approximately 8 hours into the event. This expected early termination is the result of the ice condenser design which provides substantial cooling of the containment atmosphere and containment sump pool.

**Draft**
**Attachment 2**

## REQUESTS FOR ADDITIONAL INFORMATION

## DONALD C. COOK NUCLEAR PLANT, UNITS 1 AND 2

## SUPPLEMENTAL RESPONSES TO GENERIC LETTER (GL) 2004-02

*Debris Generation/Zone of Influence*

*1. a) Please identify what zone of influence (pipe diameters) was determined for the new D. C. Cook Rubatex/Armaflex configuration and how it was arrived at from the referenced Wyle Labs test report data.*

Response:

The minimum tested ZOI was provided in the February 29, 2008 supplemental response, Section 3.b.3, Table 3b3-6. The applicable tests were 6, 7, and 9. These tests matched our currently installed configuration of use of a double jacketing with 6 inches of overlap in both the axial and circumferential directions with bands spaced at a nominal 6 inches. The minimum ZOI for these tests was 4.3D. No failure occurred during these tests. A failure ZOI was not determined due to limitations on target to nozzle configuration.

*b) Please state whether there were any potential break locations within the zone of influence for this material. If so, please describe how much debris would be generated from this source, how much would be expected to arrive at the strainers, and what its contribution would be to strainer blockage and head loss.*

Response:

For the DEGB (Region II) break, there is approximately 2 ft of pipe at the outer edge of the sphere from the break location on the RCS crossover leg. The location of this section of piping is not in the path of a direct jet due to it being above several structural members surrounding the RCP. Assuming that the double jacketing did completely fail for this section (not expected based on testing), the contribution to strainer blockage would be approximately 2.62 $ft^2$. This is well within the sacrificial strainer area available for the strainers. For the DGBS (Region I) break, there are no locations within the associated ZOI.

*Debris Characteristics*

*2. Please describe the scaling process used to apply the results of the debris generation testing of the Marinite, Armaflex, fire barrier tape, and other materials to the plant condition. In particular, the NRC staff noted that the size of the nozzle (2.45 inches) used for the testing resulted in a significantly smaller jet than would be created by a large-break loss-of-coolant accident (LOCA). As a result, large test targets may only have been exposed to the peak pressure at the jet centerline over a limited area due to the radial decay of the jet pressure. Thus, a significant area of the target material could have been exposed to much lower jet pressures than this peak pressure.*

a) *As a result, the significant portion of the targets away from the centerline of the test jet would have experienced reduced fragmentation than had they been exposed to the jet from a prototypically sized LOCA jet.*

b) *This radial pressure decay effect could be significant, not only with respect to ablation of base material by the impinging jet, but also to applying the total force necessary to rip off insulation jacketing or break insulation banding.*

c) *The much larger forces from a LOCA jet could also create a higher proportion of fine debris by imparting significant energy to dislodged debris pieces, resulting in further fragmentation of larger pieces through impacts with solid structures in containment, an effect that is not modeled in the licensee's ZOI tests.*

*In light of the discussion above, please describe how the radial decay of the jet pressure was accounted for in the analysis of the test results, specifically addressing items (a), (b), and (c) to demonstrate that the ZOI test results have been prototypically or conservatively scaled to the plant condition.*

Response:

As described in the February 29, 2008 supplemental response, the jet impingement testing determined the effects of a direct jet impinging on the target material. Due to the small size of the CNP containments, there is significant congestion surrounding the target materials with very few exceptions. This will result in predominantly deflected jets impinging on the targets.

For the Marinite board testing, as stated in the supplemental response, the failure mode was the deformation of the simply supported cable tray section on which the board was mounted. The installed configuration of Marinite within the plant is on both cable trays and electrical junction boxes. The cable trays are rigidly supported by angle steel that is welded or bolted to the cable tray and the cable trays will also resist bending due to the tie plates that are installed at each location the cable tray changes direction. In addition, the cable trays have cables installed within them that would limit the maximum amount of deflection. I&M also conservatively treated the Marinite installed on the electrical junction boxes as if it had been attached to cable trays. The electrical junction boxes would not deflect as the cable tray sections did. There was very little ablation of the material as a result of direct impingement by the jet. It is acknowledged that the jet pressure will decay radially from the centerline of the jet. Since the failure mode was the structural deflection (buckling) of the simply supported cable tray section and not the result of the maximum pressure from the jet acting on the Marinite material itself, I&M judges that the testing performed was conservative in establishing the debris quantities that would be available for participation in strainer head loss.

For the label testing, the jet size was very closely matched to the size of the labels. For this material, the width of the maximum pressure from the jet would not be any different for a DEGB in the plant than it was for the testing. It should also be noted that all valve labels that were below the maximum containment sump water level were assumed to completely fail and were included in the total other latent debris sources that could block strainer flow passages. These values were included in the February 29, 2008 supplemental response and were enveloped by the sacrificial strainer area assumed for both the main and remote strainers.

For the fire barrier tape testing, the failure mode was the stretching of the material at the points where clamps secured the ends of the tape. The remaining tape was easily dislodged from the conduit and resulted in large non-transportable pieces. The portion of the tape that could contribute to strainer head loss concerns were the fines that were calculated to be generated following post-test weighing of the recovered tape pieces. Conservatism was included within this testing since the assumed weight of a roll of tape was established at a high value that resulted in a maximum value for the quantity of tape that was assumed to fail as fines. Also, a conservative ZOI was established for this material. At the lowest ZOI tested (4.0D), 6.97% was destroyed as fines. At the largest ZOI tested (8.2D), 1.02% was destroyed as fines. For debris generation input, a ZOI of 8.2D was used with 6.97% of the material destroyed as fines Again, it is judged that had a 30 inch jet been used, the results would not have been significantly different than the results that were obtained. For most locations in the plant where this material is installed, the clamps are installed only at the ends of the tape and not where there is overlap from one roll of tape to another. This would further limit the production of fines which are the only concern from this material.

For the Armaflex/Rubatex tests, the jet was intentionally directed toward the openings of the jacketing to maximize the forces acting on the material to determine if failure would occur. The single jacket tests demonstrated that failure would occur. The double jacketed tests (as installed in the plant) did not result in failure of the jacketing. Debris generation from jet impingement requires that the jacketing material be removed from the underlying insulation material. Since the jacketing material that is installed in the plant is installed to ensure that seams from the inner and outer jackets are offset from each other (approximately 180 degrees) and include an overlap 6 inches, the potential for failure of both jackets is judged to be extremely small. Specific scaling of the test results was not performed for this testing. In lieu of scaling, the alternative approach is to determine the force acting of the jacketing material between the bands and compare it to the shear strength of the jacketing material and the tensile strength of the banding material. For the minimum ZOI tested, 4.3D, the jet pressure would be slightly lower than 40 psi, the value established for a ZOI of 4D. Assuming that the jet pressure would act upon a greater length of the insulated pipe in the plant following a DEGB, the failure potential for the jacketing can be determined. To determine the forces acting on the double jacketed insulated piping, it will be assumed that the spacing between the bands is 6.5 inches which is a greater spacing than the installed configuration. Since the largest diameter pipe is 3 inches with one inch of insulation installed, the effective area of the jacketing between the bands can be determined. Assuming that the jet pressure will act on one-fourth of the total circumferential area of the jacketing results in an area of 25.87in$^2$. At 40 psi, this results in calculated shear in excess of the allowable for the 0.010" jacketing material installed. The expected result for this condition would be that sections of the outer jacket would be removed where not restrained by the bands. The bands which are 0.020" thick and either 1/2" or 3/4" wide would not fail in tension from this applied pressure. It is also expected that the mechanical clamps that secure the bands will not fail since they are looped sections of the banding cinched in a formed retaining fixture. Since there is an inner jacket underneath the section of outer jacketing that failed, with their seams diametrically opposed, the jet will not act on the underlying insulation material.

RAI 2.c) states that the potential debris generation from the impacting of liberated debris sources on other containment structures is not considered in the analysis of the jet impingement testing that was performed. The purpose of the material testing was to determine the failure mode and establish conservative ZOIs for these materials, which do not constitute a large quantity of potential debris sources within the CNP containments. In response to this RAI, it is the opinion of I&M that the provisions of GDC 4 apply for this particular issue. As discussed in the paragraphs above, the failure mechanisms, the quantities of materials involved, and the conservatisms that were applied in establishing the quantities of debris generated provide for a reasonable assurance input to the overall issue resolution. Since these tests were not attempting to determine the destruction of large quantities of materials resident in the plant, the use of a 2.45 in. diameter jet is judged to be reasonable and acceptable.

3. *Please identify which destruction test or tests were used as the basis for the Marinite size distribution given in Table 3c1-2 of the supplemental response. Please further discuss the applicability of these tests to provide a basis for characterizing the size of the Marinite debris within the entire 9.8D ZOI, recognizing that increased fragmentation of debris could occur at radial distances less than those tested.*

Response:

Tests 9, 11, 13 as described in the February 29, 2008 Supplemental Response, Section 3.b, Table 3b3-3, Page 63 were used as the basis for the Marinite size distribution. To address applicability of the tests, the failure mode for the Marinite was the result of the dynamic effects of the jet acting on the unrestrained cable tray section. Marinite installed in the plant, is for the most part, secured to restrained cable trays and junction boxes. Restrained cable trays are cable trays which are welded or bolted to angle iron supports, are continuous sections, have more substantial connection plates where they change direction, and contain various quantities of cable. This will limit the dynamic deflection of the cable tray sections, thus limiting the generation of debris. The testing that was performed determined that debris was generated at ZOIs of 3.4D, 4.5D, and 5.5D. To conservatively bound the results, a ZOI of 9.8D was used for determination of the quantity of debris that could be generated following a break. An additional conservatism is that NEI 04-07 established a destruction pressure for Marinite at a ZOI of approximately 3D (64 psi). As defined within NEI 04-07, destruction pressure is the pressure at which damage starts to occur. Taken together, these considerations provide reasonable assurance that the established destruction quantities are conservative and bounding.

4. *Please provide description and results of verification or analysis done to ensure similarity between the calcium silicate at D. C. Cook and the material tested for both erosion and for the jet destruction testing performed by Ontario Power Generation that is reference in the licensee's submittal.*

Response:

During the extended shutdown for Cook in the 1997 to 2000 time frame, substantial work was performed on the installed insulation systems. This included replacing existing hot pipe fiberglass insulation in potential HELB areas with Cal-Sil or RMI, and reworking a substantial portion of the Cal-Sil insulated piping. The replacement Cal-Sil that was used was Johns-Manville Thermo-Gold 12. The OPG tests were performed with Thermo-Gold 12, as confirmed through discussions with one of the individuals involved with the OPG testing. The ALION erosion testing performed for CNP also utilized this pre-2002 Thermo-Gold 12 insulation, as supplied by CNP.

*Debris Transport*

5. *Please describe the basis for considering the Loop 4 break to be bounding, not only from the standpoint of transporting the greatest quantity of problematic debris, but also from the standpoint of the degree of uniformity in the debris distribution (i.e., in terms of debris quantities per unit strainer surface area) between the main and remote strainers.*

Response:

Refer to Figures 4-1 through 4-4 for this discussion (Attachment 4).

Since the breaks considered as the bounding breaks for both DEGB and DGBS occur in the area of containment between the primary shield wall and the crane wall (loop compartment, approximately 12:00 position on Figure 4-1), the majority of the debris will remain resident within this area immediately following the break. The remote strainer is outside the crane wall (annulus, approximately 5:00 position on Figure 4-1), far removed from the location where the pool fill and recirculation water can exit the inside the crane wall area (approximately 10:00 position on Figure 4-1). During the injection (pool fill) phase of the event, some of the material that was resident inside the loop compartment will be transported to the annulus, approaching but not reaching the remote strainer since water from the loop compartment will also be flowing out of the remote strainer (Figure 4-3). The fine debris transport fractions as a function of time are provided in Figure 4-2 (Figure 3e1-8 from the February 29, 2008 supplemental response). At the initiation of recirculation flow, Figure 4-4 provides the velocity profiles for the recirculation sump pool.

CNP utilizes an ice condenser containment. Ice condenser containments are smaller than the large dry containments of most other PWRs. Due to this smaller size, the materials generated within the area of containment where breaks are postulated provides for a more even distribution of debris within the sump pool. The loop 4 break location results in a greater fraction of material available for transport to the area of containment approaching the remote strainer. The other break locations (Loops 1, 2, 3) generate significantly less quantities of problematic debris, closer to the main strainer which is located in the loop 2 area (diametrically opposed from the Loop 4 break location). The Loop 4 break does not generate the greatest quantity of debris. It provides the greatest quantity of problematic debris. Since the remote strainer is significantly removed and separated from the breaks that could occur within the loop compartment, there will not be a uniform distribution of debris between the main and remote strainer. Following the break, during the injection phase, there will be two distinct flow directions for the water and debris within the loop compartment. One will be toward the main strainer and the other will be toward the debris interceptor at the flood-up overflow wall openings (approximately 10:00 position on Figure 4-1).

For the DEGB and DGBS, the distribution of transportable particulate and fibrous debris between the main and remote strainers is provided in the table below. The main strainer has 900 $ft^2$ of surface area available and the remote strainer has 1072 $ft^2$ of surface area available. For strainer testing purposes, 50 $ft^2$ was set aside as sacrificial strainer area for the main strainer and 72 $ft^2$ was set aside as sacrificial strainer area for the remote strainer. The particulate and fibrous values used are those that were used for strainer testing.

| | Total Particulate lbs | Particulate per Surface Area of Strainer lbs / $ft^2$ | Total Fibrous $ft^3$ | Fibrous per Surface Area of Strainer $ft^3$ / $ft^2$ |
|---|---|---|---|---|
| DEGB Main | 1094.03 | 1.287 | 7.793 | 0.009 |
| DEGB Remote | 705.38 | 0.705 | 5.418 | 0.005 |
| DEGB Total | 1799.41 | **0.973** | 13.211 | **0.007** |
| DGBS Main | 894.87 | 1.053 | 7.793 | 0.009 |
| DGBS Remote | 472.22 | 0.472 | 5.418 | 0.005 |
| DGBS Total | 1367.09 | **0.739** | 13.211 | **0.007** |

As detailed in the Margins and Conservatisms Evaluation, Section 7.2.c (Attachment 3 to this document), the quantities of particulate and fibrous material used for testing is significantly greater than the quantity of material that would be available following an event. The following table provides the actual quantities of particulate and fibrous available and their distribution in terms of quantity per unit strainer area as a function of the total quantity and total strainer area (1850 ft$^2$ which excludes the sacrificial strainer area).

| | Total Available Particulate DEGB lbs | Total Available Fibrous DEGB ft$^3$ | Total Available Particulate DGBS lbs | Total Available Fibrous DGBS ft$^3$ |
|---|---|---|---|---|
| | 760.67 | 7.42 | 329.86 | 7.40 |
| | | | | |
| Available Particulate per Unit Strainer Area lbs / ft$^2$ | **0.411** | | **0.178** | |
| Available Fibrous per Unit Strainer Area ft$^3$ / ft$^2$ | | **0.004** | | **0.004** |

As can be seen when comparing the two tables, the available quantity of debris per unit strainer area is in all cases significantly less than the quantity of material per unit strainer area that was tested. This confirms that the testing that was performed to establish the debris only strainer head loss is significantly conservative and bounding.

6. *Please provide adequate basis for the following assumptions made in the debris transport analysis in deriving the flow and debris distributions between the main and remote strainers.*

   a) *During pool fill up, the flow resistance on the main strainer is assumed to be negligible, even though a substantive amount of debris is assumed to accumulate there during fill up. Given the reduced water levels and high flow velocities, along with the fact that static head is the only driving force to move water through the main strainer at this time, the neglect of this flow resistance could have a non-negligible impact on the flow distribution during fill up, resulting in increased flow to the remote strainer.*

Response:

As provided in the February 29, 2008 supplemental response, Figures 3f4-29 and 3f4-32 for the DEGB and DGBS Event Sequence tests and the accompanying discussion (Pages 202 – 206) demonstrate that the pool fill debris quantity on the main strainer only provides a negligible increase in head loss across the main strainer. For the DEGB, the head loss following the pool fill debris addition with the flow rate through the main strainer that was calculated to exist during this period was approximately 0.2 in. $H_2O$. For the DGBS, the head loss was even lower, approximately 0.07 in. $H_2O$. When these head loss values are analyzed to determine the total equivalent reduction of the clean strainer area at 100% flow, the results are approximately 79% for the DGBS and 90% for the DEGB. Based on these test results, the flow distribution would not significantly shift to provide a greater quantity of debris to the remote strainer area.

b) *Ten percent of the area of the main strainer is assumed to remain clean during recirculation, even though large-scale test results for D. C. Cook suggest a greater degree of flow resistance consistent with the formation of a continuous debris bed over the entire strainer flow area. In addition to this plant-specific evidence from the D. C. Cook testing, a significant number of head loss tests with a variety of different strainer geometries have similarly demonstrated the potential for debris to form a continuous bed over the entire strainer surface area rather than leaving part of the strainer area open (presuming a sufficient quantity is available). Therefore, a more representative analytical model of head loss at the main strainer during recirculation would likely result in significantly larger flow and debris fractions arriving at the remote strainer.*

Response:

The main strainer was not assumed to be 10% free of debris (clean) during recirculation. Even with a continuous debris bed formed, there will still be flow areas through the debris bed that represent a 10% unblocked case. The analysis was treated as if 90% of the strainer surface area was completely blocked. Additional analysis has determined that the debris bed formed across the main strainer during the extended debris only DEGB head loss test resulted in a total head loss equivalent to a reduction of the clean strainer area by approximately 94.7%, and the debris bed formed across the main strainer during the DGBS event sequence test resulted in a head loss equivalent to a reduction of the clean strainer area by approximately 93.0%. Based on the conservatively large values of particulate and fibrous debris utilized during testing, as described in the response to RAI 5, the results of the testing performed are considered to be conservative and bounding for the expected head loss that would result from the available debris quantities. It is further judged that with the lower debris quantities, any shift in debris quantities between the two strainer sections would not result in head loss values greater than those achieved during the testing that was performed. Additional analysis of the data obtained during testing is ongoing and the results of that analysis will further support this conclusion. To further support this point, as the main strainer becomes effectively blocked beyond the assumed 90%, the debris that is resident in the volume inside the crane wall will then tend to move with the varying water flow towards the remote strainer. As discussed earlier, this flow path is a significant distance from the main strainer with many obstacles for the debris to pass through on its path toward the remote strainer. No credit was taken for hold up of the particulates and fibers within this flow path. Additionally, one of the two flow paths outside the crane wall was modeled to provide increased velocity for transport. These conservatisms, along with the 50% increase in strainer system head loss above the as-tested head loss, more than account for the potentially slight variation in head loss that could develop from a redistribution of debris between the two significantly separated strainers.

c) *Water draining into the containment pool during the fill-up phase is assumed to be clean. This assumption contributed to the overestimation of debris transport to the main strainer (and underestimation of debris transport to the remote strainer) because the licensee's transport calculation predicted a significant amount of debris transport to the main strainer during the pool-fill phase of the LOCA (and none to the* *remote strainer). Assuming that water draining into the containment pool is clean is not realistic, and the time dependence of blowdown, washdown, and pool-fill-up transport modes is not well known and can vary significantly from one accident scenario to the next. For this reason, conservatively estimating time-dependent debris transport is very challenging.*

Response:

The water draining into the containment pool was assumed to be clean because all debris, from all sources, was assumed to be resident in the associated pool volumes at T=0 of the event initiation. This is an extremely conservative assumption since it makes all debris available to interact with the strainers at the onset of recirculation. Prototypically, many of the debris sources will take a substantial period of time for even a portion of the total debris quantity to make it to the pool. This is especially true of the coatings debris assumed to fail during the event. As described in the response to RAI 5, there are two separate but connected pool volumes in the CNP containments. The loop compartment is where the high energy line breaks occur, the volume that the ice condenser drains to, and the vast majority of the spray from upper containment drains to, in addition to the sprays that directly enter this volume. The annulus receives its water from the flow openings that separate the loop compartment from the annulus, direct sprays that enter above the floor that is above the annulus floor, and for Unit 1, a small amount that drains from the Containment Equalization (CEQ) Fan rooms that drain into the annulus sump pit. During pool fill, water also enters this volume via the main strainer and reverse flow through the remote strainer and waterway. If a time dependent approach to debris liberation and accumulation were taken, the greatest quantity of debris would still enter the loop compartment and preferentially transport to the main strainer until such time that the main strainer was significantly blocked. At that time, the flow would shift to supplying a greater quantity to the annulus region and ultimately the remote strainer. As stated previously, there would be significant obstacles in this path to capture some of this debris, including the debris interceptor that protects the entrance to the flood-up overflow wall openings and the significant components and equipment that reside in the annulus region at low elevations. When this flow shift occurs, it will also create more quiescent areas in the loop compartment where gravity will provide for less transport of debris from this compartment.

We do not agree that the assumption of clean water entering the pool contributed to the overestimation of debris transport to the main strainer. The CNP layout and recirculation sump strainer design strategy is significantly different than the other PWRs that are addressing this issue. It is acknowledged that this can make it somewhat more challenging to understand the dynamics associated with its operation, but we fully believe that the approach that has been taken has resulted in a conservative and bounding approach for resolution of this issue. Considering the quantity of debris that was used for testing when compared to the debris that would be expected to exist, and the application of a 50% increase in as-tested head loss provides further support that reasonable assurance exists that the requirements of 10 CFR 50.46 will be met for all LOCAs that may occur.

*As a result of these observations, the NRC staff does not consider the flow and debris distributions to the main and remote strainers (including the time-dependent transport modeling used to determine these distributions) to be adequately justified. The measured flow rates to the main and remote strainers in the large scale tank tests performed at Control Components Inc. (CCI) further provide support to the NRC staff's view that the fractions of flow and debris transport to the main strainer were overestimated by the transport analysis. The NRC staff believes the flow distribution*

> *between the two strainers would be more uniform because, as demonstrated in the head loss testing conducted by D. C. Cook as well as other pressurized-water reactor licensees, as debris accumulates on strainer surfaces and increases the local flow resistance, the flow and suspended debris tend to redistribute to more open areas of the strainer. Since non-uniformity of the flow and debris loading tends to reduce the overall system head loss, this overestimate of flow and debris transport to the main strainer appears non-conservative.*

Response:

As addressed in the individual items for this RAI and RAI 5, the combination of conservative versus prototypical sequence of debris availability and delivery and the conservative increase that was applied to the as-tested head loss values for establishing the design and licensing basis head loss values provides the necessary reasonable assurance that the required core and containment cooling will be satisfied. An additional point that needs to be emphasized is that there is a substantial difference in head loss between the main strainer and the remote strainer and its interconnecting waterway. The testing that was performed did not utilize the equivalent of the waterway that exists in the plant. As a result, a direct comparison between the testing and the expected plant response can not be made. For this reason, additional analysis was performed to establish overall system head losses as described in Section 3.f of the February 29, 2008 supplemental response. A redistribution of debris from the main strainer to the remote strainer will have less of an impact on overall system head loss than a redistribution of debris from the remote strainer to the main strainer. The reason for this difference is that the main strainer is constructed such that water has to simply flow directly through the horizontal pockets at which time it enters the reservoir that supplies the suctions of the ECCS and CTS pumps. At the remote strainer, water enters the horizontal pockets on each side of the strainer into an internal flow channel that gradually increases in size from the furthest end of the strainer assembly to the end that is connected to the waterway. This flow channel creates a resistance to flow through the strainer. The waterway that connects the remote strainer to the recirculation sump enclosure (reservoir) also creates a resistance to flow in the remote strainer system. As a result of the installed design, we do not believe that there will be a uniform distribution of flow and debris between the two strainer sections, even with the slight difference in strainer area.

7. *Please provide additional information concerning the erosion testing of calcium silicate insulation and Marinite board, including the following items:*

   a) *The basis for not accounting for erosion and dissolution effects in combination. The presence of chemicals in the test fluid may enhance the erosion rate, and, conversely, a high erosion rate may lead to increased dissolution.*

Response:

Dissolution testing was performed in solutions that modeled expected plant conditions of pH and temperature and included the principal constituents that are resident in the containment sump pool; boric acid, sodium tetraborate, and sodium hydroxide. This testing determined that the primary mechanism for weight loss was due to the handling of the small samples, not the interaction of the chemicals with the materials. Since this mechanism would be present in the flow erosion testing, the determination was made that the dissolution test results and erosion test results need not be added to each other. The Cal-Sil insulation and Marinite board dissolution testing in post-LOCA chemical conditions has concluded that large scale dissolution will not occur.

> *b) The basis for not including the plant buffer materials in the test fluid.*

Response:

The dissolution testing was performed at plant pH and temperature conditions as described in the response to RAI 7.a) above. Since the material was relatively unaffected by the plant conditions, the erosion testing was performed in water treated through a reverse osmosis system to prevent the particulates that could be in other water types from affecting the measured weight loss. Additionally, the results of the erosion testing were applied to the debris generation analysis at a conservatively higher value than was tested.

> *c) The basis for using a velocity of 0.4 ft/s, since calcium silicate pieces larger than those tested (i.e., in the large piece category) would not transport at this velocity based on the metric of 0.52 ft/s cited in Table 3e1-5 in the February 29, 2008 supplemental response. As a result of exposure to higher velocity flows than tested, erosion from settled large pieces of calcium silicate could be underestimated.*

Response:

To address this question, pool floor specific velocities are being developed to validate that the expected velocity will be below the tested velocity. Figure 4-4, Attachment 4, provides some indication of the sump pool velocities that exist at the floor during recirculation. This information shows that the expected velocities are below 0.4 ft/sec. The information cited from the February 29, 2008 supplemental response refers to the velocity required to transport large pieces of Cal-Sil. The only time period during which sump pool velocities exceeded 0.4 ft/sec is during the pool fill period which was assumed to occur for approximately 18 minutes. Figure 4-3, Attachment 4, illustrates the turbulent kinetic energy and velocity in the pool at the end of pool fill. As stated at the beginning of this response, additional velocity diagrams are being developed to demonstrate that the pool floor velocities remain below 0.4 ft/sec, except for the short duration during pool fill. Additional information regarding the basis for use of 0.4 ft/sec for erosion testing is provided in the following excerpt from the ALION test report, ALION-REP-AEP-4462-02, D. C. Cook Material Transport, Erosion and Dissolution Report:

> The basis for the solid flow velocity of 0.4 ft/s for flow erosion testing is the measured incipient tumbling velocity of similarly sized Cal-Sil samples based on size. Since the incipient tumbling velocity is the velocity at which the debris would start moving in the pool, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being carried to the sump strainer. Therefore, it is considered the velocity that would produce the most insulation fines that would travel to the sump strainer while the piece of insulation itself would remain stationary in the pool. The flow erosion velocity for all samples (0.4 ft/s) was not based on D. C. Cook pool analysis, but rather the incipient tumbling velocity from industry-standard data as described above. If the D. C. Cook containment floor pool velocities do not reach 0.4 ft/s, then the erosion that was observed during testing will be bounding. If the pool velocities exceed 0.4 ft/s, then the Cal-Sil insulation debris will be transported to the sump strainers and its flow erosion would not apply.

d) *The basis for considering the turbulence conditions prototypical or conservative, since defining a limiting condition for turbulence is difficult given that a variety of conditions may exist throughout the containment pool at different times following a LOCA.*

Response:

It is acknowledged that turbulence conditions will be different during the initial stages of the event (pool fill) than they will be during extended recirculation. As the event progresses, the velocity in the sump pool will decrease as a function of removal of unnecessary pumps from operation (CTS) after approximately 8 hours, followed by ECCS flow reduction within the first day of the event. Since the erosion test extrapolated the quantity of fines generated over the entire 720 hour duration based on the changes in mass over approximately a day, it is judged that the turbulence effects that may be present in the first 18 minutes is more than offset by the methodology used to calculate a total fines generation over 720 hours.

8. *Please provide the basis for the assumed calcium silicate tumbling transport velocity metrics for small pieces (0.33 ft/s) and large pieces (0.52 ft/s) and state whether these metrics were based on measurements of incipient tumbling, bulk tumbling, or some other criterion. The metrics cited were larger than the reported values in NUREG/CR-6772, which identifies an incipient tumbling velocity of 0.25 ft/s for small pieces of calcium silicate.*

Response:

Specific testing was performed by ALION to establish both incipient tumbling and tumbling velocities. The test report that documents the results of this test is ALION-REP-LAB-2532-81, Testing to Evaluate the Settling and Tumbling Velocities of Cal-Sil Insulation Debris. This is an ALION proprietary document. The following has been excerpted from the test report:

> The Cal-Sil insulation samples were tested in the Transport Flume under uniform flow conditions. The assembly shown in Figure 2.6 was used. An internal channel was inserted in the Transport Flume to reduce the cross sectional area from 21.5X24 in$^2$ to 12.25X24 in$^2$ to achieve a higher velocity at a particular flow rate. A flow distributor and flow straightener were used to achieve a laminar and unidirectional flow.
>
> The flow rate through the Transport Flume was monitored to ensure that it is at the desired operating specifications. This was done by either adjusting the variable speed pump or by throttling the discharge valve. After a steady state flow rate was established in the Transport Flume, the Cal-Sil samples were placed on the Transport Flume floor and the flow was gradually increased while keeping the water level constant (18") until the samples began to slide or tumble. The velocity at which some of the Cal-Sil samples began to slide or tumble was recorded as the incipient tumbling velocity. The velocity at which all of the Cal-Sil samples slide or tumble was recorded as the tumbling velocity.

The size distribution referred to in the excerpt is Small Debris Samples (<1 in. diameter), Medium Debris Samples (between 1 in. and 3 in. diameter), and Large Debris Samples (>3 in. diameter). The tests results show that the incipient tumbling velocity for small Cal-Sil samples is approximately 0.23 ft/s and the tumbling velocity is 0.35 ft/s. The incipient tumbling velocity for medium Cal-Sil samples is approximately 0.33 ft/s and the tumbling velocity is 0.45 ft/s. The incipient tumbling velocity for large Cal-Sil samples is approximately 0.33 ft/s and the tumbling velocity is 0.68 ft/s. The incipient tumbling velocity of small Cal-Sil according to the test report is 0.23 ft/s as compared to NUREG/CR-6772 which states the same as 0.25 ft/s.

9. *Please clarify how debris transport percentages greater than 100% for a number of debris types were computed, to the extent the licensee credits these percentages as conservatisms in its transport calculations. In Table 3e6-4 in the supplemental response dated February 29, 2008, a number of debris types have transport percentages exceeding 100%, for example latent fiber (108%) and flexible conduit PVC jacketing (130%). However, when considering the quantities of debris generated versus the quantities transported to the main and remote strainers in Tables 3e6-6 and 3e6-7, it appears that the transport fractions should be computed as 100% (for latent fiber out of 12.5 $ft^3$ generated, 6.5 $ft^3$ reaches the main strainer and 6 $ft^3$ reaches the remote strainer; for flexible conduit PVC jacketing, 1.57 $ft^2$ is generated, 1.57 $ft^2$ reaches the main strainer and 0 $ft^2$ reaches the remote strainer).*

Response:

We acknowledge that there can be some confusion regarding the quantities of debris available at the strainers based on the information previously provided. For the example of latent fiber, the February 29, 2008 Supplemental Response, Section 3.f.4, Tables 3f4-2 and 3f4-3 provide the quantities that were used for testing which more closely align with the transport fractions contained in Table 3e6-4. Table 3e6-6 provided the calculated debris quantity to arrive at the main strainer based on the main strainer debris transport fraction. Table 3e6-7 was developed from tables provided by our vendor that provided debris quantities that were calculated to arrive at the remote strainer based on the difference between the total debris generated and the quantity delivered to the main strainer. The actual debris at the remote strainer in Table 3e6-7 was determined based on the remote strainer transport fraction unless that calculated value was greater than the amount available to transport to the remote strainer. In those cases, the amount available was listed as the actual amount at the remote strainer.

*Head Loss and Vortexing*

10. *According to the licensee's supplemental response, the debris was added directly in front of the strainer to reduce near-field settling. The NRC staff has found that this debris introduction method can result in non-prototypical bed formation and non-conservative head loss values during testing. Please provide justification that the debris introduction methods used during head loss testing resulted in prototypical or conservative head loss results.*

Response:

The debris introduction methodology that was used provided for a more even distribution of the finer debris within the strainer pockets over the height of the strainer and prevented settling of any debris before it could reach the strainer. From a prototypical perspective (what would be expected to occur in the plant following an event), the lower pockets would tend to become more heavily loaded with debris with resulting deposition of debris on the floor at the approach to the strainer. Due to the strainer design, when the debris is added, a portion of the debris will pass through the strainer and when it recirculates through the loop, the tendency will be for the debris to be transported to those strainer pockets that have a higher flow. This will continue until all the debris is filtered out. Additional evidence of the uniformity of debris distribution can be seen in the flow propeller measurements that were taken during the tests. For each side of the test strainer assembly, there was a fairly even distribution of flow through the top, middle, and bottom flow openings. This information was provided in the February 29, 2008 supplemental response, Section 3.f.4.

Due to CNP being a low fiber (latent fiber only) plant, latent fibers and significant quantities of particulate will not all be available at the strainer at the onset of recirculation. Additionally, since the quantities of debris used for testing were significantly greater than would be expected to be available in the plant, and that the as-tested head loss values were conservatively increased by 50% to account for uncertainties, there is reasonable assurance that the methodology employed for debris addition during strainer testing was adequate.

11. *The licensee's supplemental response stated that the fibrous debris was shredded, and then blasted with a water jet to render it into fine debris. The submittal stated that the fibrous debris was verified to be less than 10 mm in size. It is not clear that the debris was easily suspendable, which is the primary consideration for fine fibrous debris. In addition, the submittal did not state the extent to which the fibrous debris was diluted. Therefore, agglomeration of debris could have occurred resulting in non-prototypical debris bed formation and non-conservative head losses.*

Response:

The response to the issues discussed in this RAI are included with the response to RAI 12.

12. *Please provide information that shows that the debris preparation and introduction methods used during head loss testing were conducive to prototypical debris arrival at the strainer and resulted in prototypical or conservative head loss results, or evaluate the effects of the non-prototypical debris on the head loss results. Specifically, please explain how the fibrous debris was verified to be easily suspendable and how agglomeration was prevented.*

Response:

The fibrous debris was prepared for the large scale test head loss only tests in the same manner as it was for the MFTL tests. During the large scale head loss tests, the particulate and fibrous debris were mixed together and then stirred with a power driven paddle to minimize the potential for agglomeration of the debris. As the debris mix was being added to the test pool, additional frequent stirring of the material was performed to also prevent agglomeration. These steps to prevent agglomeration were successful as evidenced by the lack of agglomerated debris on the floor of the test pool following testing. From the perspective of what would be expected to occur in the plant (prototypical), there would be natural agglomeration of the particulate and fibrous sources within the sump pool in containment prior to arrival at the strainers. Also, prototypically, as described in the response to RAI 10, the expected debris arrival at the strainers would tend to fill the lower pockets in the strainer first due to heavier particles tending to more readily settle. This is especially true for the remote strainer since the turbulence and velocity at the approach to the remote strainer is very low, as shown in Figure 4-4 of Attachment 4 to this document. Figure 4-5 of Attachment 4 shows a photograph of the fiber prepped (approximately 0.25 kg) and in an approximate 30 gallon container, filled with about 20 gallons of water. Figure 4-6 of Attachment 4 shows the homogeneous debris addition to the MFTL at the start of one of the chemical effects test. As can be seen from the photograph, the debris was easily suspendable. Pictures of this type could not be taken at the large scale test facility which is a steel lined concrete hydraulics pool at the university. The March 2008 Staff

Review Guidance, Strainer Head Loss and Vortexing, Page 6, 4th Paragraph states that the use of homogeneous debris addition is acceptable if sufficient numbers of tests are performed. CNP considers that their testing satisfied these criteria. Since the debris quantities used for testing were significantly greater than the amount of debris expected to exist in the plant, additional assurance is provided that the testing methodology was significantly conservative.

13. *Reflective metallic insulation (RMI) debris was added to the head loss tests. In pictures of the chemical testing in the multi-functional test loop (MFTL), the RMI was piled up in front of the strainer and transported into the bottom several rows of the strainer. The NRC staff considers this non-prototypical for the flow conditions specified for the plant in the licensee's submittal because of the known transport properties of RMI, and it could result in non-conservative head loss values. In particular, some of the RMI added during the licensee's testing was part of the earlier-transported "pool-fill" transported debris. This resulted in an RMI layer being formed between the fibers and particulate added early (representing pool-fill transport) and that which was added later (representing recirculation transport). Please justify that RMI would always arrive at the strainer, or describe what the head loss result would be if little or no RMI arrived at the strainer.*

Response:

The pictures being referred to are those of the chemical effects testing that modeled the main strainer only to determine a chemical effects bump-up factor. During the MFTL testing, there was no "pool-fill" sequence for debris addition. The inclusion of RMI in a test is prototypical due to the significant quantities of RMI that would be generated during a pipe break at the onset of an event. During pool fill there would be significant transport of RMI toward the main strainer resulting in a buildup of RMI at, in, and near the main strainer, and a significant buildup of RMI at the debris interceptor that protects the flood-up overflow wall holes that are the hydraulic communication path between the loop compartment and annulus. Regardless of where the RMI beds exist, there will be significant capture of particulate and fibrous debris by the RMI. During testing, we only considered and added the RMI that was predicted to actually reach the main strainer. No RMI was considered to reach the remote strainer and no RMI was added to the remote strainer during testing. Additionally, the strainer head loss testing was performed with debris quantities in excess of those that would actually exist in the plant. This provides significant conservatism to the test results.

14. *During head loss testing the flow rate was started at between 38% and 60% of the maximum scaled flow rate, depending on the test. Additionally, 60% of the debris was added during the fill-up phase during some testing. This amount of debris was greater than that calculated to be at the strainer during this phase. During the event sequence testing debris was added so that RMI was introduced between fibrous and particulate debris additions. These practices can result in non-conservative head loss test results. Low test flow rates can result in non-conservative results due to lower bed compression. Overestimating debris addition during the fill-up phase is likely nonconservative because it would result in less uniform debris bed formation and reduced debris bed compression as compared to a more prototypical addition sequence. Also, since the plant water level was not modeled in the head loss test, the lower pool velocity in the test may have non-conservatively affected the accumulation of debris on the strainer as well as the bed compression. Introducing RMI between fibrous and particulate debris additions can result in a stratified bed that would affect head loss non-conservatively. Please provide information that justifies that these test practices did not result in non-conservative head loss results or provide information that shows that the potential non-conservatism of*

*these practices were offset by other conservatisms contained in the test protocol.*

Response:

It appears that there is some confusion regarding the test methodologies as described in this RAI. For the non-event sequence and non-debris sequence testing (standard head loss testing), flow rates were established and debris additions occurred in steps of 60%, 80%, and 100%. The event sequence testing utilized flow rates equivalent to 75% of the predicted pool fill flow rate and 100% of the predicted pool fill flow rate with 100% of the predicted pool fill debris added to the main strainer with the remote strainer completely blocked off. At the "initiation" of recirculation flow, flow was increased to 50% of the total recirculation flow rate, the blanking plate was removed from the remote strainer, and debris additions were made to both the main and remote strainers to bring the total debris load to 100% of the recirculation debris load. After 5 minutes, the flow rate was increased to 100% of the recirculation flow rate.

It is acknowledged that RMI was added in steps along with the other debris sources. This is considered to be a prototypical response in that in the plant following an event, the RMI and other break generated debris sources, along with a portion of the latent debris sources would arrive at the main strainer during pool fill. Following the initiation of recirculation flow, additional "mixed" debris would arrive at the main strainer as a function of pool flow. Pool flow to the main strainer will change in stages as a function of time following the event. During the pool fill phase, it is acknowledged that bed compression will not be as great as it is with 100% recirculation flow. However, we believe that as long as the correct debris quantities are provided and flow rates are maximized during the testing sequence, the appropriate bed compression will occur for CNP since we can not form a complete fiber bed upon which compression effects are the most pronounced. Therefore, we believe that the test methodologies that were used provided the necessary conservatism for determining strainer system head loss.

Within this RAI, concerns are also raised about the formation of a uniform debris bed during the pool fill phase of the event. During pool fill, the prototypical debris bed formation will be that the lower pockets of the main strainer will receive the greatest quantity of debris as the pool is filling. After the pool is filled to the height of the strainer, there will be a more uniform distribution of debris to all of the pockets of the strainer. The testing that was performed utilized debris addition methodologies that maximized the potential for the creation of a more uniform debris bed, which we agree is the most conservative, but not necessarily the most prototypical.

We also believe that the quantities of debris used during testing which are in excess of the debris quantities that are expected to be available for transport to the strainers provides significant conservatism to the as-tested head loss values. Once again, to account for uncertainty, we chose to increase the as-tested head loss values by 50%. This, in itself, bounds any uncertainty with the test results.

15. *The test sequences that resulted in the maximum tested head losses for the double-ended guillotine break and debris generation break size scenarios were different. The double-ended guillotine break (DEGB) limiting head loss was attained by adding a homogeneous debris mixture in steps of 60%, 80%, and 100% while increasing flow in the same steps. The debris generation break size (DGBS) limiting head loss was attained during a sequence intended to mimic the flows that would occur through the strainer following a LOCA. The tests resulted in the following head losses (approximately):*

*DEGB – 27 mbar*
*DGBS – 13 mbar*
*DEGB Event Sequence – 22 mbar*
*DGBS Event Sequence – 20 mbar*

*There is no apparent reason that different test sequences would result in the limiting head loss for these breaks.*

*Please provide an evaluation of why similar test sequences would result in different relative head losses (i.e., differences between the nominal and event sequence tests for a given test scenario). Given this apparent disparity, please explain how the test results are repeatable. Provide the results of any tests run at 100% flow throughout larger portions of the test. If no other tests were run, then state this.*

Response:

To put this in an appropriate perspective, the maximum values for head loss extracted from the curves associated with the various testing sequences can not be directly compared since the water temperatures were not the same. Within our February 29, 2008 supplemental response, Section 3.f.4, we provide the 68°F normalized values for the maximum head loss seen in each of the tests. These normalized maximum head losses are:

DEGB Head Loss Test – 11.3 in. $H_2O$ at 16 hours
DGBS Head Loss Test – 5.6 in. $H_2O$ at 23 hours
DEGB Event Sequence Test – 8.4 in. $H_2O$ at 4 hours
DGBS Event Sequence Test – 7.2 in. $H_2O$ at 3.75 hours

For the DGBS cases, the difference in head loss between the two tests is 1.6 in. $H_2O$. 1.6 in. $H_2O$ represents approximately 5% of the allowable head loss of 2.65 ft. We believe that these two tests demonstrate repeatability. For the DEGB cases, the difference between the two tests is 2.9 in. $H_2O$. Since the DEGB cases utilize a greater quantity of RMI, we expect that there would be a larger difference in head loss between tests. In our judgment, 2.9 in. $H_2O$ is not a significant delta for head loss. 2.9 in. $H_2O$ represents approximately 8.6% of the allowable head loss of 2.8 ft. As we stated in our response, we chose to use the highest normalized head loss from the tests, even if the values were from different tests. Again, to account for potential uncertainties we conservatively increased system head loss values by 50%. The deltas between the test results are substantially bounded by this factored increase.

The debris sequence tests for both the DEGB and DGBS were run at 100% flow from the beginning of the test. Since the head loss results of these tests were substantially lower than the standard and event sequence tests, their results were not used to establish design basis head loss. The results from this testing was described on Page 206 of the February 29, 2008 supplemental response and the graphs from this testing were provided on Page 208.

16. *During the chemical effects testing, non-chemical head losses were significantly greater than large-scale non-chemical head loss testing with a similar debris mixture.*

    a) *Please provide an explanation for the higher non-chemical debris head loss.*

Response:

The testing performed in the MFTL was performed with the main strainer equivalent only, including the total (pool fill and recirculation) debris loads applied to the main strainer. These test results can not be compared directly to the large scale testing that included both a main and remote strainer sections.

b) *Please provide justification that a higher non-chemical debris head loss, attained prior to adding chemical debris, would not affect the calculated bump-up factor. In general the NRC staff has considered that chemicals should be added to the non-chemical debris bed with the highest head loss to attain the most limiting total head loss for a plant. However, this is for tests that are applied directly to the head loss and vortexing evaluation. For tests that determine bump up factors, the considerations are different and more complex. One example: If a non-chemical debris bed is generally packed with particulate the addition of chemical debris may not have as significant an effect on head loss as if the bed had a lower particulate to fiber ratio. This would likely result in a lower calculated bump up factor than if the chemical debris was added to a debris bed with a relatively low particulate to fiber ratio.*

Response:

Based on the testing performed, we judge that the approach used for developing the bump-up factor was reasonable and conservative. A highly compacted bed, as was developed during our chemical effects testing, limited the flow paths through the debris bed. Introduction of the chemical precipitates into the bed resulted in an approximate 50% increase in the overall head loss. Since we are a low fiber plant, decreasing the particulate to fiber ratio would be expected to result in a more porous bed and resultant lower head loss, decreasing the effect of chemical precipitate on strainer head loss. To address potential uncertainty with the results, the head loss increase factor attained through testing was further increased by 17% to bring the total chemical effects bump-up factor to 70%.

To provide further justification that the overall testing sequence resulted in significantly conservative results, in addition to those described above, the debris quantities for the fibrous and particulate debris sources used for establishing debris loads for testing were significantly greater than those that are expected to exist in the plant. If testing had been performed with those reduced quantities, we fully expect that the debris beds would have been substantially more porous, resulting in a significantly smaller increase in head loss due to chemical effects. The basis for this assertion is that particle size for the chemical precipitates is significantly smaller than the particle size of the particulate debris and there would have been substantially less fibrous debris for interacting with the chemical precipitate.

c) *Please provide a justification for the licensee's choice not to apply the chemical test head loss directly to the net positive suction head and vortexing/air entrainment evaluations.*

Response:

As stated in the response to RAI 16.a) above, the MFTL testing only modeled the main strainer and not the strainer system as installed at CNP. Our intent for testing was to test the overall strainer system to the extent practical. Since the chemical effects testing was performed with the main strainer only with a significantly developed and compressed debris bed, we chose not to use the results of that testing as a direct input to the strainer system head loss evaluation. We consider that this approach would be unnecessarily conservative and not representative of plant conditions.

17. *Please provide an evaluation of the sensitivity of overall system head loss to various debris loads split between the main and remote strainers as predicted by the transport evaluation. Because it is difficult to determine how much debris will arrive at each strainer, this information is needed to establish confidence in the licensee's head loss results.*

Response:

Based on the testing performed, the quantity of debris used during testing that is in excess of the quantity expected to be available in the plant for transport to the strainers, the conservative increase factors that were applied to both the debris only head loss and chemical effects head loss results, the significant physical separation that exists between the main and remote strainers, the actual interferences within the flow path between the two strainers that would result in substantial debris capture that was not credited, the knowledge that reduced debris at the main strainer would result in greater flow through the main strainer than a corresponding change to debris load on the remote strainer would have, and that additional conservatisms are inherent within the process for resolving this issue, we believe that redistribution of debris between the main and remote strainer will not negatively impact the conservative values for head loss that have been established for CNP. Refer also to the response to RAIs 5 and 6.

18. *The submittal (pg 227) stated that the debris-only head loss would be considered to be 1.57 ft after being increased by 50%. It was not clear that the clean strainer head loss was included in this value. Please provide the total head loss including the clean strainer portion or confirm that this value includes the clean strainer head loss.*

Response:

Clean strainer head loss was included in the evaluation of strainer system head loss which resulted in the final debris only head loss for the DEGB and DGBS cases.

19. *The head loss charts for the chemical effects testing show a large rapid increase in head loss immediately following non-chemical debris addition. The increase is followed by an immediate decrease in head loss to a significantly lower value, then a slower decrease until chemical precipitates are added (see pages 303 and 304). This behavior is unexpected and has not been observed previously by the NRC staff.*

    a) *Please provide an explanation for the rapid increase and decrease in head loss that occurred during this testing. Provide justification that this behavior would not occur in the plant or justify that the head losses observed during the initial spike would not adversely affect the response of the plant to a LOCA.*

Response:

The initial spike in head loss was the result of the short duration addition of the total debris sources to the test loop and the location of the differential pressure connections. The high pressure connection was located at the bottom of the test tank directly upstream of the strainer module. The low pressure connection was on the collection box downstream of the strainer module and just upstream of the pump suction. With the short duration of debris addition, this differential pressure connection configuration would be more sensitive to the dynamics of debris bed development. Any slight perturbation in the debris bed would result in a significant short term change in differential pressure indication. The rapid increase in head loss would not be expected to occur in the plant since many of the debris sources will take substantial time to arrive at the strainers and the fact that there are two separate paths to provide water to the recirculation sump enclosure. The debris addition during this testing was not prototypical of expected plant conditions. It can also be seen from the same plots that following the debris addition, the head loss decrease nearly followed the pool temperature increase.

> b) *Please provide justification that the chemical precipitates were added at a time such that a prototypical or conservative bump-up factor would be calculated. The NRC staff considers that adding chemicals when baseline head loss is continuing to decrease would likely result in a non-conservative bump-up factor because the decreasing non-chemical debris bed head loss could counteract and thereby obscure the measurement of the full head loss impact of the chemical precipitates. Therefore, to accurately measure the ratio of chemical to non-chemical head loss (bump-up factor), stability of the non-chemical debris bed head loss should be ensured prior to the addition of chemical precipitate.*

Response:

The primary driver for the decreasing head loss was the increasing temperature within the test loop. Refer to the February 29, 2008 supplemental response, Section 3.o.13, Figures 3o13a-1 and 3o13a-2 on pages 303 and 304. These figures show the increasing temperature as a function of time which nearly mirrors the decreasing head loss. The debris bed had been allowed to establish for approximately 24 hours prior to the first addition of the chemicals to the loop. Since the CNP debris bed is not fiber based, rapid development of a stable debris bed and accompanying head loss is not expected to occur. This was also seen in the large scale head loss tests where normalized head loss was decreasing slightly at the end of the test. Given that sufficient time had been allotted to develop the most stable debris bed possible, it is judged that the point at which the chemicals were added was appropriate.

20. *The submittal stated that the design maximum head loss is 2.8 ft for a large-break LOCA based on the available driving head of water at the recirculation sump. This limit was based on NUREG-CR-6808 guidance that head loss should not exceed 1/2 of the strainer height (or in this case submergence above the bottom of the strainer). A slightly lower limit for the debris generation break size was also listed. No limit was provided for the small-break LOCA, and no calculation of potential head losses associated with a small break was provided. Please provide this information or otherwise justify that the strainer will maintain its function under all required scenarios including a small-break LOCA.*

Response:

The minimum water level for the SBLOCA (2 in. diameter pipe break) is 5.1 ft above the containment floor. Subtracting the 0.3 ft for the elevation of the strainer results in 4.8 ft of water of which half of that value is the allowable head loss. Additional analysis and testing was not performed for the SBLOCA since the debris quantities that would be generated from that break would be substantially less than for the DGBS. Since the factored maximum debris only head loss for the DGBS was 1.23 ft $H_2O$, and the factored maximum head loss with chemicals was 2.09 ft $H_2O$, the head loss value is below the allowable head loss for the SBLOCA.

21. *Please provide the basis for the comparison being made on page 306 of the licensee's supplemental response, that the resulting head loss for the large-scale head loss on the main strainer only is 3 ft, which compares favorably to the MFTL debris only head loss of 2.67 ft. This basis is needed since the statement referenced helps to undergird the bump-up factor approach.*

    *Please address in your response whether the scaling back of this head loss result based on the reduced flow rate can be justified because flow rate determination in the large-scale tank was based ultimately on arbitrary assumptions made during the transport analysis. The discrepancy in flow rate for this test indicates that too little debris may have been assumed to transport to the remote strainer (versus the main strainer) and that a higher flow rate would occur at the main strainer, presumably with slightly less debris. In other words, it appears to be a non-converged solution.*

Response:

For the first part of this RAI, our intent was to demonstrate that the calculated main strainer only head loss value from the large scale testing compared favorably with the as-tested head loss value from the main strainer only MFTL testing that was performed.

For the second part of the RAI, there was no scaling back of the head loss result based on a reduced flow rate. The MFTL testing included the main strainer only. For the MFTL testing, we established a constant flow rate to ensure debris bed formation, debris bed compaction, and the resulting head loss could be used to establish the chemical effects bump-up factor. Since we had established a strainer condition that was heavily loaded with debris, we expected that the resulting increase in head loss from the chemical precipitate would bound both strainers. As discussed in the response to RAI 6, shifting debris from the main strainer to the remote strainer will result in a decreased overall system head loss. Therefore, the test methodology that was utilized is considered to be bounding and conservative. Attachment 5 provides a tablulation of the testing performed with the key parameters associated with the testing.

*Coatings Evaluation*

22. *In the licensee's supplemental response, non-original equipment manufacturer alkyds and epoxies are treated as failing as chips in accordance with Keeler and Long Report No. 06-0413. However, the Keeler and Long report is only applicable to degraded qualified epoxies and not unqualified epoxies or alkyds. Please provide additional justification for the assumption that unqualified non-original equipment manufacturer alkyd and epoxy coatings would fail as chips.*

Response:

The Keeler and Long report specifically applies to the epoxy coatings identified as Non-OEM epoxy coatings. These coatings are the qualified coating systems that were applied to substrates (copper and galvanized steel) that renders them as degraded or non-conforming. We fully expect that their failure mode will be as chips of the epoxy system, as demonstrated in the Keeler and Long report. Plant walkdowns did not identify failure of the epoxy coatings applied to these substrates except where mechanical damage had occurred. The Non-OEM alkyd coatings were observed in the plant to be failing as chips where these coatings were applied as color coding to the galvanized steel splice plates of safety related cable trays and galvanized steel conduits.

23. *a) Please provide the characteristics of the paint chip surrogate including the density and type of paint used.*

Response:

The epoxy was Carboline 890, 98 lb/ft$^3$. The alkyd was Rustoleum with an approximate density of 70 – 80 lb/ft$^3$.

*b) Please clarify how the paint chip surrogate simulates the expected coating debris.*

Response:

It is expected that the actual coatings in the plant would fail in chip sizes larger than were assumed in the analysis based on observations and the Keeler and Long report. This would make less of the chips available for transport. It was conservatively decided to have the majority of the chips smaller than the strainer openings. Due to the relatively small quantity of this coatings debris source as compared to the other coatings that are included in the debris generation analysis, it was judged that it was not unreasonable to include coating chips of this size in the strainer head loss testing. The majority of the chips that were used were of a size smaller than the strainer openings. Also, since we are a low fiber plant (latent fiber only), we believed that the introduction of these larger particles would tend to increase the probability of the particulate debris being able to bridge the strainer openings, increasing head loss through the strainer.

*Downstream – in vessel*

24. *Based upon the information provided in the response, it appears that the potential exists for a break location to be submerged by the water in the containment pool, potentially resulting in a flow path for unfiltered pool water to enter the reactor vessel. The centerline for the reactor inlet nozzle is at 614 ft elevation. The maximum containment pool water level is also 614 ft elevation.*

*a) Please address whether the potential for debris bypass into the reactor vessel through this pathway has been analyzed.*

Response:

A specific analysis of the potential for debris introduction into the reactor vessel due to a break location that could be below the maximum flood elevation in containment was not performed. We believed that such an analysis was not necessary since the water will be flowing out of the break location due to ECCS injection flow. At no time is core cooling suspended to allow water to flow back into the vessel. The containment maximum water level analysis utilizes assumptions that maximize the potential containment water level, which is the opposite of the assumptions utilized for the containment minimum water level analysis. One of the key assumptions is the quantity of ice in the ice condenser. Using more realistic values results in a 6 in. to 12 in. lower water level. Another significant contributor is the temperature of the sump pool that is assumed which provides for increased volume of the water. Additional conservatisms within this analysis include available volume from the RWST, RCS, and Accumulators, and the quantity of items within containment that can displace water. At the later stages of the event when injection flow is minimized to maintain core cooling, all debris within the sump pool will have either been filtered by the recirculation sump or settled to the floor of containment. This would preclude the potential for debris to enter the reactor vessel.

*b) Are there any adverse debris effects from submerging other reactor coolant system (RCS) break locations?*

Response:

There are no adverse debris effects as a result of submerged RCS break locations. The only known debris effect from a submerged break location will be the increased turbulence at the break location which results in increased potential for debris transport, which was accounted for in the debris transport analysis as reported on in Section 3.e of the February 29, 2008 supplemental response.

*NPSH*

25. *The submittal stated that the minimum water level calculation included 1/2 of the RCS volume and the volume of the accumulators. It is not clear that these volumes should be credited for all breaks. For example a small-break LOCA could result in the accumulators remaining full for an extended period and the RCS maintaining more than 1/2 of its volume. In addition, the RCS would accommodate a larger mass of water as it cooled off due to increased water density with lower temperature. Based on these observations it is not clear that the levels used in the vortexing evaluation are conservative. It was not clear that the increasing density of RCS inventory as it cooled was considered in the sump level calculations.*

*a) Please provide information that justifies that the sump pool level calculations resulted in realistic or conservative levels for the large- and small-break LOCAs.*

Response:

The supplemental response statement was strictly referring to the large break scenarios. For small breaks, the analysis considered the effects of cooldown, refill, and delayed accumulator volume additions as a function of RCS pressure. Refer to the following description of the containment minimum water level analysis.

The current licensing basis containment sump inventory analysis was performed using the MAAP4 code version 4.0.4.1 (FAI, 1999). The MAAP4 code calculates the behavior of and interactions between the ECCS, RCS and containment following a postulated accident. Consequently, the predicted containment sump inventory reflects time-dependent mass and energy inputs from ECCS/containment spray injection and recirculation, ice melt, RCS holdup, accumulator injection, and water flow between containment compartments. The Cook Nuclear Plant reactor coolant system is represented as a typical Westinghouse 4-loop design available in MAAP4. Two RCS loops are included in the standard MAAP4 model, with one loop including a single steam generator and associated piping, and the other loop including the composite behavior of the remaining three steam generators and associated piping. The spectrum of RCS break sizes evaluated include a Double-Ended Cold Leg (DECL) and a variety of smaller breaks. The MAAP4 primary system break flow model determines mass and energy releases for steam and water flows leaving the reactor coolant system by assuming they are in thermodynamic equilibrium. This characterization of the break flows maximizes water enthalpy, and minimizes steam release to containment atmosphere that is available to melt ice.

The physical arrangement of the D.C. Cook containment is modeled in MAAP4 by 14 nodes with 44 flow junctions coupling the various nodes. Typically, a simple free volume versus height table is used to represent each node, although a detailed volume versus height table is used for the reactor cavity. The flow junctions account for both forced and natural convection flows. Two junctions are included to represent holes in the primary shield wall between the loop compartment and the reactor cavity that accommodate Nuclear Instrumentation System (NIS) reach rods. In addition to the physical arrangement of the Cook Nuclear Plant containment, the ice condenser lower inlet doors were determined to have a major effect on the containment response. The lower inlet doors control the flow of steam entering the ice condenser, and consequently the amounts of condensate and melted ice flowing back to the loop compartment. MAAP4 models the lower inlet door response (degree of opening) as a function of the imposed flow rate consistently with the lower inlet door characteristic.

The objective of the MAAP4 analyses of containment sump inventory was to determine if there was a sufficient amount of water in the containment sump to support recirculation without considering the effects of debris-laden fluid and recirculation sump strainer blockage. The directions of conservatism for key parameters in the containment sump inventory analysis were evaluated and validated by a formal Failure Modes and Effects Analysis that was performed to identify the key parameters and appropriate directions of conservatism. These key parameter values were determined to either minimize the amount of water available to collect in the containment sump or to affect the rate that water accumulated in the containment sump. For example, an assumption that increases the rate of RCS cooldown would increase the amount of water held-up in the RCS and would affect both the rate that water accumulates in containment and the total amount of water available to containment. An assumption that increases heat removal from the lower containment atmosphere would reduce the amount of energy reaching the ice condenser; this would reduce the rate of ice melting and, consequently, the rate that water from ice melt accumulates in the containment.

The modeling assumptions for the containment minimum water level analysis considered those conditions that would result in the least amount of water being available for the containment sump. These included use of a maximum procedurally driven cooldown rate of the RCS along with maximum refill of the RCS for those breaks where inventory in the RCS could be restored. The analysis also considered the accumulators at their minimum pressure and temperature with water addition from the accumulators being controlled by RCS pressure and pressure head driven flow from the accumulators.

The water levels provided for the DEGB, the DGBS, and 2 in. line break in the February 29, 2008 supplemental response represent these conservatisms.

> *b) Please provide the basis for concluding that there are no small breaks near the top of the pressurizer that should be analyzed for sump performance.*

Response:

We will provide additional supporting information for this RAI through revalidation of the Operator response to a break in this location or determination of the specific debris quantities that could be generated to demonstrate that a break in this location is bounded by the DGBS debris quantities, considering the potential for increased hold-up of water in the RCS.

When this was first evaluated four years ago, based on the ability of the Operators to respond, it was concluded that for the maximum 6 in. break, transfer to recirculation would not be required. Discussions with members of the Licensed Operator Training staff confirmed the original conclusion. Even if a break did occur near the top of the fully enclosed pressurizer enclosure, due to the size of the break, its location, and significant structural members within the enclosure, the quantity of debris that would be generated is expected to be significantly less than that generated for the breaks that were specifically analyzed and reported in the February 29, 2008 supplemental response.

c) *If entry into shutdown cooling is being used as a basis to avoid analyzing certain small-break LOCAs, then please verify that operators have the ability to cooldown and depressurize in sufficient time to prevent switchover for all breaks for which less inventory from the RCS and accumulators would reach the sump than was assumed in the licensee's analyses. Please explain how a single failure and the use of non-safety-related equipment are accounted for in this analysis.*

Response:

As described for RAI 25.b), one of the paths will be revalidation of the ability of the Operators to identify, respond, and place the plant in a condition where RCS injection cooling is no longer required prior to the initiation of recirculation. The equipment and supporting systems required to place shutdown cooling in service are all safety related. Since CNP is not licensed as a cold shutdown plant, there are single failures that could prevent placing the shutdown cooling system in service. In the unlikely event that this was encountered, the steam generators with natural circulation flow in the RCS would be utilized to provide the necessary core cooling until the failure in the shutdown cooling system was corrected. The assumed single failure for the containment minimum water level analysis is the failure of one CEQ fan which reduces ice melt in the ice condenser.

d) *If the currently calculated minimum water levels require revision as a result of addressing the above questions, please provide updated vortexing and air entrainment evaluations using conservative submergence values.*

Response:

The currently calculated minimum water level analysis will not require revision.

*Chemical Effects*

26. *The licensee's submittal states that D. C. Cook uses both sodium tetraborate in the ice and sodium hydroxide in the containment spray. Tables 3o1-1 and 3o1-2 indicate that only sodium tetraborate is added to the multi-functional test loop for in-situ chemical precipitate formation in the chemical effects head loss testing. Please provide a justification for not including sodium hydroxide in these tests.*

Response:

The addition of NaOH was unnecessary for this test. Ample quantities of Na and OH existed in the test solution as a result of the sodium aluminate and Sodium Tetraborate additions to the test loop. The sodium aluminate is a strong alkaline which maintains the pH at the specified level of 8.9.

27. *Please explain why the late additions of chemicals into the multi-functional test loop do not impact the measured head loss. These late chemical additions are stated to provide conservatism in that they exceed the calculated plant loading of chemical precipitates. If the chemical additions do not impact the measured head loss, as indicated by the test data, describe what actions were taken to verify that later additions of chemicals were actually forming the intended chemical precipitates.*

Response:

We are continuing to evaluate this question. Once we have established what we believe to be the mechanism associated with this issue, we will contact the staff to discuss our understanding. The one point that we want to make at this time is that the late chemical additions were those that were in excess of the 100% value. As can be seen in the head loss plots for the chemical effects tests, there were significant increases in head loss up to and including the 100% chemical addition. The head loss plots being referred to are Figures 3o13a-1 and 3o13a-2 on pages 303 and 304 of the February 29, 2008 supplemental response.

*VUEZ Testing*

*The NRC staff performed a detailed review of the test procedures used by Alion at the small loops at the VUEZ test facility in Slovakia. The NRC staff concluded (e.g., ML082560233) that it was highly unlikely that the plants relying on this testing could use it as a basis for demonstrating strainer design adequacy to resolve Generic Letter 2004-02. The NRC staff's review did not specifically address testing performed in the larger loop at VUEZ that was used for the D. C. Cook testing. Although some similarities existed in the small-scale and larger-loop test programs, there were also some significant differences. If VUEZ testing is being used as part of the basis to demonstrate the adequacy of the D. C. Cook strainers, then please address the following requests for additional information on this testing below. If VUEZ testing is not being used in the licensing basis for addressing Generic Letter 2004-02, the licensee should state that, in which case the licensee need not address the RAIs that follow.*

Response:

I&M is not crediting the VUEZ testing to support design and licensing basis acceptance of the resolution for GSI-191 and GL 2004-02.

28. *Please provide the following additional information concerning the modeling of debris transport for the VUEZ testing:*

    a) *Please explain the basis for the minimum flowrate of 1 L/min to preclude stagnant regions in the test tank.*

    b) *Please provide a basis for the statement on pages 56 and 64 of 100 of the VUEZ appendix that the water volume was much smaller than the actual plant condition, and therefore the turbulence and velocity in the (test) pool is higher. The relative size of the fluid volumes does not appear to the NRC staff to be directly related to the velocity and turbulence.*

*Please compare the test tank flow characteristics to the velocity and turbulence contour plots for the plant condition provided in the February 2008 supplemental response.*

c) *Please state whether agitation or manual stirring of the tank was performed during the testing, and please describe the direction that the recirculation discharge flow entered the large tank relative to the opening of the pocket strainer.*

d) *Please provide photographs of the tank floor at the completion of the test. Please provide the estimated quantity of the debris that settled on the tank floor, and state whether any of the settled debris was manually pushed into the strainer pockets.*

e) *Please discuss how the reduced velocities used during debris bed formation affected the settling of debris in the test tank. For instance, the licensee's supplemental response (e.g., page 74 of 100) indicates that debris settled in tank, particularly prior to the initiation of full recirculation flow. Please state the basis for allowing debris settlement at strainer approach velocities that are significantly less than the prototypical value.*

29. *Please explain how the containment spray flow for the first 25 minutes of the experiment was scaled, and the basis for the flow rate that was chosen.*

30. *Debris does not appear to be prepared as fines in the photograph provided in the Alion test report (pg. 66). Fiber is conservatively expected to be only individual fibers because it is all latent debris. Calcium silicate insulation at the strainer is analytically expected to be 86% fines and 14% small pieces. Similar observations can also be made for Marinite debris. These important debris sources do not appear to have been prepared per the plant-specific debris transport results.*

    *Please demonstrate that the debris sources used for the VUEZ testing were eventually prepared into a representative form. Photographs, if available, showing the as-prepared debris slurries or of the debris during the addition process that show an appropriate form of this debris immediately prior to the addition to the tank would be helpful in making this demonstration.*

31. *Debris predominately entered the bottom row of pockets as evidenced in the photo on Page 67 of the Alion test report. The debris used for this testing should have been very nearly 100% fines (although some calcium silicate is small pieces). Although there may be some bias toward the bottom pockets during a LOCA even for fines, based on the photo, the biasing toward the bottom pockets seems much more pronounced than expected by the NRC staff. Such significant non-uniformity can be attributed to either non-representative debris preparation or the non-prototypical introduction of the debris so close to the bottom strainer pockets that it approached the strainer on a non-representative flowstream into the bottom pockets nearest the debris addition line.*

    a) *Please provide additional photos of the debris accumulation on the strainer that more clearly show the distribution of the accumulated debris on the strainer.*

    b) *Please identify the level the water was when the debris was being added, and identify whether the water level was representative of the plant condition at that time.*

32. *All of the debris for the VUEZ test appeared to be added during the pool-fill phase. This approach appears to be non-conservative because of the lower velocities during the fill-up phase (2/3rds of the value during recirculation). This lower flow rate through the strainer would lead to reduced debris bed compression. Furthermore, it is not clear whether a representative water level modeling was used. The use of a non-representative water level would further reduce the velocity during bed formation and further contribute to reduced bed compression. Additionally, due to pump cavitation, the flow in the VUEZ loop had to be substantially reduced during the debris bed formation process, which resulted in a bed being formed at velocities substantially lower than even the reduced velocities during pool fill.*

    *a) Please address the potential for a non-prototypical non-uniform debris distribution on the 2x2 pocket strainer module as a result of the above debris addition practice, with more debris going toward the bottom pockets as well as some piling of debris at the pocket openings rather than the formation of a thin bed.*

    *b) Please also address the potential for reduced debris bed compression due to non-representative test conditions that had the potential to underestimate the potential limiting head loss for the plant condition.*

33. *Similar to a staff observation for the small-scale VUEZ test loops, when taken in aggregate, uncertainties are not negligible on the VUEZ large scale test apparatus:*

    *a) Approximately 1% of volume is discarded due to sampling*

    *b) Approximately a 3% reduction in head loss because less calcium silicate debris was added to test than revised calculations showed.*

    *c) Temperature uncertainty is +/-5°F*

    *d) Flow measurement uncertainty is 5%*

    *e) Pump flow uncertainty is 5%*

    *Please explain how uncertainties have been accounted for in the application of the head loss results from the VUEZ testing.*

34. *Please explain why the head loss increased early in the head loss test to a fraction of a kPa (see figure 7.2-14) before the official start of the test.*

35. *Please identify the concentration of the debris slurry used for the VUEZ tests and the degree to which agglomeration of the debris in the slurry affected the prototypicality of the test debris.*

Draft

# Attachment 3

## Margins and Conservatisms Evaluation

## 1 Introduction

The purpose of this document is to demonstrate how the Cook Nuclear Plant ECCS is conservatively designed and operated with respect to the requirements of 10 CFR 50.46 following completion of the corrective actions associated with the resolution of GL 2004-02 (GSI-191).

As discussed at public meetings on the topic of GSI-191 issue resolution, the defined course of action was for licensees to provide, as part of their supplemental responses to GL 2004-02, identification of the margins and conservatisms that exist for the various aspects of the issue. These margins and conservatisms are to be provided to offset the uncertainties that could exist within the analysis or testing approach taken by the licensee. The supplemental responses provided by the licensees were to be reviewed by the NRC technical staff with any questions resulting from those reviews brought forward to the Independent Review Team (IRT). The described charter of the IRT was to assess the questions provided by the Staff in light of the margins and conservatisms provided by the licensee to determine if "Reasonable Assurance" could be established that the licensee had demonstrated that the ECCS functions of 10 CFR 50.46 would be met.

## 2 Design Basis Event Scenarios

### 2.1 Overview

The following describes the CNP containment design and the sequence of events that occur following a LOCA inside the CNP containment (either unit). The same sequence of events occur within containment regardless of the size of the break for those breaks considered within the boundaries of GSI-191, as defined by NEI 04-07. The only significant difference between a double ended guillotine break of a 2 inch diameter line and a 30 inch diameter line is the time it will take for various containment parameters to change and actions to be taken to place the ECCS and CTS in the recirculation mode of operation.

CNP Containment Design

The CNP ice condenser containment consists of four uniquely defined and separated volumes: 1) upper containment, 2) ice condenser, 3) lower containment, and 4) reactor cavity. Refer to the February 29, 2008 Supplemental Response, Attachment 4, Figures A4-2 through A4-10 for illustrations of various views of lower containment and a plan view of upper containment.

The upper containment area (Figure A4-2), which does not contain any high energy piping, is physically separated from the lower compartment by the divider barrier and the ice condenser.

The ice condenser forms an approximate 300° arc around containment between the containment wall and the crane wall. The ice condenser has 24 paired doors in the lower containment area that will open following a pipe break allowing for suppression of the initial pressure surge in containment. There are also doors just above the ice bed and at the top of the ice condenser section to allow steam and non-condensable gases to vent to the upper containment volume.

The lower containment volume contains both the loop compartment inside the crane wall and the annulus area between the crane wall and the containment wall. The crane wall that separates these two regions is three feet thick. There are ventilation openings in the crane wall which are above the maximum flood elevation of containment. These ventilation openings provide for the supply of cooled air to the loop compartment from the containment lower ventilation units, and also provide a relief path for the mass and energy release from a HELB for short term containment subcompartment pressurization considerations. Within the loop compartment above nominal elevation 648 ft are the SG and PZR enclosures. These enclosures utilize the crane wall as one part of the enclosure with cylindrical concrete walls forming the rest of the enclosures. Each of these enclosures has a concrete roof, the top of which is at nominal elevation 695 ft. The cylindrical wall sections and the roof comprise a portion of the divider barrier separating the lower containment from the upper containment. The loop compartment is surrounded on its outside perimeter by the crane wall. The primary shield wall and refueling cavity walls are on the inside perimeter of the loop compartment. The nominal distance from the primary shield wall to the crane wall varies from 22 to 23 ft. The nominal distance from the crane wall to the containment wall is 13 ft.

The final volume, the reactor cavity, is the volume that is below (the lower reactor cavity), above (the upper reactor cavity), and around the reactor vessel (annular area). The upper reactor cavity is bounded by the primary shield wall, the vertical bulkheads, and the CRDM missile shields. The primary communication path between the lower reactor cavity and lower containment via the overflow wall exists only after water level in either of the volumes exceeds the 610 ft elevation. This level is approximately 11.2 ft above the lower containment floor (where the recirculation sump strainers are located) and approximately 42.3 ft above the lower reactor cavity floor. A secondary communication path exists between the loop compartment and the lower reactor cavity. This path is through the sleeves in the primary shield wall that contain the hardware to position the ex-core nuclear instrumentation in the operating or maintenance positions. The containment liner is attached to the exterior containment wall concrete.

## Event Sequence

All postulated pipe break LOCAs for which sump recirculation would be required would take place within the loop compartment, which is the area inside the crane wall, or in the reactor cavity. For an LBLOCA, once water level in the loop compartment exceeds approximately 4 in. during the injection phase, debris laden water would begin to flow through the main strainer into the recirculation sump. When the level in the recirculation sump reaches slightly above floor level (598 ft 9 3/8 in. elevation), strained water from the recirculation sump would begin to flow through the waterway toward the remote strainer. Initially, this would only fill the waterway until the water level reaches approximately 8 1/2 in. above the floor, the height of the lowest set of strainer elements in the remote strainer. When the loop compartment water level exceeds this height, strained water would begin back-flowing out of the remote strainer. A significant quantity of debris laden fluid would be transported to the main strainer, partially loading it with debris. During this pool fill (injection) phase, the calculated maximum reverse flow rate is approximately 6400 gpm.

Debris laden water would also flow from inside the loop compartment to the debris interceptor installed to protect the 10 in. diameter flow holes through the overflow wall. This flow into the area between the overflow wall and the curb at the annulus side of the crane wall opening would continue until the level reached approximately 12 in. above the floor. This is the height of the curb on the annulus side of the overflow wall area. By the time this level is reached, water flow out of the remote strainer would have been established.

Actuation of the containment spray system (CTS) in containment would have occurred when lower containment pressure reached a nominal 2.9 psig. CNP's design has CTS spray in the upper containment volume, loop compartment, and annulus region. The CTS spray in the containment upper compartment would primarily return to the loop compartment via the three drains in the lower refueling cavity. Some of the spray would also flow to the two containment equalization/hydrogen skimmer (CEQ) fan rooms. The water would drain through the new debris interceptors covering the drain line openings and down the CEQ fan room drain lines. In Unit 1, the CEQ fan room drain lines lead to the annulus drain system which flows to the annulus pipe tunnel sump. The pipe tunnel sump contains a flow opening to allow water to flow into the lower containment annulus region. In Unit 2, the CEQ fan room drain lines lead to the lower containment sump. The lower containment sump contains a flow opening to allow water to flow into the loop compartment.

When the RWST reaches 20% level (approximately 18 to 20 minutes after the LBLOCA, approximately 45 minutes after the 2 in. line break), the operators will manually initiate recirculation core and containment cooling flow. This sequence, as described in CNP's UFSAR (Section 6.2.2), results in the securing of the low head RHR, and CTS pumps. The intermediate head SI pumps and high head CCPs continue to draw from the RWST and inject into the RCS. The RHR and CTS pumps are realigned to take suction from the recirculation sump. At the time of initiation of recirculation flow, the water level in lower containment is approximately 7.7 ft above the floor (606 ft 6 in.) for the DEGB (LBLOCA). For the DGBS, the water level would be approximately 6.9 ft above the floor (605 ft 8 in.). For a 2 in. line break, the water level would be approximately 5.1 ft above the floor (603 ft 11 in.). Once water level in the RWST decreases below 11%, the SI and CCPs are realigned to receive their suction from the RHR pumps (piggyback mode).

With recirculation flow established, the reverse flow through the remote strainer will cease. Water will then flow into the sump through both the main strainer and through the remote strainer and waterway. Since a pipe break requiring recirculation would not occur in the annulus, the debris that would be available to the remote strainer would be the debris that was transported from the loop compartment to the annulus region from the initial blowdown, the debris that was transported to the annulus region through the overflow wall flow holes during pool fill, and latent debris resident in the annulus prior to the event. As a result, the remote strainer would be essentially debris free at the beginning of recirculation. Due to the waterway head loss, the preferential flow path would be through the main strainer until the main strainer became substantially blocked by debris. The division of flow between the main and remote strainers would therefore be a function of the head loss through the associated strainer and the waterway.

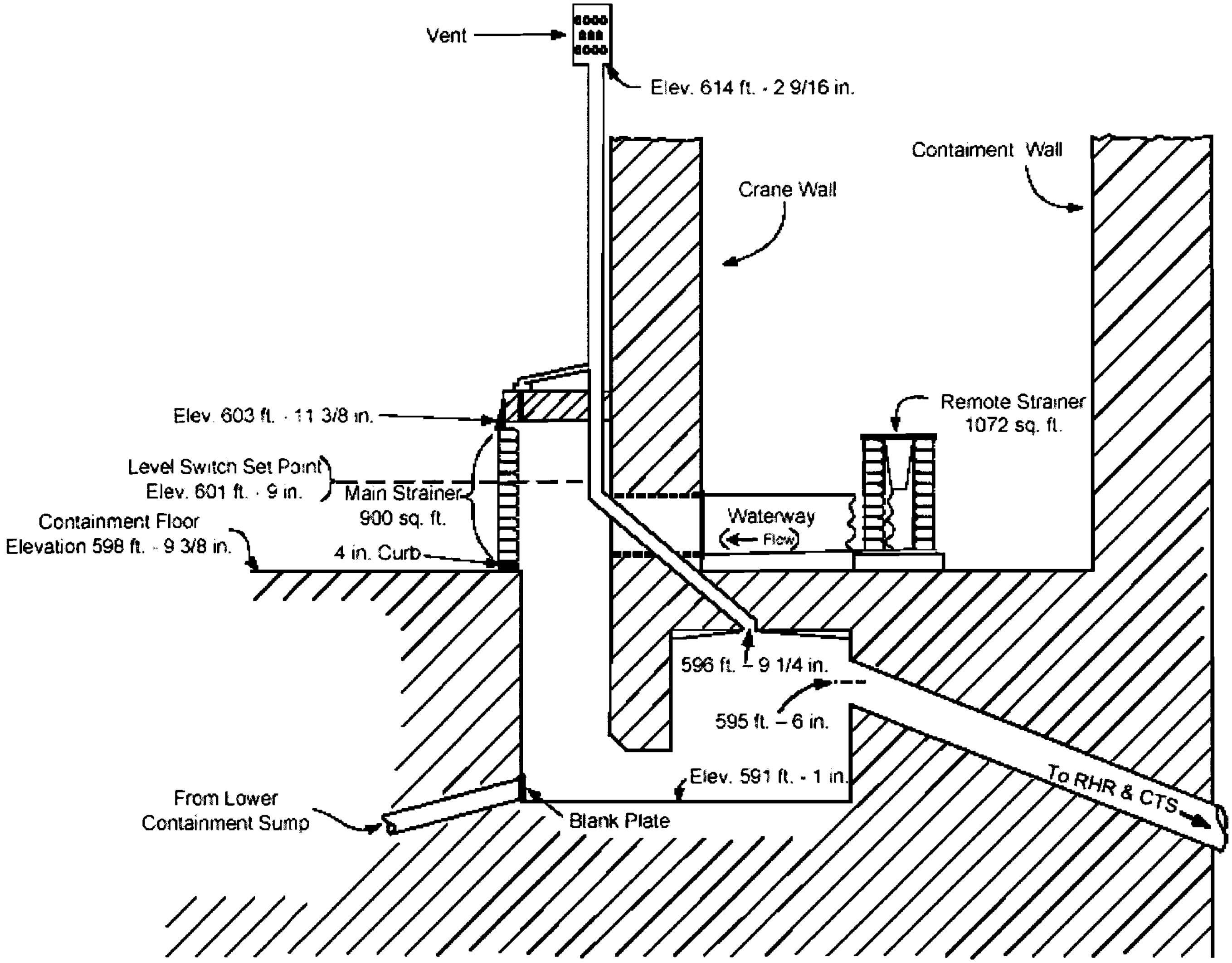
For the DEGB, water level in lower containment would decrease from the level that existed at the beginning of recirculation flow (7.7 ft) until the minimum water level of 5.9 ft above the floor (604 ft 7 in.) is reached. For the DGBS, a minimum water level of approximately 5.6 ft above the floor (604 ft 6 in.) is reached. These decreases in water level are the result of a conservatively assumed minimum ice melt and the flow into the lower reactor cavity via the ex-core nuclear instrumentation position device sleeves in the primary shield wall. For the 2 in. line break, a minimum water level of approximately 5.1 ft above the floor (603 ft 11 in.) is reached.

A cross-section view of CNP's recirculation sump is provided on the following page. CNP's sump is a fully vented sump in that the vent extends above the maximum predicted containment flood elevation for both units. The absolute limit for continued operation of the recirculation sump to satisfy core and containment cooling requirements is the prevention of significant air entrainment in the suction piping supplying the ECCS and CTS pumps. This means that the rear chamber of the recirculation sump must remain essentially water solid to prevent slugging air into the suction pipes exiting the sump, and significant air entraining vortices must not develop within the recirculation sump that would allow the transport of gas bubbles to these same suction pipes. With the rear chamber and a portion of the vent pipe remaining full of water, the potential for a gas intrusion event originating in the sump and challenging the operation of the pumps is negligible. The minimum level in the recirculation sump to ensure NPSH required for the most limiting pump is at approximately 2 ft below the centerline of the suction piping at its connection to the recirculation sump. As stated above, a water level this low would result in significant air entrainment into the operating pumps.

**Draft**

**Attachment 3**

Figure 1 General Arrangement of Recirculation Sump



## 3 Debris Generation / Zone of Influence

### 3.1 Methodology

a. The insulation debris sources were determined through extensive walkdowns to be different between CNP Unit 1 and Unit 2. The insulation debris sources for Unit 2 were determined to be bounding for both units and were used as the input for analysis and testing. The total quantity of Cal-Sil insulation in Unit 2 that could be subjected to a LOCA jet is approximately 50% greater than that in Unit 1.

### 3.2 Key Conservatisms / Margins

b. For Cal-Sil insulation, the predicted quantity of Cal-Sil fines that would be available at the recirculation sump strainers versus the quantities that were used for testing were less for both the DEGB and DGBS. For the DEGB and DGBS, the tested quantity was approximately 3% greater than the predicted quantity.

c. There is no fibrous insulation within the areas of containment that could be subjected to a LOCA jet.

d. For Marinite board, a ZOI of 9.8D was used which is conservative to the tested ZOI of 5.6D which did not generate any debris. This is also conservative to the information contained within NUREG/CR-6772 which established a destruction pressure of 64 psi for Marinite board (a ZOI of approximately 3D).

e. The debris generation analysis conservatively determined the limiting break location by considering the combination of problematic insulation types as the significant contributors to strainer head loss.

f. A ZOI of 5D was conservatively applied to qualified coatings which is greater than the 4D recommended by WCAP-16568-P.

g. For the small amount of Min-K installed at CNP, no credit was taken for the stainless steel flashing installed around the Min-K.

In summary, the debris generation analysis conservatively maximized the quantity of debris that could be generated following a LOCA. This resulted in conservatively increasing the strainer head loss and increasing the potential for wear and blockage of downstream components.

## 4 Latent Debris

### 4.1 Methodology

a. The quantity of latent debris to be considered for contributing to strainer head loss was conservatively established at 200 lbs in containment, with 15% assumed to be fibrous.

b. The contribution of latent debris on vertical surfaces was conservatively assumed to be 30 lbs.

c. 80 latent debris samples were taken in Unit 1 during separate outages and 104 samples were taken in Unit 2 during separate outages. The samples were all taken in areas that are not routinely cleaned as part of containment closeout activities or had some accumulation of oily residue (below RCPs, on polar crane rails).

### 4.2 Key Conservatisms / Margins

a. The calculated quantity of latent debris was determined to be 161.72 lbs for Unit 1 and 117.26 lbs for Unit 2. This represents a margin of 38.28 lbs for Unit 1 and 82.74 lbs for Unit 2. The assumed quantity of 200 lbs represents a 23.7% increase for Unit 1 and a 70.6% increase for Unit 2.

b. Out of the total of 184 latent debris samples collected in both units, there were only a few that had a visible fiber in the sample. In these cases, the fibrous material appeared to be human hair or lint.

c. Sacrificial strainer areas were established for the main and remote strainers of 76 $ft^2$ and 83 $ft^2$, respectively. The design basis value assumed for strainer blockage is 26.06 $ft^2$ for the main strainer and 29.22 $ft^2$ for the remote strainer. The determined main strainer blockage, based on walkdown information, is 17.27 $ft^2$ for Unit 1 and 15.51 $ft^2$ for Unit 2. The determined remote strainer blockage is 25.13 $ft^2$ for Unit 1 and 24.31 $ft^2$ for Unit 2. These values provide a margin of 58.73 $ft^2$ and 60.49 $ft^2$ for the Unit 1 and Unit 2 main strainers, and a margin of 57.87 $ft^2$ and 58.69 $ft^2$ for the Unit 1 and Unit 2 remote strainers.

In summary, the latent debris analysis conservatively increased the quantity of latent debris available for strainer head loss and increased the potential for wear and blockage of downstream components. Additionally, the latent debris analysis conservatively established values for strainer blockage that resulted in a conservatively reduced strainer area which also leads to increased strainer head loss.

## 5 Debris Transport

### 5.1 Methodology

a. The debris transport methodology utilized as-built containment information to model flow paths and significant obstructions to flow within lower containment.

b. The debris transport methodology modeled the main and remote strainers and determined the flow split between the two strainers as a function of head loss through the system. The methodology also modeled the flow path through the flood-up overflow wall holes and the surrounding structural features.

c. Additional information regarding the debris transport methodology is contained within the February 29, 2008 and August 29, 2008 Supplemental Responses to GL 2004-02.

## 5.2 Key Conservatisms / Margins

a. Debris in the sump pool would not transport to the reactor cavity, an inactive volume, while it was filling through the nuclear instrumentation detector positioning device penetrations.

b. The debris transport methodology established transport fractions that resulted in greater than 100% of the debris source available for transport to the strainers. These were the values that were used for strainer head loss testing. The materials and quantities are provided below.

| Debris Source | Quantity | Percentage of Total (for that material) |
|---|---|---|
| Unqualified OEM Epoxy | 2.03 lbs | 12% |
| Unqualified OEM Alkyd | 2.98 lbs | 4% |
| Unqualified Non-OEM Alkyd | 0.58 lbs | 17% |
| Cold Galvanizing Compound | 217.7 lbs | 28% |
| Particulate Latent Debris (1) | 13.6 lbs | 8% |
| Fibrous Latent Debris (1) | 2.4 lbs | 8% |

(1) Quantities and percentages based on the 200 lbs default value.

c. There was no debris hold-up on containment equipment or structural elements, including debris that could be blown into the ice condenser, as a result of the LOCA.

d. 100% of the debris sources in upper containment would fail and be transported to the area of the refueling canal drains.

e. It was conservatively assumed that debris that had not been transported to the annulus or the main strainer during pool fill (injection phase) would be evenly distributed within the loop compartment. This is conservative because a significant portion of the debris in the loop compartment would either be at, or near, the overflow wall debris interceptor and main strainer at the end of pool fill, therefore reducing the quantity of debris available for transport to the main strainer or remote strainer upon initiation of recirculation flow.

f. All unqualified coatings, labels, and other miscellaneous debris sources in containment were assumed to be in the containment pool at the initiation of recirculation. This is conservative in that many of the materials will require a substantial period of time for them to fail, if they would in fact fail.

g. The debris transport analysis conservatively did not consider the debris interceptor installed at the flood-up overflow wall flow openings as a debris limiting device for those fines and other debris sources that would be capable of being transported to the remote strainer. In other words, no credit was taken for the filtering capability of the debris interceptor (DI) and the RMI bed that would exist at the DI.

h. The debris transport analysis conservatively modeled the vertical face of the DI as being fully blocked during recirculation transport. The effect of this was to maximize the velocity of the pool water passing through the design 6 inch opening at the top of the DI increasing the transportability of the debris sources in the pool.

i. The debris transport analysis conservatively maximized the effects of water sources entering the containment pool to increase the turbulence of the pool which led to greater transport fractions for the debris sources.

j. The debris transport analysis conservatively neglected the capture of fibrous and particulate debris by the significant quantity of components that exist in the annulus including the debris gates that exist on either side of the approach area to the remote strainer.

k. The debris transport analysis conservatively neglected the potential for settling out of debris in the quiescent area at the Reactor Coolant Drain Tank pit.

In summary, the debris transport analysis provided conservative values for transport of debris to both the main and remote strainer in excess of the quantities that would be generated, and conservatively discounted the prototypical capture of fines and other small debris by the installed DI and the RMI that would be distributed within the loop compartment. Additionally, the debris transport analysis conservatively maximized pool turbulence to increase the suspension and transport of debris within the containment pool.

## 6 Containment Coatings

### 6.1 Methodology

a. To determine the quantity of unqualified coatings in containment, two separate efforts were undertaken.

   - The first was to perform walkdowns to determine the types of components that were coated with materials for which qualification of the coating system could not be established. Following these walkdowns, design drawings and databases were used to establish conservative values for the number and size of the components. This information was then used to calculate a conservative surface area for the unqualified coatings using conservatively established coating thicknesses. These were the values that were used for determining the total quantity of coatings that would be input into the debris generation analysis, and when combined with the debris transport analysis, establish the quantity of coatings to be used for strainer head loss testing.

   - The second was to perform more extensive walkdowns of containment to catalog the unqualified coatings that exist in containment. This effort completed following the strainer testing that was performed.

b. For qualified coatings that would be subjected to a LOCA jet, an extensive CAD model of containment was developed that included the structural elements that exist. The debris generation analysis overlaid the ZOI sphere onto the model which then calculated the affected areas of concrete and steel surfaces.

c. All OEM unqualified coatings outside of the coatings ZOI were assumed to fail initially as paint chips with a thickness equivalent to the original coating thickness. The EPRI report for OEM coating failures documented autoclave DBA tests of non-irradiated and irradiated unqualified OEM coatings that demonstrated that the majority of the failures were as chips. The debris generation analysis assumed that OEM coatings failed as 83 micron particles.

6.2 Key Conservatisms / Margins

a. The assumption that all unqualified coatings are available for transport at the initiation of recirculation results in the most significant conservatism associated with coatings inside containment. The magnitude of this conservatism has been supported by various tests that have been performed in support of the early BWR and current PWR recirculation sump efforts.

b. A ZOI of 5D was used for qualified coatings instead of the recommended 4D from WCAP-16568-P.

c. The EPRI report for OEM coating failures documented testing on various types of unqualified coatings, alkyds, epoxies and IOZ. A 100% failure of all OEM unqualified coatings is conservative, since the EPRI report has indicated that only about 20% of unqualified OEM coatings actually detached as a result of autoclave DBA testing. Detachment is considered failure of a coating system. Any non-detached coatings are not considered failed. This illustrates that assuming 100% failure of OEM unqualified coatings is conservative. The coatings detach initially as chips that have a thickness equivalent to the original coating thickness which is consistent with the EPRI report. The EPRI report concluded from the autoclave tests that the failed coating average particle size was 83 microns for some samples and 301 microns for other samples. These particles were retrieved from the DBA test autoclave from recirculating loop filters, and hence the coating debris was constantly being recirculated throughout the autoclave test. Therefore, an average particle size of 83 microns was conservatively used in the debris generation calculation for unqualified OEM epoxy and alkyd coatings outside the ZOI. Additionally, the report "Failed Coating Debris Characterization" documents use of autoclave test data gathered by the BWROG Containment Coating Committee to simulate LOCA exposure and gain insight into post-LOCA failure mechanisms. The results showed that all but the IOZ paint failed in macro-sized pieces.

d. The non-OEM unqualified coatings outside the ZOI have the same failure rate as the OEM coatings outside the ZOI (100%). Since the non-OEM unqualified coatings are not applied to a correctly prepared substrate, it is expected that these coatings would fail as chips of various sizes. Therefore, the non-OEM unqualified epoxy and alkyd coatings outside the ZOI were assumed to fail with chip sizes of 10% (250 – 500 microns), 80% (500 - 1000 microns), and 10% (1000 – 4000 microns). Autoclave testing (Keeler & Long Report 06-0413, DBA Testing of Coatings Samples for Comanche Peak) indicates that paint chips would be generated in sizes larger than 4000 microns which shows that the distribution used in this calculation is conservative.

e. The cold galvanizing coating used at CNP is an organic zinc material. For determination of debris transport and ultimately strainer head loss testing, the cold galvanizing compound was conservatively assumed to fail as 10 micron particles.

f. The conservatively calculated unqualified coatings quantities within containment are as follows:

| Unqualified Coating Type | Surface Area ($ft^2$) | Weight (lbs) |
|---|---|---|
| OEM Alkyd | 2271.2 | 74.4 |
| OEM Epoxy | 538.0 | 16.9 |
| Non-OEM Alkyd | 105.8 | 3.4 |
| Non-OEM Epoxy | 991.2 | 31.0 |
| Unqualified Alkyd inside 10D ZOI | 57.7 | 1.9 |
| Unqualified Epoxy inside 10D ZOI | 112.0 | 3.5 |
| Cold Galvanizing Compound | 9324.98 | 777.5 |
| Total | 13400.88 | 908.6 |

g. Based on detailed walkdowns performed in the Unit 1 and Unit 2 containments, the surface area of unqualified coatings were determined to be 9393 $ft^2$ for Unit 1 and 6784 $ft^2$ for Unit 2. This provides a margin of approximately 4007 $ft^2$ for Unit 1 and 6616 $ft^2$ for Unit 2. Conservatively assuming the coating thickness is 2 mils DFT, and the density is 94 $lbs/ft^3$ results in a margin of 62.8 lbs for Unit 1 and 103 lbs for Unit 2.

h. DBA testing was performed on the cold galvanizing compound. This testing determined that less than 2% of the cold galvanizing compound failed. Conservatively assuming that 5% of the cold galvanizing compound could fail in containment results in 38.88 lbs of cold galvanizing available for transport to the recirculation sump strainers as compared to the calculated value of 777.5 lbs. This provides a margin of 738.6 lbs of coating debris that would not be available for transport. Use of this margin would result in reducing the unqualified coatings debris available for transport to the recirculation sump strainers from 908.6 lbs to 170 lbs.

In summary, the conservatively determined quantities of unqualified coatings that were assumed to fail and be available for transport at time zero of recirculation is significantly greater than the quantities that exist. This represents a significant conservatism in that the increased quantity of particulate increases strainer head loss and increases the potential for wear and blockage of downstream components. Additional conservatism exists through the use of a ZOI of 5D for qualified coatings in lieu of the 4D recommended by the test report, and the assumption that unqualified coatings will principally fail as small particulate.

## 7 Head Loss and Vortexing

### 7.1 Methodology

a. Head loss testing was performed by the strainer vendor, CCI, at their facilities in Winterthur, Switzerland. All testing was witnessed by a CNP representative.

b. Due to the unique installed strainer configuration for CNP, the debris only strainer head loss testing was performed using a dual sided strainer assembly with the test pool configured to provide equivalent surface areas for the main and remote strainer and locations to introduce the appropriate debris quantities to each strainer section.

c. CNP performed multiple tests to determine the bounding debris only head loss for both the DEGB and DGBS, including extended test durations to ensure head loss had reached a stable value.

d. Since the strainer head loss testing could not model the waterway that connects the remote strainer to the recirculation sump, additional analysis was performed to establish an overall system head loss for the installed strainer configuration.

e. Testing was performed with a methodology that ensured there would be no near field settling of debris in front of the strainers.

f. Debris was prepared to ensure that individual constituents of the debris source would arrive at the strainer in a non-agglomerated state.

g. Testing for vortices was performed to ensure that air would not be drawn into the strainers.

h. To support the installed configuration qualification, a vortex analysis was performed that demonstrated that air entrainment would not occur within the recirculation sump flow stream.

### 7.2 Key Conservatisms / Margins

a. One of the significant margins established during strainer head loss testing was the inclusion of a 50% increase in strainer system head loss to address uncertainties that could exist as a result of debris distribution, test methodology, or other factors.

b. Margin is also available in the strainer system head loss values as a result of normalizing the results to 68°F (20°C). The margin exists in that at the initiation of recirculation, the containment pool water temperature is at a maximum of 190°F with temperature ultimately decreasing to approximately 100°F. With containment pool temperature at 100°F, the strainer system head loss would be about 30% less than it would be at the normalized value of 68°F.

c. Significant margin is also available as a result of the conservative total debris quantities that were used for testing as compared to the quantities that would be available for transport to the strainers. Considering the margins discussed in Sections 3, 4, 5, and 6 of this document, the expected head loss through the strainer system would be significantly reduced due to the reduction in fibrous and particulate debris that would be at the strainers. The table below provides a comparison of the as-tested values (conservative) and the as-expected (realistic) values for debris quantities.

**Debris Quantities Margin Determination Table**

| Debris Type | Units | DEGB Test Quantity | Actual Quantity Available at Both Strainers | Margin | DGBS Test Quantity | Actual Quantity Available at Both Strainers | Margin |
|---|---|---|---|---|---|---|---|
| Cal-Sil Fines | lbs | 307.665 | 298.82 | | 77.227 | 74.94 | |
| Marinite I Fines | lbs | 0.188 | 0.1894 | | 0 | 0 | |
| Marinite 36 Fines | lbs | 1.5228 | 1.534 | | 1.1285 | 1.136 | |
| Min-K | lbs | 1.52 | 1.536 | | 0 | 0 | |
| Epoxy Paint (inside ZOI) | lbs | 203.585 | 207.4 | | 3.8 | 3.84 | |
| Alkyd Paint (inside ZOI) | lbs | 0.57 | 1.82 | | 0.57 | 0.57 | |
| Unqualified OEM Epoxy | lbs | 19.712 | 16.9 | | 19.712 | 16.9 | |
| Unqualified OEM Alkyd | lbs | 78.416 | 74.4 | | 78.416 | 74.4 | |
| Unqualified Non-OEM Epoxy | lbs | 8.32 | 16.12 | | 8.32 | 16.12 | |
| Unqualified Non-OEM Alkyd | lbs | 4.212 | 3.4 | | 4.212 | 3.4 | |
| Unqualified Cold Galvanizing Compound | lbs | 995.2 | 38.88 | | 995.2 | 38.88 | |
| Dirt/Dust | lbs | 178.5 | 99.67 | | 178.5 | 99.67 | |
| **Total (Particulates)** | **lbs** | **1799.41** | **760.67** | **1038.74** | **1367.09** | **329.86** | **1037.23** |
| | | | | | | | |
| Latent Fiber | $ft^3$ | 13.125 | 7.33 | | 13.125 | 7.33 | |
| Fire Proof Tape Fines | $ft^3$ | 0.057 | 0.0576 | | .057 | 0.0456 | |
| Ice Storage Bag Fibers | $ft^3$ | 0.0273 | 0.026 | | 0.0273 | 0.026 | |
| Ice Storage Bag Liner Shards | $ft^3$ | 0.000236 | 0.00022 | | 0.000236 | 0.00022 | |
| Pieces of Work Platform Rubber | $ft^3$ | 0.0021 | 0.002 | | 0.0021 | 0.002 | |
| **Total (Fibers)** | **$ft^3$** | **13.2116** | **7.41582** | **5.79848** | **13.2116** | **7.40382** | **5.80778** |

As can be seen from the information in the preceding table, there is significant margin between the debris quantities that were used for strainer head loss testing and the actual quantity of debris in containment that would be expected to be available to the strainers during an actual LOCA event. This margin could be further increased by considering the relative absence of fibers within the latent debris inside containment, as discussed in Section 4 of this document.

d. As discussed in Section 8 of this document, the flow rate assumed for testing was approximately 1000 gpm greater than the conservatively determined maximum flow rates for both trains of ECCS and CTS taking suction from the recirculation sump. This 7% reduction in flow represents an approximate 20% reduction in head loss across the strainer.

e. The strainer system head loss analysis conservatively assumed the water level in containment was at its minimum water level at the time of maximum head loss. For the bounding DEGB case, the containment water level at the time of maximum head loss (16 hours) would be approximately 6.1 ft. This provides an additional allowable head loss of 0.1 ft. For the bounding DGBS case, the containment water level at the time of maximum head loss (3 3/4 hours) would be approximately 5.65 ft. This provides an additional allowable head loss of approximately 0.05 ft.

f. The vortex analysis conservatively evaluated the potential for formation of a vortex assuming the water surface being evaluated was in the same chamber of the sump as the suction piping for the recirculation sump. The lowered water surface would actually be in the front chamber of the recirculation sump with the vent pipe for the sump in the rear chamber, and there would not be flow through the vent pipe. Refer to the section view of the sump provided as Figure 1 in this document.

g. Additional conservatism was established for recirculation sump strainer head loss and vortex as a result of installing dual safety related level instruments inside the recirculation sump. The level instruments will alert the operators of a decreasing level inside the recirculation sump that could result from an excessive head loss across the strainer. As part of the resolution path for GSI-191, CNP opted to use the alternate analysis methodology from Section 6 of NEI 04-07. The methodology utilizes the level instruments in combination with a defined and proceduralized flow reduction sequence to ensure excessive air entrainment into the ECCS and CTS pumps does not occur, while maintaining core and containment cooling.

In summary, significant and quantifiable margins exist for determination of strainer head loss as compared to actual and expected plant conditions. Conservatisms also exist to support determination of strainer head loss and requirements to prevent excessive air entrainment or vortexing in the recirculation flow path. Given the margins and conservatisms identified in this section of the document, it is readily apparent that the installed configuration at CNP will ensure the requirements of GL 2004-02 have been met for allowable strainer head loss and vortexing.

## 8 NPSH

### 8.1 Methodology

a. In the 1998 to 1999 time frame, CNP performed a complete reanalysis of containment water level. The analysis performed considered all parameters that would minimize the quantity of water available in the containment pool, including those that would minimize ice melt and minimize displacement.

8.2 Key Conservatisms / Margins

a. The containment minimum water level analysis did not consider the increase in water level that would occur if the equipment that occupies the lower containment volume was considered. This would increase the water level at the initiation of recirculation and during recirculation by at least 2.2 in.

b. For the small break analysis, the assumed maximum RCS cooldown rate of 100°F/hr was used. This minimized the energy discharged into containment thus decreasing ice melt.

c. The RWST temperature was assumed to be at its minimum temperature (70°F) thus increasing the effectiveness of the containment sprays at removing energy from the containment atmosphere, resulting in reduced ice melt.

d. The lake water temperature was assumed to be 33°F, increasing the cooling of CTS during recirculation, increasing its effectiveness at removing energy from the containment atmosphere, resulting in reduced ice melt.

e. Initial containment temperature was at 60°F which minimized the steam partial pressure to be condensed.

f. The assumed mass and energy release from the RCS summed the contribution of water and steam flows leaving the RCS and assumed a thermodynamic equilibrium for this mixture. This maximized the water enthalpy and minimized the steam released to the containment atmosphere.

g. The assumed actuation setpoint for CTS was biased low such that CTS would initiate sooner and provide a greater contribution to cooling the containment atmosphere.

h. The assumed single failure for containment water level analysis was the failure of one CEQ fan. This reduced the flow through the ice condenser, minimizing ice melt.

i. The assumed CEQ fan flow was biased low to minimize flow through the ice condenser thus reducing ice melt.

j. Assumed hold-up volumes were conservatively biased high to minimize water available for the containment sump pool.

k. The flow rate assumed for recirculation flow was approximately 1000 gpm greater than the conservatively modeled maximum flow rate for two train ECCS and CTS operation. This represents an approximate 7% reduction in flow through the strainer system.

l. For the SBLOCA, conservative values were established for the quantity of water remaining within the RCS and not available for sump water inventory.

m. The NPSH analysis assumed a minimum water level of 601.5 ft in the recirculation sump, which provides a minimum NPSH margin of 9.2 ft.

In summary, these conservatisms minimized the driving head for flow through the recirculation sump strainers by minimizing the containment water level, maximized the demand on strainer head loss through establishment of flow rates in excess of those calculated for worst case system operation, and minimized the NPSH available to the ECCS and CTS pumps.

## 9 Downstream Effects – Ex-Vessel

### 9.1 Methodology

a. The methodology utilized for the ex-vessel downstream effects analysis was per the guidance provided in WCAP-16406-P with the conditions and limitations of the NRC SER considered.

### 9.2 Key Conservatisms / Margins

a. For non-pump component blockage evaluation, the size of the strainer openings was considered to be 33% larger than the maximum openings in the strainer.

b. For the component wear evaluation, no credit was taken for particulate debris filtration by the recirculation sump strainers or any other component within the recirculation flow path. This is a significant conservatism since strainer head loss testing repeatedly demonstrated that the recirculation sump strainer effectively reduces the quantity of suspended particulates within the flow stream within a period of time substantially less than the required mission time for the pumps.

c. The pump wear evaluation considered the pumps to be at minimum operability limit (MOL) for hydraulic verification at the start of recirculation.

d. The pump wear evaluation used IST results to predict wear for the pumps to the end of plant life and then added the determined wear due to pumping debris laden water for the mission time for mechanical verification.

e. The downstream effects wear evaluation considered that approximately 28.5% of total cold galvanizing compound would pass through the recirculation sump strainers. This is significantly greater than the less than 2% failure of the cold galvanizing compound that was identified through DBA testing.

f. As described in Section 7 of this document, the use of more realistic values for the debris quantities in containment demonstrate additional conservatism for the methodology that was used for the ex-vessel downstream effects analysis.

In summary, these conservatisms maximized the potential for blockage and wear of components downstream of the recirculation sump strainers, including consideration of the pumps being at their MOL and at the end of plant life wear point.

## 10 Downstream Effects – In-Vessel

### 10.1 Methodology

a. The methodology that was used for performing the in-vessel downstream effects analysis was to utilize the LOCADM code (Excel spreadsheet) to determine the debris buildup on the individual fuel rods. The particulate that was determined to be fines were all considered to pass through the strainer and be available for interaction with the reactor core. The fibrous debris that would pass through the strainer was determined through testing. The quantities of debris that were assumed to pass through the strainer result in a significantly low debris quantity per fuel assembly.

### 10.2 Key Conservatisms / Margins

a. The debris quantities used for consideration of the potential for adverse interaction with the reactor vessel and fuel were conservatively established as described in Section 7 of this document.

In summary, the in-vessel downstream effects evaluation that was performed has demonstrated that a coolable geometry will be maintained within the reactor vessel and fuel, and that considerable margin exists between the analysis values and the actual plant values for those debris sources that could contribute to adverse effects.

## 11 Chemical Effects

### 11.1 Methodology

a. The methodology that was used to determine the chemical effects impact was that provided in WCAP-16530-NP.

b. Chemical effects testing was performed at CCI's MFTL facility using the chemical injection into the loop methodology.

c. Chemical effects testing was also performed at ALION's Vuez test facility using the large scale test facility. This testing was an 30-day integrated chemical effects test.

### 11.2 Key Conservatisms / Margins

a. The CCI chemical effects testing determined a maximum increase in head loss across an established debris bed of 53%. CNP increased this to 70% for the entire recirculation sump strainer system for both the DEGB and DGBS to provide additional margin for uncertainty.

b. The chemical effects testing performed at CCI established a debris bed for the main strainer only which is expected to be the most heavily laden with debris. This provides conservatism in that for this strainer, the head loss will be greater than that for the remote strainer since a higher head loss is indicative of less available flow area through the strainer and a more highly compacted debris bed. With less available flow area, chemical precipitates will more readily block flow through the strainer bed, resulting in a higher head loss increase as a result of the chemical effects.

c. Additional conservatism exists with chemical effects as a result of the debris source term margins and conservatisms discussed in Section 7 of this document. If testing were to be performed with the more realistic debris quantities, the impact of the chemical precipitates would be significantly reduced.

d. Conservatism exists as a result of normalizing the chemical effects test results to 68°F. This is below the expected low temperature of 100°F in the RCS and containment pool.

e. Conservatism exists within the determination of chemical effects precipitates that would be formed as a result of biasing the containment pool pH values higher than would be expected in the post accident containment pool.

f. Conservatism exists as a result of the analysis assumption that 100% of the aluminum fins on the RCP motor air coolers would be subjected to containment spray. Due to the design of the coolers and their orientation with respect to the falling containment spray droplets, not all of the rows of tubes would be subjected to the alkaline spray. These components represent the greatest quantity of aluminum in containment that can lead to the formation of precipitates that can interact with the recirculation sump strainers.

g. The most significant conservatism that exists for chemical effects is that the chemical precipitates will not readily form (for CNP's sources and chemistry) until containment pool temperature has decreased below the precipitate associated value. This will not occur until later in the event at which time the containment water level will be considerably higher, providing a greater allowable head loss, and the flow rate through the strainer system will be reduced as a result of having reduced flow through normal post-accident recovery.

h. The ALION chemical effects testing, even though the results of the testing are not being used to establish design basis, does support the conservative results attained during the CCI testing.

In summary, the chemical effects testing that was performed has demonstrated that CNP will be able to mitigate the consequences of a LOCA considering the inputs and methodologies that were used to establish bounding conditions for determination of the impacts.

## 12 Upstream Effects

### 12.1 Methodology

a. The methodology that was used for performing the upstream effects analysis was to consider all required flow paths that will either return water from upper containment to the containment pool, or will provide the necessary flow path to the main and remote strainers in lower containment.

12.2 Key Conservatisms / Margins

a. The analysis of the upstream effects flow paths determined that specific flow paths would be required to ensure continued core and containment cooling. A Technical Specification License Amendment Request was submitted to and approved by the NRC to include these flow paths. Additionally, debris interceptors were installed at these flow paths to prevent them from becoming blocked by debris in the post accident containment. It was determined that the three refueling cavity drains, which were already monitored by TSs, could not credibly become blocked by post accident debris due to their large size (10 in. and 12 in.), and that if one of them were to become blocked, the remaining two drains were capable of returning containment spray water to the lower containment pool.

In summary, the upstream effects analysis, including the licensing basis and design basis actions, ensure that the water sources for the recirculation function will be maintained.

## 13 Strainer Structural Analysis

13.1 Methodology

a. The methodology that was used for establishing the strainer system for qualification from a structural perspective was performed in accordance with the CNP code of record, AISC 7th Edition.

b. For structural qualification of the strainers, it was assumed that water level would be at the conservatively assumed maximum water level in containment following a LOCA (approximately 15 ft above the lower containment floor) with the strainer completely blocked. Since the recirculation sump at CNP is a vented sump, this provided the maximum differential pressure across the strainer.

c. The strainer structural analysis also considered the different phases of the event including temperature and pulse pressure from the failure of the pressurizer surge line, as well as the flow effects on the strainer system, and seismic effects.

13.2 Key Conservatisms / Margins

a. Use of the code of record provides conservatism within the code itself.

b. The values of the margins for structural analysis were provided in the February 29, 2008 and August 29, 2008 Supplemental Responses to GL 2004-02.

In summary, the strainer structural analysis provides margin to design allowable stresses which ensures that the strainer system will perform its function as long as is necessary following an event which requires its use.

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Attachment 3

## 14 Debris Source Term

### 14.1 Methodology

a. The methodology for ensuring the debris source term will be maintained for the life of the plant was to review all design standards, design specifications, and plant procedures to ensure that sufficient controls were in place to prevent challenging the inputs and analysis assumptions established for the design and licensing basis that reflects resolution of the GSI-191 issue.

### 14.2 Key Actions Taken

a. A principal feature of the debris source term was to establish an engineering program, Containment Recirculation Sump Protection Program. Additionally, many procedures and design documents were revised to include the necessary attributes.

b. To ensure that proposed changes to the plant do not adversely impact the inputs and assumptions associated with the GSI-191 issue resolution path, the FSAR was updated to include the necessary information to provide for effective 10 CFR 50.59 evaluations. These changes to the FSAR included identification of the programmatic controls necessary to maintain the availability of the recirculation function.

### 14.3 Identification and Protection of Margins Associated with the CRS Function

a. Definitions

| | |
|---|---|
| Bounding Value | This value represents the analytical value used in the containment recirculation sump analysis and/or testing. This value is applicable to both units. These values are provided in the UFSAR. |
| | |
| Design Basis Value | This value represents the analytical value for a specific parameter that was used as design input to the containment sump analysis and/or testing. These values were provided in the UFSAR if a bounding value was not utilized. |
| | |
| Design Basis Margin | This value is the difference between the bounding value and the design basis value or is the difference between the as tested value and the design basis value. |
| | |
| Operability Value | This value represents the analytical value for a specific parameter that was used to validate that the design basis value was appropriate. This value typically represents the as installed configuration of containment. In some cases, this value represents quantities applied in the analysis which were not specifically credited in the design basis value. This value may be unit specific. |
| | |

| | |
|---|---|
| Operability Margin | This value represents the difference between the bounding value or design basis value and the operability value. |
| | |

b. To ensure the analysis inputs and assumptions would be maintained for the life of the plant, the February 29, 2008 Supplemental Response to GL 2004-02, included the following commitments.

1. In accordance with CNP procedures, commencing with the Unit 2 Spring 2009 RFO, and for every Unit 1 and Unit 2 RFO thereafter, an assessment of containment debris sources will be completed. (Response to Information Item 3.i.1) This is an ongoing commitment.
2. I&M will perform sampling of latent debris in containment when major work activities that could result in the generation of significant quantities of latent debris are performed, e.g., SG replacement. (Response to Information Item 3.i.1) This is an ongoing commitment.
3. I&M will maintain the necessary programmatic and process controls, such as those described in the response to Information Item 3.i.2, to ensure the ECCS and CTS recirculation functions are maintained in accordance with the applicable regulatory requirements identified in GL 2004-02. (Response to Information Item 3.i.2) This is an ongoing commitment.
4. I&M will change the licensing basis to reflect the mechanistic evaluation of the effect of post accident debris on the ECCS and CTS recirculation function. (Response to Information Item 3.p) This commitment was completed on May 31, 2008.

c. The UFSAR was updated to include the bounding and design basis values for the analysis and testing that was performed. To further define the application of design values and operability values, a CNP specific calculation was developed. This calculation, MD-12-SUMP-001-N, Containment Recirculation Sump Function Margins Document, specifically identifies the debris sources and their application from either a design perspective or operability perspective. The definitions provided above are from that calculation.

In accordance with 10 CFR 50.59 and NEI 96-07, changes to the plant design shall be subjected to the 50.59 process to determine whether a license amendment is required prior to implementation of the change. For proposed changes to CNP that are related to the CRS function, including potential changes to (increase in) debris quantities, an evaluation of those changes will be performed to determine if the proposed change adversely affects the CRS design function. For a proposed increase in debris quantities, the question associated with 10 CFR 50.59(c)(2)(ii), does the proposed change "Result in more than a minimal increase in the consequences of an accident previously evaluated in the final safety analysis report (as updated)" would require evaluation. With the specific debris quantities specified within the UFSAR, more than a minimal increase in debris quantities would result in a license amendment prior to implementation of the change.

d. CNP specific procedures, design specifications, and design standards were revised to prevent the introduction of additional debris sources within containment that could adversely affect the CRS function. Procedures were also revised to require specific monitoring of latent and other debris sources within containment to ensure that containment will be maintained as clean as practical, with no new debris sources, prior to ascension to Mode 4 following a refueling or maintenance outage during which significant work activities are performed. The procedures implement the associated commitments made to the NRC, including referencing those commitments within the procedures.

   Design specifications and procedures related to insulation materials and coatings were revised to prevent the introduction of insulation materials and unqualified coatings into containment that would adversely impact the CRS function. These procedures also contain the commitments made to the NRC which ensure standards associated with the current debris source term methodology will be maintained for the life of the plant.

e. Specific to containment latent debris quantities, the methodology utilized to determine the total quantity of latent debris is as described within the February 29, 2008 and September 29, 2008 Supplemental Responses to GL 2004-02. This debris source quantity was not established as either an as-found or as-left value. What this means is that the latent debris samples were obtained after significant maintenance activities had been completed or were underway in containment during the refueling outages, and prior to performance of the significant clean-up activities prior to ascension to Mode 4 during the outage. This provided a substantially conservative value for latent debris resident within containment. The procedures that govern the debris source term for containment ensure that these design basis values will not be exceeded during those periods when the containment recirculation sump is required to be operable in support of core and containment cooling requirements as a function of ECCS and CTS operability.

In summary, the debris source term actions established the necessary design and licensing basis criteria to maintain the analysis inputs, assumptions, and margins for the life of the plant.

## 15 Conclusion

As discussed in this document, CNP has demonstrated that significant quantifiable margins and conservatisms have been established as part of the success path for resolving GL 2004-02 and GSI-191. CNP has also performed extensive analysis and testing, along with significant changes to the plant, to ensure that the ECCS system will meet the requirements of 10 CFR 50.46 following a LOCA. The same testing and analysis also ensures the CTS system will function to remove containment heat and radioactive iodine from the containment atmosphere for the necessary period following an accident.

**Draft**
**Attachment 4**

**Figure 4-1**

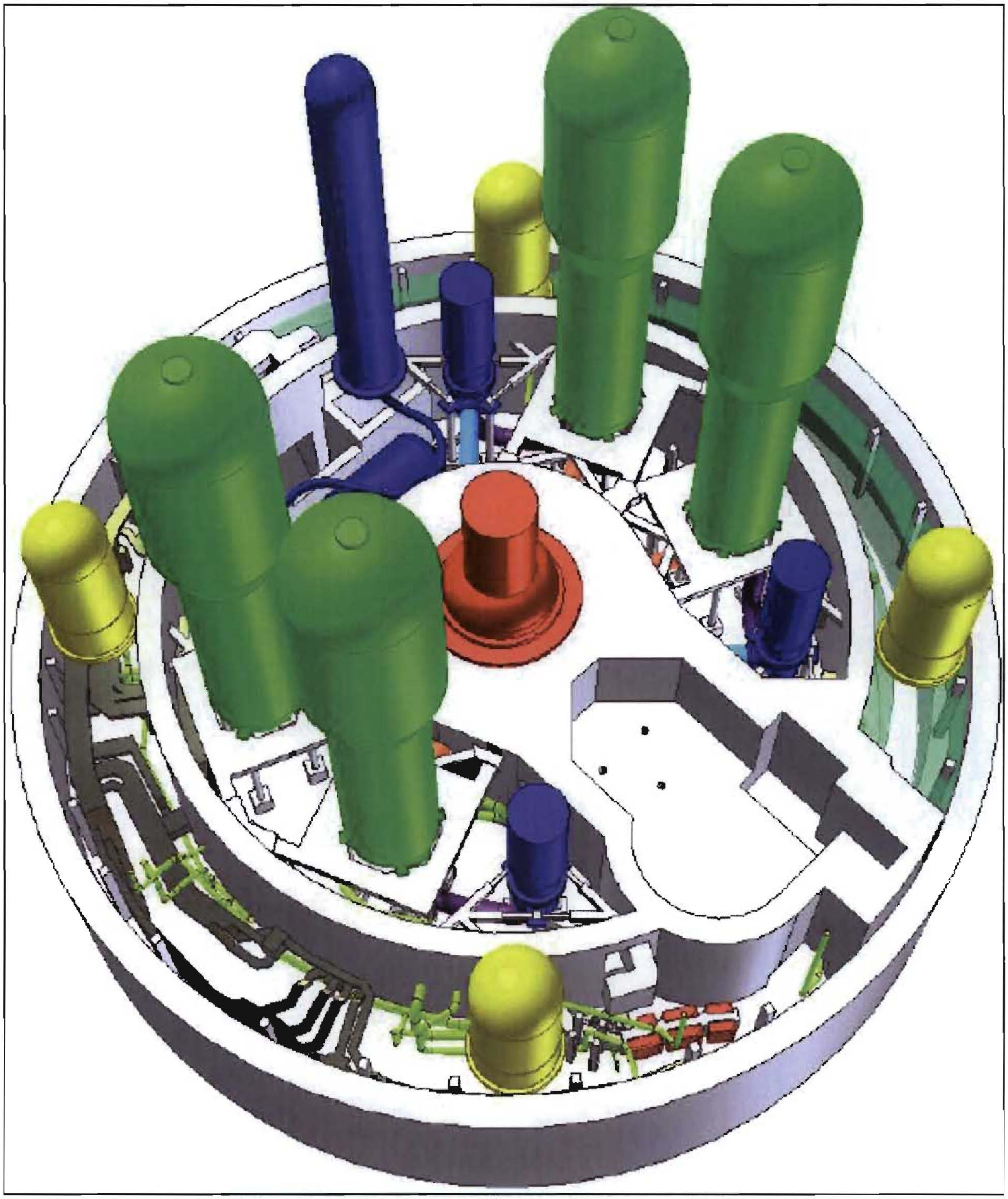

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Figure 4-2

Figure 3e1-8 (Loop 4 Break)

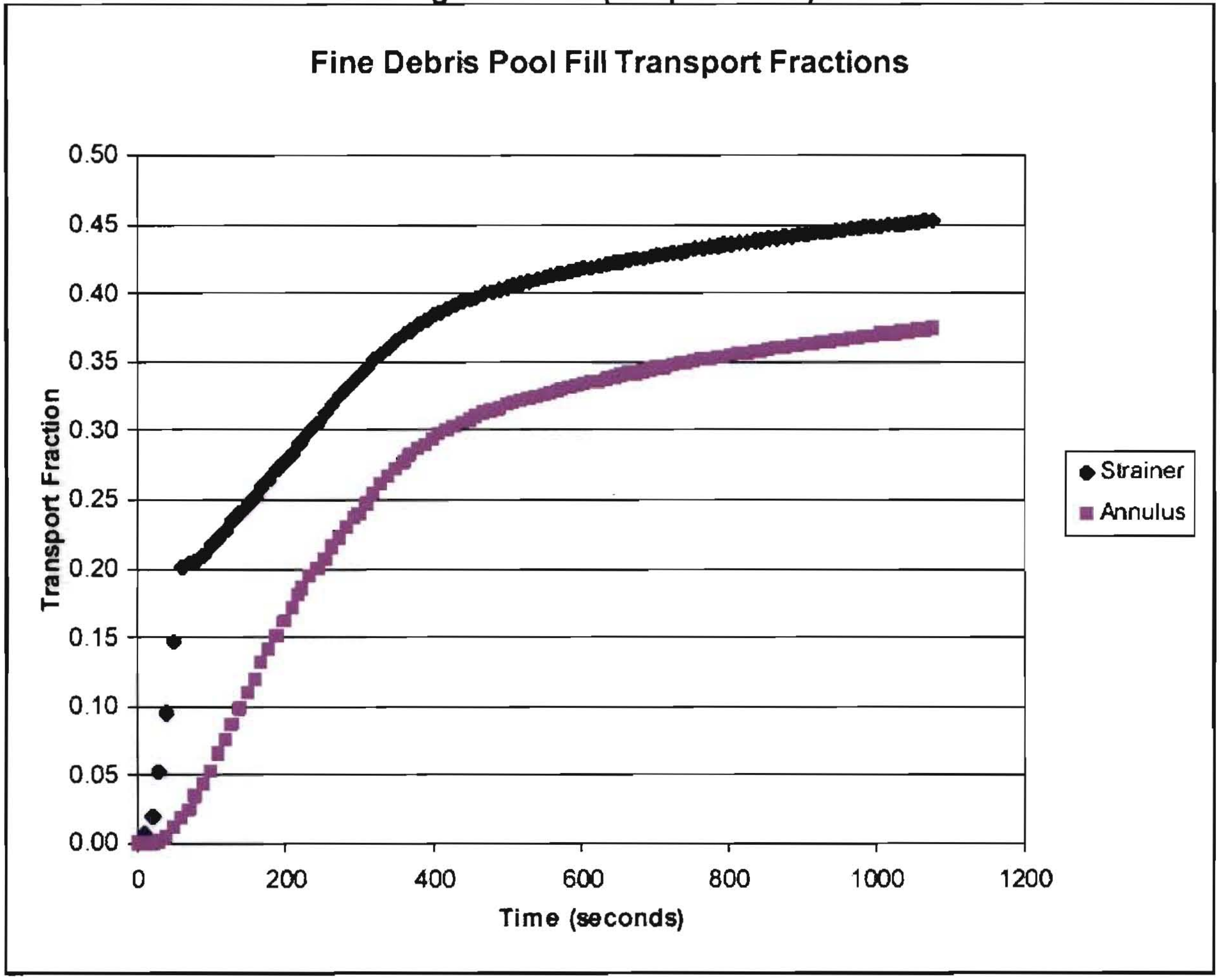

**Figure 4-3**

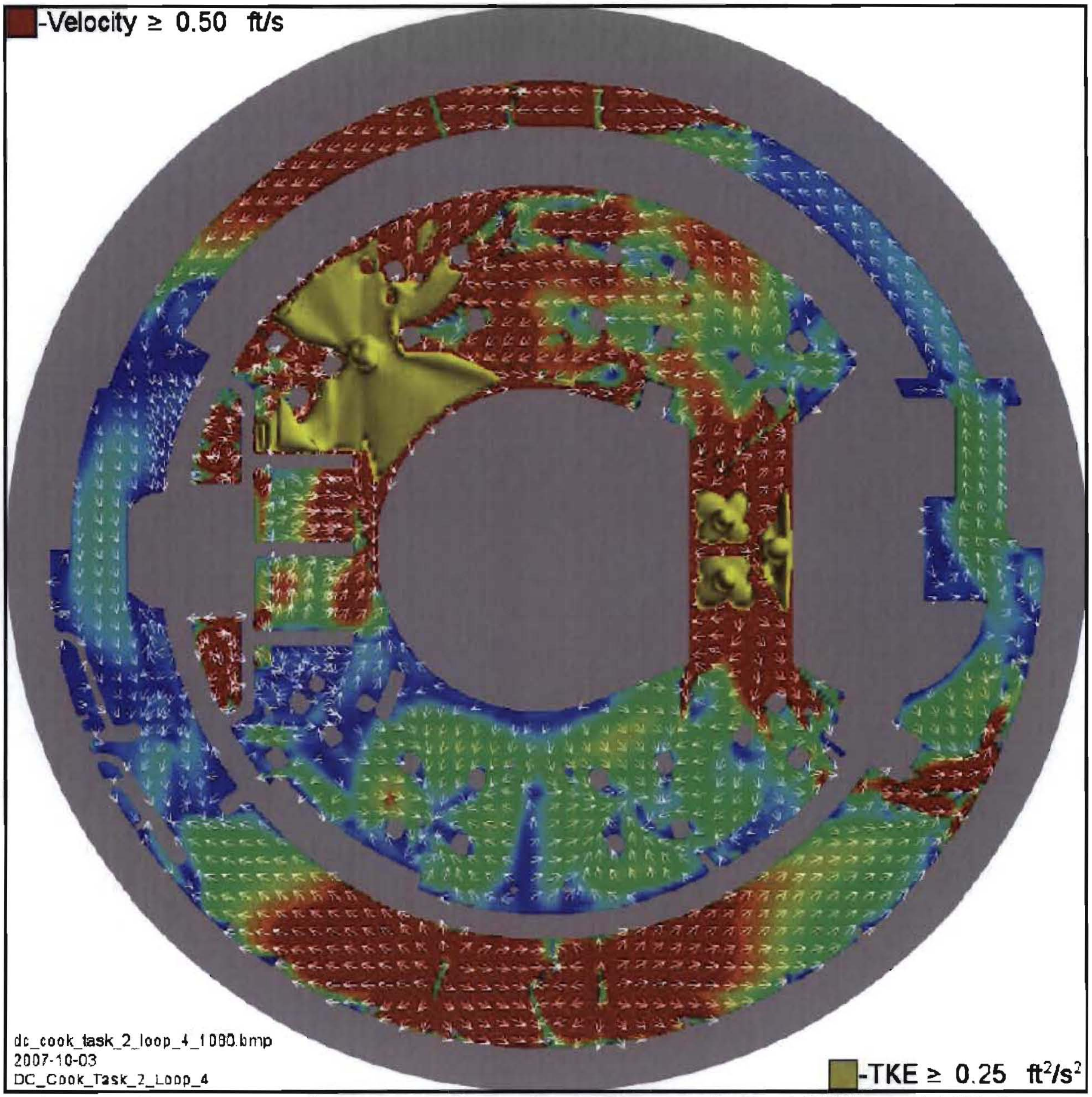

Figure 5.7.90 – TKE and velocity in the pool at 1,080 seconds (Pool Fill Loop 4 CFD Run)

## Draft
## Attachment 4

### Figure 4-4

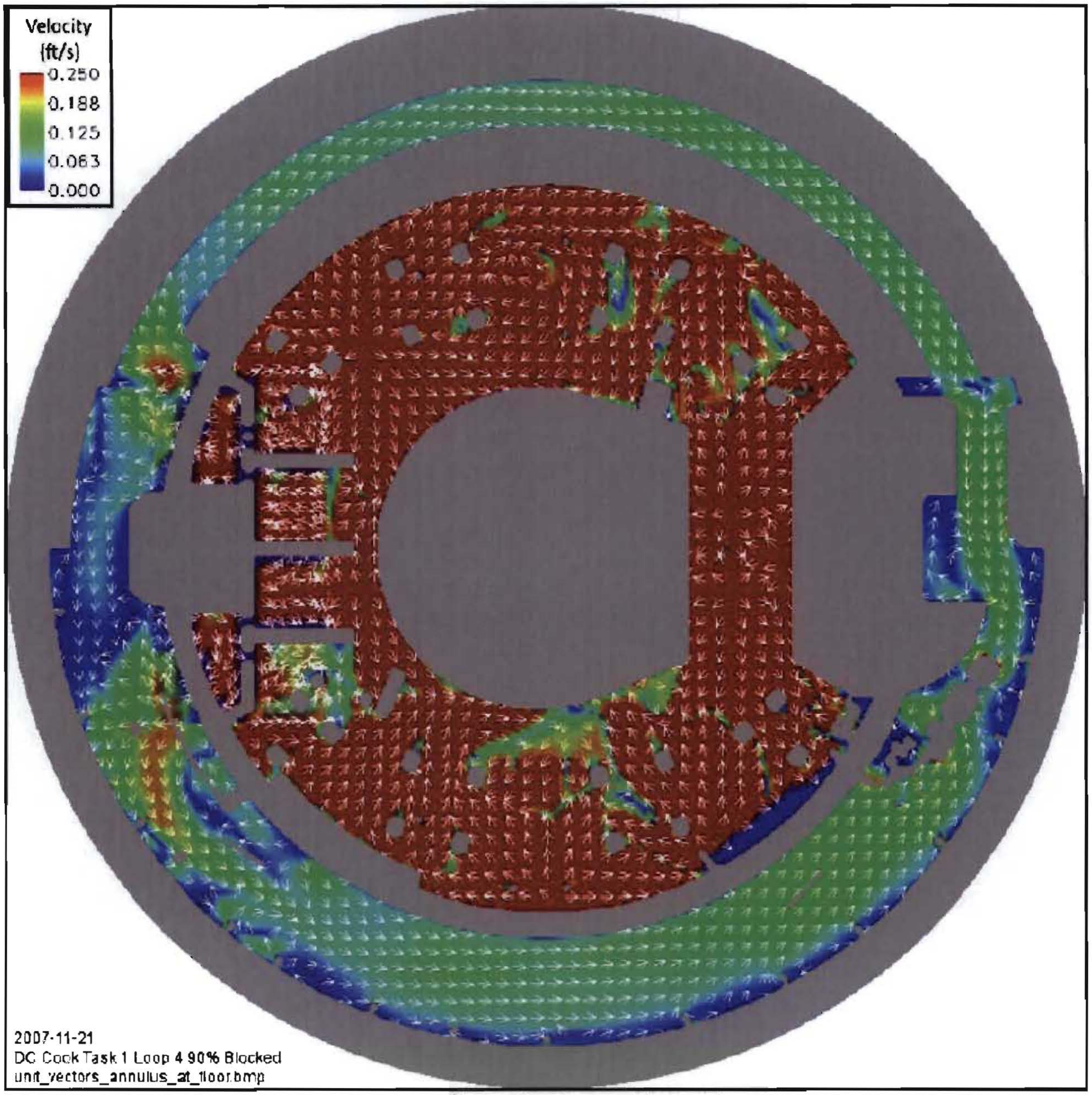

Figure 5.8.46 – Vectors showing pool flow direction, color scale set for annulus (Recirculation Pool Loop 4 90% Blocked Main Strainer CFD Run)

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Attachment 4

Figure 4-5

**Draft**
**Attachment 4**

**Figure 4-6**

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## Attachment 5

| Type of Test | Flow Rate(s) (% of 14,400) | Debris Additions (%) | Max Head Loss (ft $H_2O$) | System Head Loss (ft $H_2O$) | Temp for Max Head Loss (°F) | Comments |
|---|---|---|---|---|---|---|
| **DEGB Standard** | 60, 80, 100, 76.4, 52.8 | 60, 80, 100 (Homogeneous) | 0.942 | 1.046 | 68 | Reductions in flow resulted in reductions in head loss of 38% and 66.5%. |
| **DEGB Event Sequence** | 38.2, 49.3, 50, 100 | Pool Fill, 100 (Homogeneous) | 0.7 | 0.869 | 68 | |
| **DEGB Debris Sequence** | 100 | 1. Fiber: 40, 40, 20<br>2. Cal-Sil, Marinite: 40, 40, 20<br>3. Particulate: 40, 40, 20<br>4. RMI: 50, 50 | 0.4 | Not Calculated | 68 | |
| **DGBS Standard** | 60, 80, 100, 76.4, 52.8 | 60, 80, 100 (Homogeneous) | 0.467 | 0.515 | 68 | Reductions in flow resulted in reductions in head loss of 37% and 66.9%. |
| **DGBS Event Sequence** | 38.2, 49.3, 50, 100 | Pool Fill, 100 (Homogeneous) | 0.6 | 0.819 | 68 | |
| **DGBS Debris Sequence** | 100 | 1. Fiber: 40, 40, 20<br>2. Cal-Sil, Marinite: 40, 40, 20<br>3. Particulate: 40, 40, 20<br>4. RMI: 50, 50 | 0.133 | Not Calculated | 68 | |
| **MFTL DEGB Debris Only** | 67.5 | 100 (Homogeneous, for main strainer only) | 2.67 | Not Calculated | 68 | |
| **MFTL DEGB Debris + Chem** | 67.5, 51.6, 33.8 | Chemicals | 3.83 | Not Calculated | 68 | Reductions in flow resulted in reductions in head loss of 39% and 73% |
| **MFTL DGBS Debris Only** | 67.5 | 100 (Homogeneous, for main strainer only) | 4.43 | Not Calculated | 68 | |
| **MFTL DGBS Debris + Chem** | 67.5, 51.6, 33.8 | Chemicals | 6.80 | Not Calculated | 68 | Reductions in flow resulted in reductions in head loss of 40% and 73% |

Prior to concluding the meeting, it was agreed that an additional public meeting was needed to review each licensee RAI response and determine if the proposed response adequately answers the staff's question, or that additional information is still required. This meeting will tentatively be held at NRC Headquarters on August 12, 2009.

Members of the public were not in attendance at this meeting.

Please direct any inquiries to me at 301-415-3049, or Terry.Beltz@nrc.gov.

*/RA/*
Terry A. Beltz, Senior Project Manager
Plant Licensing Branch III-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-315 and 50-316

Enclosures:
1. List of Attendees
2. Draft Responses to NRC Requests for Additional Information

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