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May 26, 2010

AEP-NRC-2010-39
10 CFR 50.54(f)

Docket Nos.: 50-315
50-316

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, Maryland 20852

Donald C. Cook Nuclear Plant Units 1 and 2
UPDATED FINAL RESPONSE TO
NUCLEAR REGULATORY COMMISSION GENERIC LETTER 2004-02:
POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED WATER REACTORS AND A JUNE 2009 REQUEST FOR ADDITIONAL INFORMATION

This letter provides I&M's updated final response to GL 2004-02 and a June 2009 RAI. The documents referenced in this letter and its attachments are identified in Attachment 1. The abbreviations and acronyms are defined in Attachment 2.

By GL 2004-02, the NRC identified concerns regarding the potential for post-accident debris to impede or prevent the recirculation functions of emergency core cooling and containment spray systems at PWRs. The NRC requested that PWR licensees mechanistically evaluate this potential for their plants and identify corrective measures that would be taken. During the period from 2005 through 2007 I&M submitted correspondence regarding the evaluations performed for CNP to address the concerns identified in GL 2004-02. In February 2008, I&M provided a supplemental response (Reference 1) to GL 2004-02 that superseded previous GL 2004-02 responses. In August 2008, I&M provided a final response (Reference 2) to GL 2004-02. In June 2009, the NRC transmitted an RAI (Reference 15) regarding I&M's February and August 2008 responses. Attachment 3 to this letter provides I&M's response to the June 2009 RAI. Attachment 4 provides updates to the affected sections of I&M's February and August 2008 responses. Attachment 5 provides the regulatory commitments made in this letter in tabular form.

Should you have any questions, please contact Mr. James M. Petro, Jr., Regulatory Affairs Manager, at (269) 466-2489.

Sincerely,

Joel P. Gebbie
Site Vice President

A116
NRR

JRW/alm

Attachments:

1. References
2. Abbreviations and Acronyms
3. Response to June 18, 2009 RAI
4. Updated Final Response to GL 2004-02
5. Regulatory Commitments

c: T. A. Beltz – NRC Washington, DC
J. T. King – MPSC
S. M. Krawec, Ft. Wayne AEP, w/o attachments
MDNRE – WHMD/RPS
NRC Resident Inspector
M. A. Satorius – NRC Region III

AFFIRMATION

I, Joel P. Gebbie, being duly sworn, state that I am Site Vice President of Indiana Michigan Power Company (I&M), that I am authorized to sign and file this request with the Nuclear Regulatory Commission on behalf of I&M, and that the statements made and the matters set forth herein pertaining to I&M are true and correct to the best of my knowledge, information, and belief.

Indiana Michigan Power Company

Joel P. Gebbie
Site Vice President

SWORN TO AND SUBSCRIBED BEFORE ME

THIS 26 DAY OF May, 2010

Notary Public

My Commission Expires 12/14/2016

STATE OF MICHIGAN NOTARY PUBLIC AMY L. MOELLER Expires 12-14-2016

ATTACHMENT 1 TO AEP-NRC-2010-39

REFERENCES

1) Letter from M. A. Peifer, I&M, to NRC Document Control Desk, "Supplemental Response to Nuclear Regulatory Commission Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," AEP:NRC:8054-02, dated February 29, 2008 (ML080770394, ML080770395, ML080770396, ML080770400, and ML080770404).

2) Letter from L. J. Weber, I&M, to NRC Document Control Desk, "Final Response to Nuclear Regulatory Commission Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors and Associated Request for Additional Information," dated August 29, 2008 (ML082520025).

3) Letter from W. H. Ruland, NRC, to A. Pietrangelo, NEI, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," dated November 21, 2007 (ML073110269 and ML073110278).

4) Letter from P. S. Tam, NRC, to M. K. Nazar, I&M, "Donald C. Cook Nuclear Plant, Units 1 and 2 - Request for Additional Information Re: Response to Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized-Water Reactors' (TAC Nos. MC4679 and MC4680)," dated February 9, 2006 (ML060370547).

5) Letter from P. S. Tam, NRC, to M. K. Nazar, I&M, "Donald C. Cook Nuclear Plant, Unit 1 (DCCNP-1) - Extension of Completion Date for Actions in Response to Generic Letter 2004-02 (TAC No. MC4679)," dated July 28, 2006 (ML062020768).

6) Letter from P. S. Tam, NRC, to M. W. Rencheck, I&M, "Donald C. Cook Nuclear Plant, Units 1 and 2 – Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," Extension Request Approval" (TAC NOS. MC4679 and MD4680), dated December 26, 2007 (ML073540189).

7) Letter from P. S. Tam, NRC, to M. K. Nazar, I&M, "Donald C. Cook Nuclear Plant, Units 1 and 2 (DCCNP-1 and DCCNP-2) – Issuance of Amendments Re: Containment Sump Modifications per Generic Letter 2004-02 (TAC Nos. MD5901 and MD5902)", dated October 18, 2007 (ML072780605).

8) ALION Calculation, ALION-CAL-AEP-3085-14, Revision 1, "D.C. Cook Recirculation Containment Sump Hydraulic Analysis - Task 3 Results."

9) ALION Report, ALION-REP-AEP-4462-02, Revision 1, "D. C. Cook Material Transport, Erosion and Dissolution Report."

10) ALION Calculation, ALION-CAL-AEP-3085-14, Revision 2, "D.C. Cook Recirculation Containment Sump Hydraulic Analysis."

11) CCI Test Report, 680/41400, Revision 2, "Containment Sump Strainer Replacement: Large Size Head Loss Test Report."

12) ALION Calculation, ALION-CAL-AEP-3085-15, Revision 0, "D.C. Cook Units 1 and 2 Reactor Building GSI-1 91 Debris Transport Calculation."

13) Letter from W. H. Ruland, NRC, to A. R. Pietrangelo, NEI, "Revised Guidance for Review of Licensee Responses to Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," dated March 28, 2008 (ML080230234).

14) ALION Calculation, ALION-CAL-AEP-3085-12, Revision 1, "D.C. Cook Recirculation Sump Debris Generation Calculation."

15) Letter from T. A. Beltz, NRC, to J. N. Jensen, I&M, "Donald C. Cook Nuclear Plant (CNP), Units 1 And 2 - Request for Additional Information Regarding Supplemental Responses To Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors" (TAC Nos. MC4679 and MC4680)," dated June 18, 2009 (ML091490421).

ATTACHMENT 2 TO AEP-NRC-2010-39

ABBREVIATIONS AND ACRONYMS

ALION	ALION Science and Technology
AISC	American Institute of Steel Construction
BWR	boiling water reactor
BWROG	Boiling Water Reactor Owner's Group
CAD	computer aided drafting
Cal-Sil	calcium silicate insulation
CCI	Control Components Incorporated
CCP	centrifugal charging pump
CEQ	containment equalization system
CFR	Code of Federal Regulations
CNP	Donald C. Cook Nuclear Plant
CRDM	control rod drive mechanism
CTS	Containment Spray System
DBA	design basis accident
DEGB	double ended guillotine break
DFT	dry film thickness
DGBS	debris generation break size
DI	debris interceptor
ECCS	Emergency Core Cooling System
EOP	Emergency Operating Procedure
EPRI	Electric Power Research Institute
ESF	engineered safety features
°F	degrees Fahrenheit
FAI	Fauske & Associates
ft	feet
ft abs	feet of water absolute
ft H_2O	feet of water
GDC	General Design Criteria
GL	Generic Letter
gpm	gallons per minute
GR	NEI 04-07 Guidance Report
GSI	Generic Safety Issue
HELB	high energy line break
I&M	Indiana Michigan Power Company
in	inches
IOZ	inorganic zinc
IST	in-service test
K&L	Keeler and Long, PPG Industries
LBLOCA	large break loss of coolant accident
lbm	pounds-mass
lbs	pounds
LOCA	loss of coolant accident
MBLOCA	medium break LOCA
MFTL	Multi-Functional Test Loop
mil	0.001 in
Min-K	micro-porous insulation
mm	millimeter
NEI	Nuclear Energy Institute
NPSH	net positive suction head
NRC	Nuclear Regulatory Commission
OEM	original equipment manufacturer
OPG	Ontario Power Generation
PORV	power operated relief valve
ppm	parts per million
psig	pounds per square inch - gauge
PVC	polyvinyl chloride
PWR	pressurized water reactor
PWROG	Pressurized Water Reactor Owner's Group
PZR	pressurizer
RAI	request for additional information
RCP	reactor coolant pump
RCS	Reactor Coolant System
RFO	refueling outage
RG	Regulatory Guide
RHR	Residual Heat Removal
RMI	reflective metal insulation
RWST	refueling water storage tank
SBLOCA	small break loss of coolant accident
SER	NEI 04-07 Safety Evaluation Report
SE	Safety Evaluation
SG	steam generator
SI	safety injection
TS	Technical Specification
UFSAR	Updated Final Safety Analysis Report
ZOI	zone of influence

ATTACHMENT 3 TO AEP-NRC-2010-39

RESPONSE TO JUNE 18, 2009 RAI

This attachment contains the following appendices:

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

APPENDIX 1
OVERVIEW OF THE ALTERNATE EVALUATION METHODOLOGY UTILIZED BY I&M

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 GR 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 DEGB, while the Region I 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 ECCS and CTS. 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 is not as a function of 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 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 (Reference 1) 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 slightly 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

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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.

APPENDIX 2
MARGINS AND CONSERVATISMS EVALUATION

1 Introduction

The purpose of this document is to demonstrate how the CNP 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.

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 the GR. 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 (Reference 1), 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.

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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 CTS in containment would have occurred when lower containment pressure reached a nominal 2.9 psig. The CNP 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 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 the CNP 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.

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

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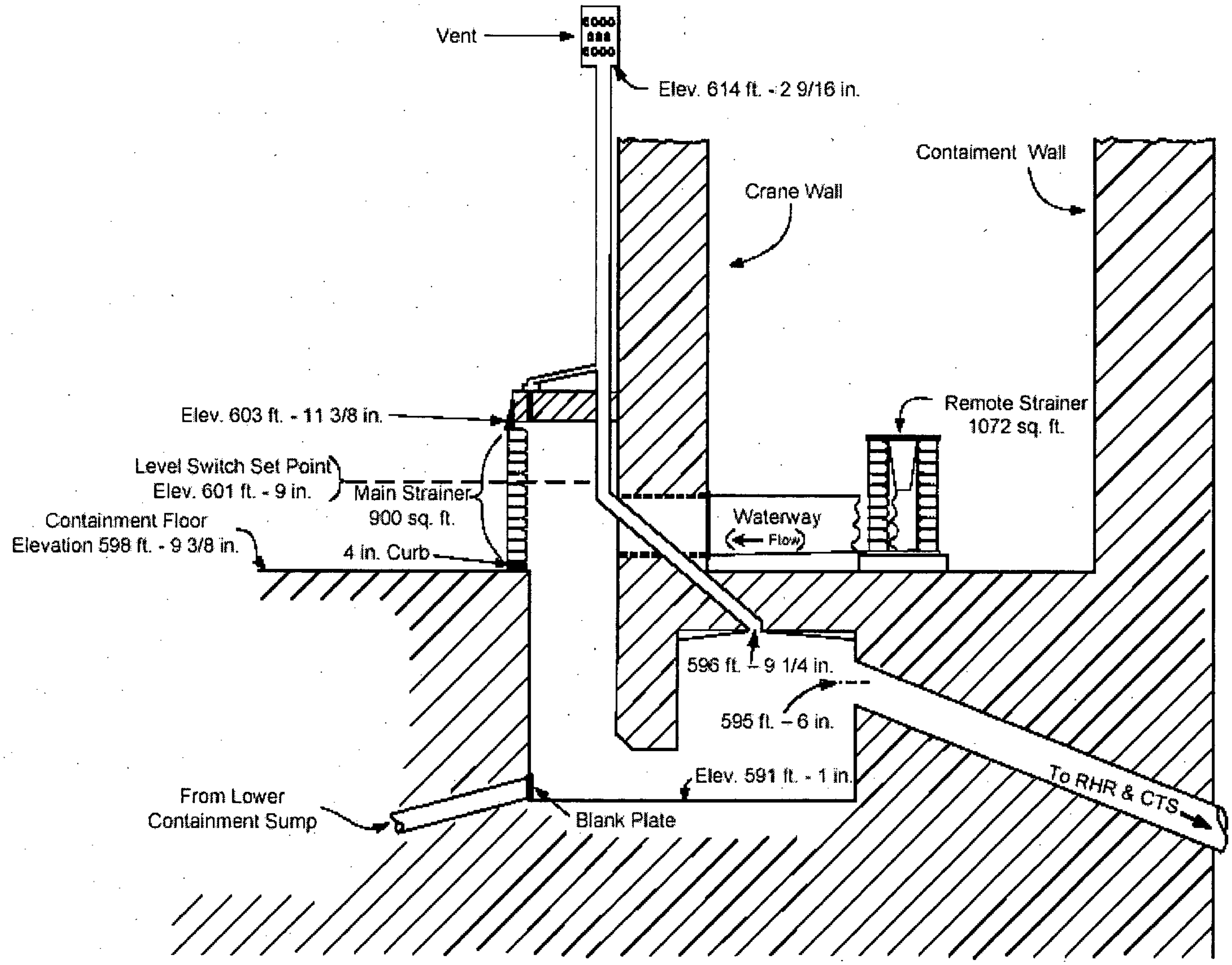
recirculation would not occur in the annulus, the debris that would be available to the remote strainer would be the debris that was transported from the loop compartment to the annulus region from the initial blowdown, the debris that was transported to the annulus region through the overflow wall flow 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 the CNP recirculation sump is provided on the following page. The CNP sump is a fully vented sump in that the vent extends above the maximum predicted containment flood elevation for both units. The 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 injesting 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.

Appendix 2

Figure 1 General Arrangement of Recirculation Sump



Appendix 2

3 Debris Generation / Zone of Influence

3.1 Methodology

a. Through extensive walkdowns, it was determined that the insulation debris sources were different between CNP Unit 1 and Unit 2. The insulation debris sources for Unit 2 were initially considered to be bounding for both units and were used as the input for analysis and testing in the 2007 time frame. In the 2009/2010 time frame, the debris generation analysis was re-performed which determined that a DEGB in Unit 1 Loop 4 was bounding for both units. The bounding DGBS was determined to remain in Unit 2 Loop 4.

3.2 Key Conservatisms / Margins

b. For Cal-Sil insulation, the actual quantity of Cal-Sil fines that would be available at the recirculation sump strainers were less than the quantities that were used for testing for both the DEGB and DGBS. For the DEGB, the tested quantity was approximately 7 times greater than the actual quantity available. For the DGBS, the tested quantity was approximately 5 times greater than the actual quantity available.

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 17D was used which is conservative to the tested ZOI of approximately 9.1D 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 earlier 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.

Appendix 2

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 determined main strainer blockage, based on walkdown information, is 14.21 ft^2 for Unit 1 and 21.84 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 61.79 ft^2 and 54.16 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

Appendix 2

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 (Reference 1) and August 29, 2008 (Reference 2) supplemental responses to GL 2004-02.

5.2 Key Conservatisms / Margins

a. It was assumed that 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. It was assumed that there would be 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. It was assumed that 100% of the debris sources in upper containment would fail and be transported to the area of the refueling canal drains.

e. It was 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 to fail, or may not 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. No credit was taken for the filtering capability of the 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 in 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 effort 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 effort 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. An additional quantity of 10% of the CAD model calculated quantity of coatings failing within the ZOI was added to the calculated value.

d. 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.

e. 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.

f. 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.

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

Appendix 2

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

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 50% of the cold galvanizing compound could fail in containment results in 388.75 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 388.75 lbs of coating debris that would not be available for transport.

In summary, the conservatively determined quantities of unqualified coatings that were assumed to fail and be available for transport at recirculation initiation are 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 an I&M representative.

b. Due to the unique strainer configuration installed at 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. I&M 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. Margin is available in the strainer system head loss values as a result of normalizing the results to 68°F. 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 could be up to approximately 30% less than it would be at the normalized value of 68°F.

b. 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 appendix, 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.

Appendix 2

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	42.214		77.227	14.738	
Marinite I Fines	lbs	0.188	0		0	1.278	
Marinite 36 Fines	lbs	1.5228	2.168		1.1285	2.904	
Min-K	lbs	1.52	1.536		0	0	
Total (Problematic)	**lbs**	**310.90**	**45.92**	**264.98**	**78.36**	**18.92**	**59.44**
Epoxy Paint (inside ZOI)	lbs	203.585	207.36		3.8	2.592	
Alkyd Paint (inside ZOI)	lbs	0.57	1.82		0.57	0.192	
Unqualified Epoxy & Alkyd Coatings	lbs	110.66	110.82		110.66	110.82	
Unqualified Cold Galvanizing Compound	lbs	995.2	388.75		995.2	388.75	
Dirt/Dust	lbs	178.5	137.46		178.5	99.67	
Fire Proof Tape Fines	lbs	0.1368	3.17		0.1368	9.98	
Total (Particulates)	**lbs**	**1488.65**	**849.38**	**639.27**	**1288.87**	**612.00**	**676.87**
Total (All Particulates & Problematic)	**lbs**	**1799.55**	**895.30**	**904.25**	**1367.23**	**630.92**	**736.31**
Latent Fiber	ft^3	13.125	10.11		13.125	7.33	
Ice Condenser Fibers	ft^3	0.0296	0.0282		0.0296	0.0282	
Total (Fibers)	**ft^3**	**13.15**	**10.14**	**3.01**	**13.15**	**7.36**	**5.79**

c. 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 appendix.

d. As discussed in Section 8 of this appendix, 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 15% 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 appendix.

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. I&M opted to use the alternate analysis methodology from Section 6 of the GR as part of the resolution path for GSI-191. 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. Further discussion on the use of the alternate evaluation methodology is provided in Appendix 1 of this attachment.

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 appendix, it is 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. I&M performed a complete reanalysis of containment water level in the 1998 to 1999 time frame. The analysis 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.

Appendix 2

8.2 Key Conservatisms / Margins

a. The containment minimum water level analysis did not consider the increase in water level that would occur due to the equipment that occupies the lower containment volume. 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 assumed to be 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. The 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 evaluation, 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 in accordance with 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 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. As described in Section 7 of this appendix, the use of more realistic values for the debris quantities in containment demonstrates 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 minimum operability limit 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 appendix.

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.

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%. I&M assumed this to be 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 appendix. 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 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.

f. The most significant conservatism that exists for chemical effects at CNP is that the chemical precipitates will not readily form 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.

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.

Appendix 2

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 and approved by the NRC (Reference 7) 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 the conservatism that exists 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.

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 GSI-191 for CNP.

14.2 Key Actions Taken

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

14.3 Identification and Protection of Margins Associated with the containment recirculation sump 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.

Appendix 2

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.

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 specifically identifies the debris sources and their application from either a design perspective or operability perspective. The definitions provided above are from that calculation. The UFSAR and margins document will be updated to reflect the information gained through development of the responses to the June 18, 2008 RAI (Reference 15).

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 containment recirculation sump 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 containment recirculation sump 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. This means 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 appendix, I&M 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. I&M 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.

APPENDIX 3
RESPONSES TO RAIs

The individual RAIs from Reference 15 are restated below in italic font followed by the associate I&M response.

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 values were previously provided in the February 29, 2008, supplemental response, Section 3.b.3, Table 3b3-6. The applicable tests were 7, 8, and 10. These tests matched the currently installed configuration which uses a double jacketing with 6 in of overlap in both the axial and circumferential directions with bands spaced at a nominal 6 in.

Subsequent to the February 29, 2008, and August 29, 2008, supplemental responses, it was determined that the jet impingement test loop at Wyle Laboratories had a choke point upstream of the 2.45 in nozzle. This condition resulted in the determination that the previously calculated ZOIs for the testing that was performed were no longer correct. It was determined that the minimum diameter choke point was 1.6131 in, 12.365 in upstream of the exit nozzle face. To determine the corresponding ZOI for each test specimen, the nozzle was assumed to exist at the choke point in the test loop and the nozzle opening was considered to be the diameter of the choke point. Considering this change in L/D, the approximate minimum ZOI that the double jacketed Rubatex/Armaflex configuration was tested at was 5.9D, without loss of underlying insulation material. A specific failure point 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

Based on the destruction testing results, the installed configuration is not expected to fail (result in release of insulation material) due to the installed double wrapped configuration. If this insulation material were to be treated the same as Cal-Sil as tested by OPG (aluminum jacketing, stainless steel bands), with a ZOI of 5.45D, as provided in the GR, and assuming 100% failure of the underlying insulation material, the following information is provided.

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The worst case break location for this material has been determined to be a DEGB (Region II) break in the RCS crossover leg at the Unit 2, Loop 1 RCP suction. Assuming that all of the material from this break would reach the main strainer during pool fill (this material floats), approximately 11.79 ft^2 of strainer blockage would occur. This quantity is substantially below the available 76 ft^2 of sacrificial strainer area at the main strainer. This is a significantly conservative estimate since 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, and since the principal force would be acting from below the piping, a portion of this readily transportable material would be entrained in the blowdown jet and enter the annulus region through the ventilation openings that exist in the crane wall above the affected piping elevation. Also, a portion of the material would be transported to the annulus through the flood-up wall openings during the pool fill portion of the event. For Unit 1, the bounding break location for debris sources that could lead to the greatest head loss across the strainers is Loop 4. The quantity of insulation material (Rubatex/Armaflex) that could be predicted to be generated for this break would result in approximately 6.49 ft^2. For Unit 2, the bounding break location for debris sources that could lead to the greatest head loss across the strainers is Loop 4. This break location would result in a predicted strainer blockage of 4.68 ft^2. For the DGBS (Region I) break, there are no locations within the associated ZOI.

<u>*Debris Characteristics*</u>

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),

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and (c) to demonstrate that the ZOI test results have been prototypically or conservatively scaled to the plant condition.

Response 2.a) and 2.b)

ZOI values provided in the following response reflect the increase in length and decrease in diameter associated with the choke point identified in the jet impingement test loop, as described in the response to RAI 1.a).

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 specific failure mode for the Marinite during testing was that a lever was applied between the face edges of the Marinite that was attached to the cable tray as the cable tray deformed. 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.

The Marinite faced cable tray sections that were tested and where observable damage was identified were at a ZOI of approximately 8.8D. The Marinite installed in the plant at the location closest to the bounding break is at a ZOI of approximately 5.9D. NUREG/CR-6772 established a destruction pressure of 64 psi (a ZOI of approximately 3D) which is the pressure at which damage starts to occur. As can be seen in Figures 2-1 and 2-2, the testing that was performed on a Marinite covered cable tray section at a ZOI of approximately 5.2D resulted in deformation to the point that further destruction could not reasonably occur. For conservatism, the quantity of debris generated from the breaks that resulted in debris generation has been applied to all Marinite installations out to a ZOI of 17D. The debris quantity and size distribution previously determined was applied to all Marinite material within the 17D ZOI. Additionally, the total quantity of Marinite available for debris generation is just a small fraction of the total particulate debris sources available (≈ 0.1%).

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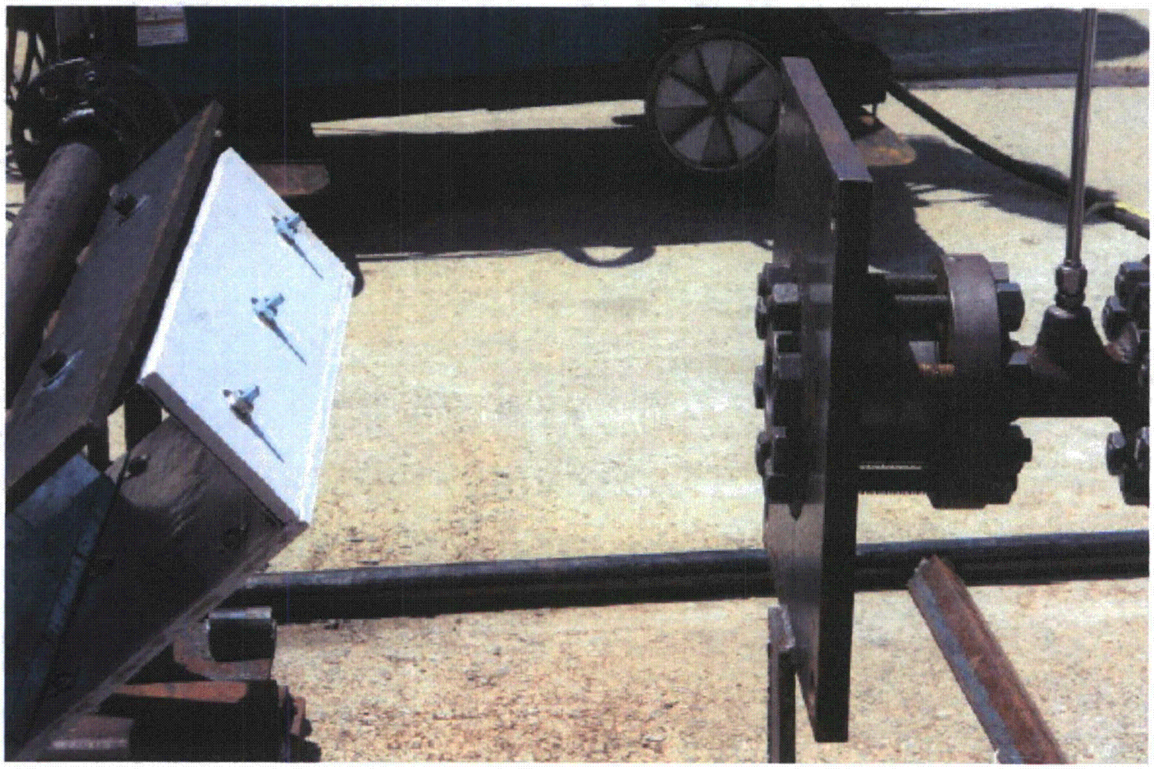

Figure 2-1: Marinite Test Setup

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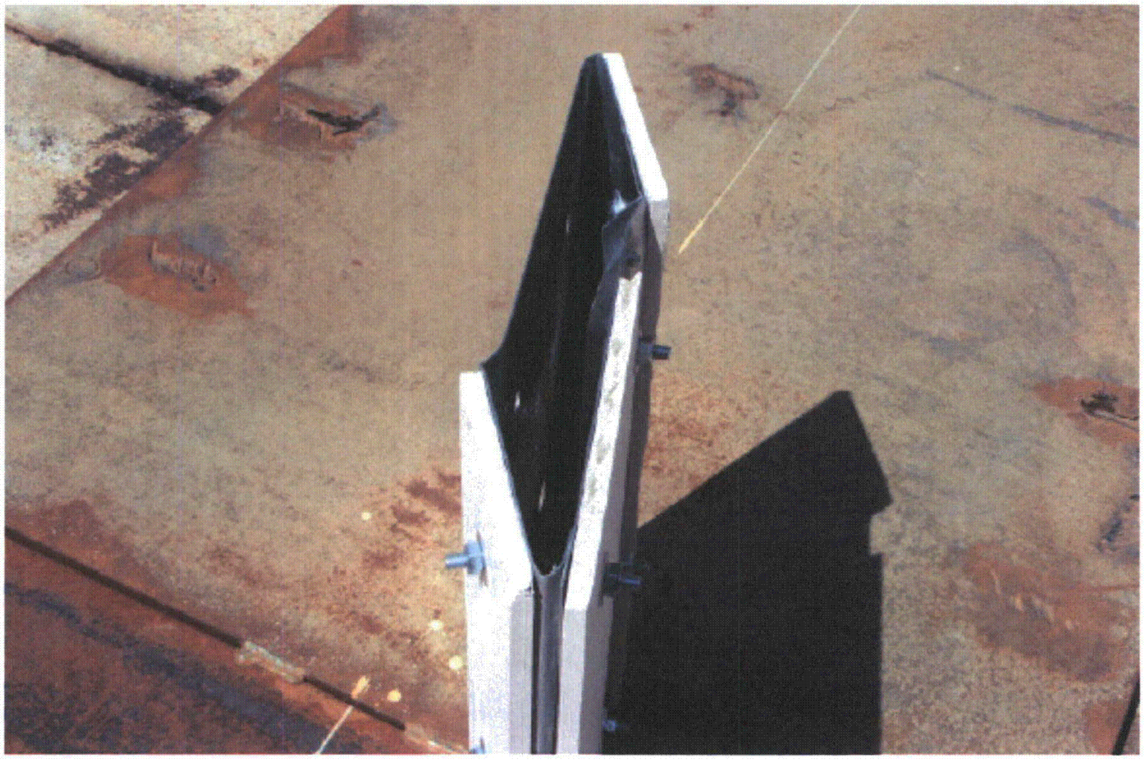

Figure 2-2: Marinite Test Result

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 (5.3D), 6.97% was destroyed as fines. At the largest ZOI tested (13.7D), 1.02% was destroyed as fines. For debris generation input, a ZOI of 17D is being used with 6.97% of the material destroyed as fines. The debris quantity and size distribution previously determined was applied to all fire barrier tape material within the 17D ZOI. Again, it is judged that had a 30 in 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 primary 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 a 6 in overlap, 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. The size of piping tested is the same as the size of the piping installed in the plant. To address radial decay of the jet, 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. For the minimum ZOI tested, 5.9D, the jet pressure would be slightly lower than 24 psi, the value established for a ZOI of 5.4D. 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 force acting on the double jacketed insulated piping, it will be assumed that the spacing between the bands is 6.5 in which is a greater spacing than the installed configuration. Since the largest diameter pipe is 3 in (3.5 in OD) 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 28.08 in^2. At 24 psi, this results in calculated shear stress below the allowable for the 0.010 in jacketing material installed. The pressure required to achieve failure of the jacketing is approximately 69 psi. This represents an approximate ZOI of 3D. None of the potentially affected piping is within this ZOI. The bands which are 0.020 in thick and either 1/2 in or 3/4 in wide, and the mechanical clamps that secure the bands are also not expected to fail as a result of the applied force. The mechanical clamps that secure the bands are looped sections of the banding cinched in a formed retaining fixture. Even if there was failure of the outer jacket, the inner jacket would continue to protect the underlying insulation material.

<u>Response 2.c)</u>

As part of the test setup that was utilized for destruction testing, a solid steel backstop and screen material was placed downstream of the nozzle to minimize the potential for debris to be blown into the field beyond the test facility. Refer to Figure 2-3 below that shows this configuration.

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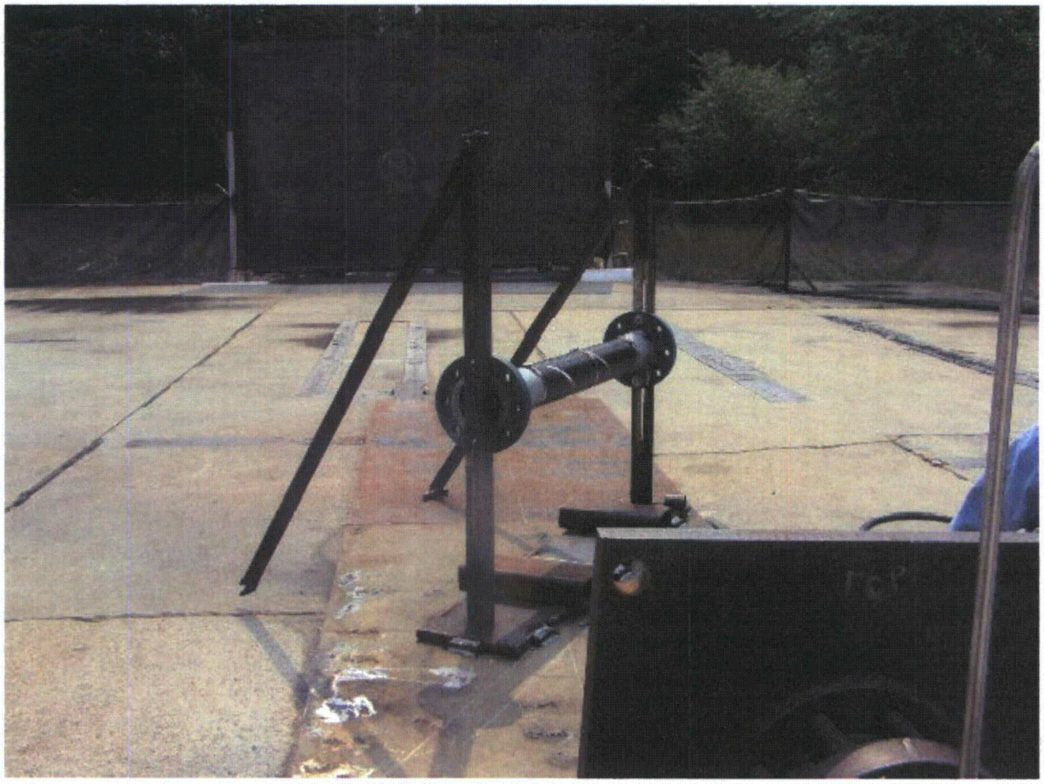

Figure 2-3: Testing Debris Capture Setup

Following the testing of the materials, in particular the Marinite, some of the larger pieces (> ≈ 4 in) were found on the concrete between the nozzle and the backstop, at about the end of the steel plate that supported the test fixture, as seen in the photo above. A few small pieces of the Marinite had impacted the steel backstop as seen in the picture below, reducing them to fines. Some of the other small pieces had traveled at an angle to the test fixture, sliding along the concrete, going underneath the bottom edge of the screen and ending up in the field beyond the test area slab. This test configuration provided for further degradation of the pieces of debris as they impacted the test fixture, concrete, or backstop.

Appendix 3

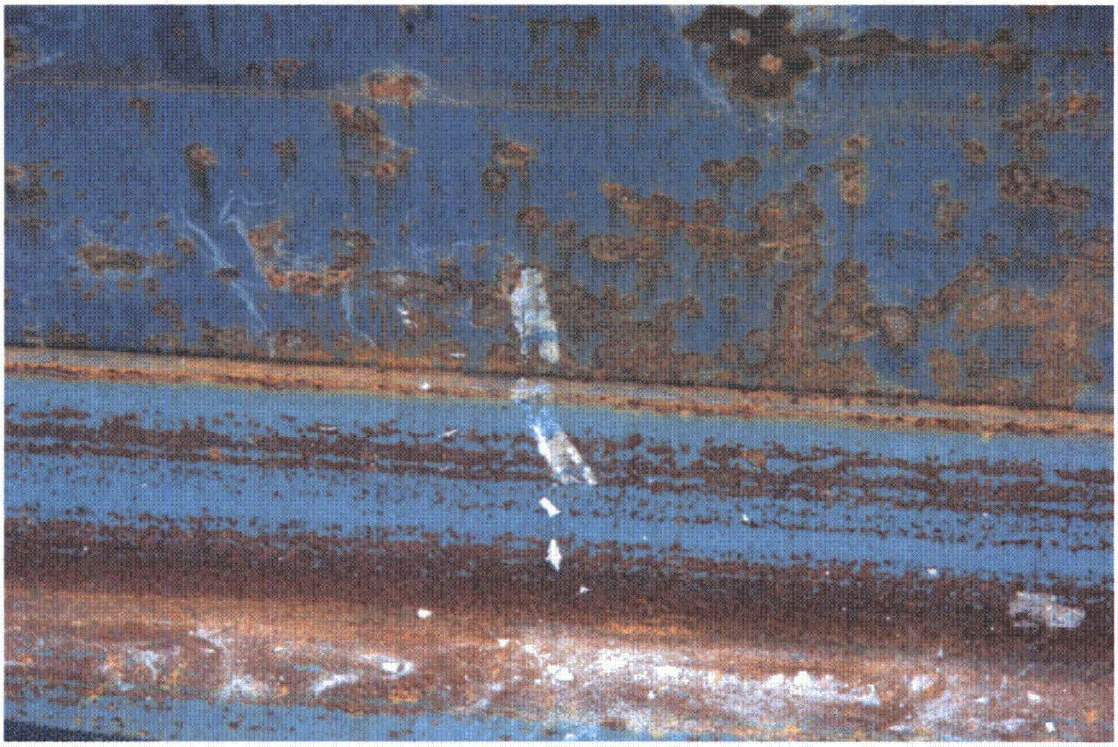

Figure 2-4: Marinite Impingement on Backstop

As can be seen from the test setup pictures, the test setup was designed to model the result of dislodged debris as a result of impact with other solid surfaces. With this test setup, dislodged debris had the potential to be reduced in size due to impact with the test fixture, backstop or concrete. From the post-test observations, smaller pieces of debris had the greatest potential for traveling larger distances from the test stand. Larger pieces were typically within a few feet of the test stand.

The assembled test targets were subjected to the summertime humidity in northern Alabama and were weighed prior to the test. Following the test, all pieces of the Marinite were dried in an oven at 200°F for 8 hours and then weighed upon removal from the oven. All post-test weights were less than the pre-test weights, even for those tests where there was no observed loss of material. This method for determination of the fines provided additional conservatism.

Based on the established test configuration and results of the testing, I&M judges that the results of the testing conservatively bounded the potential for fine debris generation for the test materials.

Appendix 3

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 5.2D, 6.4D, and 8.8D. To conservatively bound the results, a ZOI of 17D has been used for determination of the quantity of debris that could be generated following a break. An additional conservatism is that the GR established a destruction pressure for Marinite at a ZOI of approximately 3D (64 psi). As defined within the GR, destruction pressure is the pressure at which damage starts to occur. Additionally, the actual location of Marinite in relationship to the postulated break locations provides further demonstration of the adequacy of the ZOI selected for determination of the debris generated by this material. In Unit 1, the bounding unit for problematic debris generation for the DEGB, the location of Marinite closest to the bounding break location results in a ZOI of approximately 5.9D. This location is below the lower lateral restraint for the #4 SG. The next closest location is at a ZOI of approximately 11D. Taken in the aggregate, 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 CNP 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 high energy line break (HELB) areas with Cal-Sil or reflective metal insulation (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.

CNP engineering specifications for insulation in containment require that banding (20 mil) with seals (crimp lock clamp device) be placed no more than 12 in apart except for foam insulation installations which require a maximum 6 in spacing. The OPG testing utilized a maximum spacing of 8.25 in. The failure mode during the OPG testing was shearing of the aluminum jacket adjacent to the banding. CNP utilizes stainless steel jacketing (minimum of 10 mils) which has a substantially higher shear strength than the aluminum jacketing used for the OPG testing. Even with the slightly increased spacing between the bands, the quantity of Cal-Sil pieces generated following a LOCA will not be substantially increased due to the increased strength of the materials.

The OPG testing utilized test target piping with an outside diameter of 2.375 in with an insulation thickness of 1.0 in. The piping that could potentially be impacted by a break jet in the CNP Unit 1 and Unit 2 containments has an outside diameter of either 2.375 in or 3.5 in with an insulation thickness of 1.5, 2.0, or 3.0 in (one pipe section). Based on a review of the isometric drawings, the approximate percentage of piping that could have 12 in band spacing is 45% In Unit 1 and 57% in Unit 2.

The piping section with the greatest percentage of straight line pipe, where the band spacing can be assumed to be 12 in is a 3.5 in OD pipe with 2 in insulation thickness. This is a Chemical and Volume Control System pipe in Loop 4 of Unit 2. Considering the insulation thickness of the OPG testing (1 in), the effective target OD was 4.375 in. For CNP, the effective target OD is 7.5 in.

From the debris generation analysis, this line has a total of 5.0 ft^3 of Cal-Sil insulation. At a DEGB ZOI of 2.7D, none of this line is affected by the break. At a DEGB ZOI of 6.4D, 4.884 ft^3 of Cal-Sil insulation is assumed to be destroyed. If all of the Cal-Sil on this line within the 6.4D ZOI was destroyed as fines, it would represent 70.82 lbs of Cal-Sil fines. Using the current approach for Cal-Sil fines generation from this break, the total quantity of Cal-Sil fines is 48.0 lbs. This value represents the quantity of fines directly generated by the jet plus the quantity of Cal-Sil fines generated as a result of erosion of Cal-Sil small pieces. Assuming all of the affected Cal-Sil from this line is generated as fines, this represents an increase of 22.82 lbs of Cal-Sil. Table 3p-2 (Attachment 4) provides a regulatory controlled margin of 188.96 lbs of problematic debris for the DEGB. If the increased quantity of Cal-Sil fines was subtracted from this value, the regulatory controlled margin would be 166.14 lbs (188.96 – 22.82). This quantity, coupled with the regulatory controlled margin for particulates (468.16 lbs), provides a combined problematic and particulate regulatory controlled margin of 634.3 lbs of debris. This substantial margin provides the margin necessary to support any potential issues associated with flow and debris splits between the main and remote strainer as discussed in the response to RAI 5. This line is not affected by the DGBS break.

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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 (Appendix 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 Table 5-1. 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

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and 72 ft^2 was set aside as sacrificial strainer area for the remote strainer. As described in Section 3.f.4 of the February 29, 2008, supplemental response, the actual sacrificial strainer area was determined to be 76 ft^2 for the main strainer and 83 ft^2 for the remote strainer based on the actual available strainer area utilized for the large scale strainer tests. Table 5-1 provides the particulate, problematic, and fibrous debris values that were used for strainer testing, multiplied by the strainer testing scaling factor.

Table 5-1: Strainer Testing Debris Values

	Total Particulate lbs	Particulate per Surface Area of Strainer lbs / ft^2	Total Problematic lbs	Problematic per Surface Area of Strainer lbs/ft^2	Total Fibrous ft^3	Fibrous per Surface Area of Strainer ft^3 / ft^2
DEGB Main	948.95	1.152	145.15	0.176	7.77	0.009
DEGB Remote	539.70	0.546	165.75	0.168	5.39	0.005
DEGB Total	1488.65	**0.821**	310.90	**0.171**	13.16	**0.007**
DGBS Main	858.52	1.042	36.41	0.044	7.77	0.009
DGBS Remote	430.35	0.435	41.94	0.042	5.39	0.005
DGBS Total	1288.87	**0.711**	78.36	**0.043**	13.16	**0.007**

As detailed in the Margins and Conservatisms Evaluation, Section 7.2.c (Appendix 2 to this attachment), and repeated in Table 5-3 of this appendix, the quantities of particulate, problematic, and fibrous material used for testing is significantly greater than the quantity of material that would be available following an event. Table 5-2 provides the actual quantities of particulate, problematic, 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 (1813 ft^2 which excludes the sacrificial strainer area).

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Table 5-2: Available Debris Distribution

	Total Available Particulate DEGB lbs	Total Available Problematic DEGB lbs	Total Available Fibrous DEGB ft^3	Total Available Particulate DGBS lbs	Total Available Problematic DGBS lbs	Total Available Fibrous DGBS ft^3
	849.38	45.92	10.14	612.00	18.92	7.36
Available Particulate per Unit Strainer Area lbs / ft^2	**0.468**			**0.338**		
Available Problematic per Unit Strainer Area lbs / ft^2		**0.025**			**0.010**	
Available Fibrous per Unit Strainer Area ft^3 / ft^2			**0.006**			**0.004**

As can be seen when comparing Table 5-1 to Table 5-2, 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.

The following discussion provides additional supporting information regarding the margins that exist when considering the available debris quantities versus the tested debris quantities.

CNP has a unique sump strainer design which provides two parallel paths for recirculation water to reach the ECCS and CTS pumps. Understanding the relationship between these two paths is critical to understanding the overall system head losses.

The basic head loss equation is shown below in Equation 1.

Equation 1

$$H_L = \frac{KQ^2}{2gA^2}$$

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Where:

H_L is the head loss across the strainer
K a constant "K factor" determined for the screen
Q is the flow rate across the screen
g is the gravitational constant
A is the area of the screen.

The first path available to recirculation water in the pool is directly into the sump pit through the main strainer. Along this path the water would encounter resistance (taking the form of pressure head loss) only from the main strainer pockets. This head loss would be proportional to the square of the flow rate through the strainer, and would be inversely proportional to the square of the screen area, as shown in Equation 1.

The second path available to the recirculation water in the pool is through the remote strainer, whereupon it travels through ductwork into the sump pit. Along this path the water encounters resistance across the remote strainer, and then additional resistance (taking the form of additional pressure head loss) from the remote strainer plenum, the duct work linking the remote strainer to the sump pit, and the exit losses from the duct work to the sump pit. A visual diagram of the sump strainer design is shown in Figure 5-1.

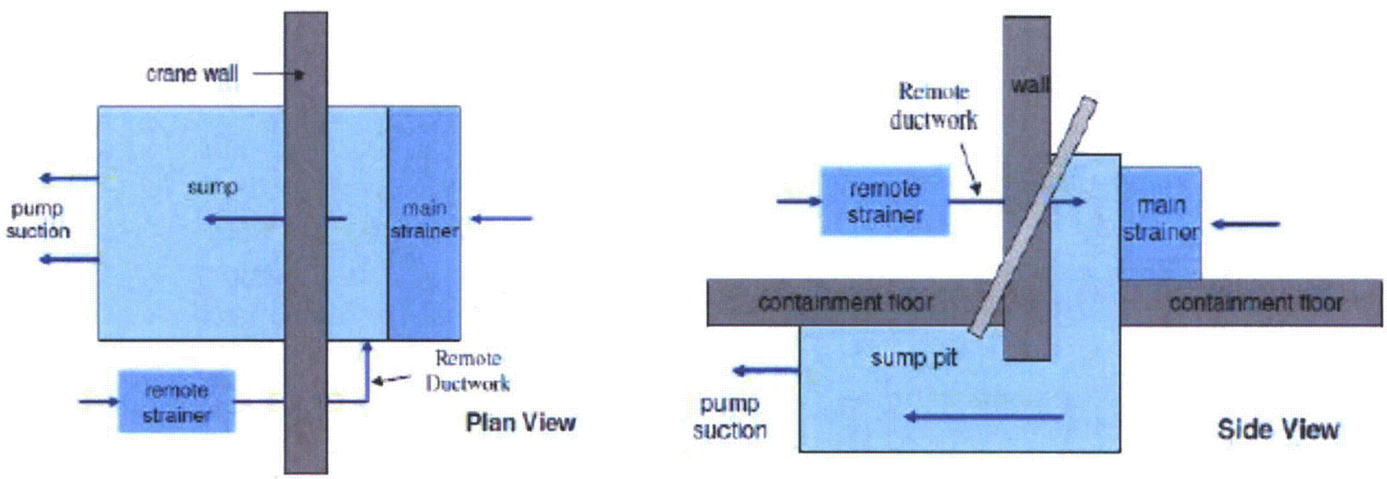

Figure 5-1: Sump Strainer System Diagram

These three resistances (and associated pressure losses) are modeled together as the "waterway losses". A more simplified diagram of the paths available to the recirculation water and the resistances encountered are presented in Figure 5-2.

Appendix 3

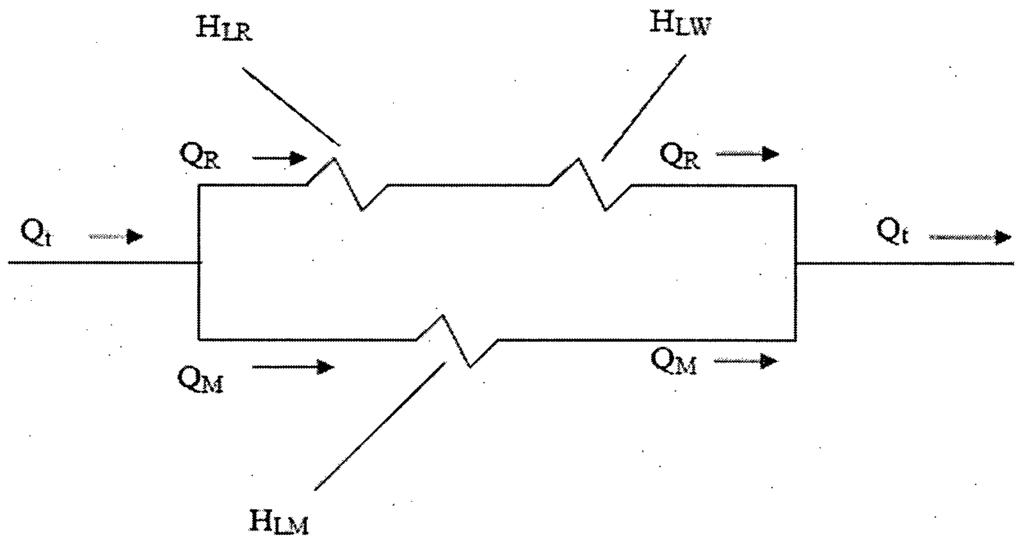

Figure 5-2: Sump Strainer Resistances Diagram

Because the paths are parallel and the entire system linked, they have by definition equal pressure losses. This is illustrated in Equation 2. This equivalent pressure loss is also referred to as the system head loss.

Equation 2

$$H_{LM} = H_{LR} + H_{LW} = H_{LS}$$

Where :

H_{LS} is the system head loss
H_{LM} is the head loss across the main strainer
H_{LR} is the head loss across the remote strainer
H_{LW} is the head loss across the waterway

As illustrated in Equation 1, the head loss across either of the strainers is proportional to the square of the flow rate, and inversely proportional to the square of the screen area. Thus stated in these terms the head loss across either of the strainers can be thought of as proportional to the square of the flow rate and increasing with additional debris.

This is important because both the flow rate through the system and the debris available to accumulate on the screens are defined and finite. *Any increase in flow rate or debris on one branch of the system must be accompanied by an equivalent decrease in flow rate or debris on the other branch.* For example, an increase in flow rate across the main strainer would necessitate a decrease in flow through the remote strainer and associated duct work. Similarly, to increase the debris load on the remote strainer, a corresponding decrease in the debris load to the main strainer would be necessitated.

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The debris utilized in testing was significantly more than the quantity predicted to reach the strainers according to the debris generation and transport calculations. The total quantity predicted to reach the strainers is compared to the quantity of debris (scaled) utilized in testing in Table 5-3.

Table 5-3: Testing Debris Quantities Vs. Actual Debris Quantities Available

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	42.214		77.227	14.738	
Marinite I Fines	lbs	0.188	0		0	1.278	
Marinite 36 Fines	lbs	1.5228	2.168		1.1285	2.904	
Min-K	lbs	1.52	1.536		0	0	
Total (Problematic)	**lbs**	**310.90**	**45.92**	**264.98**	**78.36**	**18.92**	**59.44**
Epoxy Paint (inside ZOI)	lbs	203.585	207.36		3.8	2.592	
Alkyd Paint (inside ZOI)	lbs	0.57	1.82		0.57	0.192	
Unqualified Epoxy & Alkyd Coatings	lbs	110.66	110.82		110.66	110.82	
Unqualified Cold Galvanizing Compound	lbs	995.2	388.75		995.2	388.75	
Dirt/Dust	lbs	178.5	137.46		178.5	99.67	
Fire Proof Tape Fines	lbs	0.1368	3.17		0.1368	9.984	
Total (Particulates)	**lbs**	**1488.65**	**849.38**	**639.27**	**1288.87**	**612.00**	**676.87**
Total (All Particulates & Problematic)	**lbs**	**1799.55**	**895.30**	**904.25**	**1367.23**	**630.92**	**736.31**
Latent Fiber	ft^3	13.125	10.11		13.125	7.33	
Ice Condenser Fibers	ft^3	0.0296	0.0282		0.0296	0.0282	
Total (Fibers)	**ft^3**	**13.15**	**10.14**	**3.01**	**13.15**	**7.36**	**5.79**
Latent Fiber	lbs	31.5	24.26		31.5	17.59	
Ice Condenser Fibers	lbs	0.0711	0.0677		0.0711	0.0677	
Total (Fibers)	**lbs**	**31.57**	**24.33**	**7.24**	**31.57**	**17.66**	**13.91**

It is clearly visible from Table 5-3 that the debris bed which would form in a design basis accident scenario would be composed overwhelmingly of particulate debris, which constitutes the vast majority of the debris. This can be seen in the debris beds formed during testing, one image of which is presented in Figure 5-3. It can be seen in Figure 5-3 that the bed lacks the thick structure of a more evenly mixed fibrous/particulate debris bed. Due to this lack of internal structure the bed which forms is quite thin, as the holes of the perforated plate which comprises the strainer is clearly visible even through the bed.

Figure 5-3: Debris Bed Produced During Testing

From Table 5-3, the total quantity of debris available at the strainers for the DGBS is 631.98 lbs of particulate debris and 17.66 lbs of fibrous debris, as shown in Figure 5-4.

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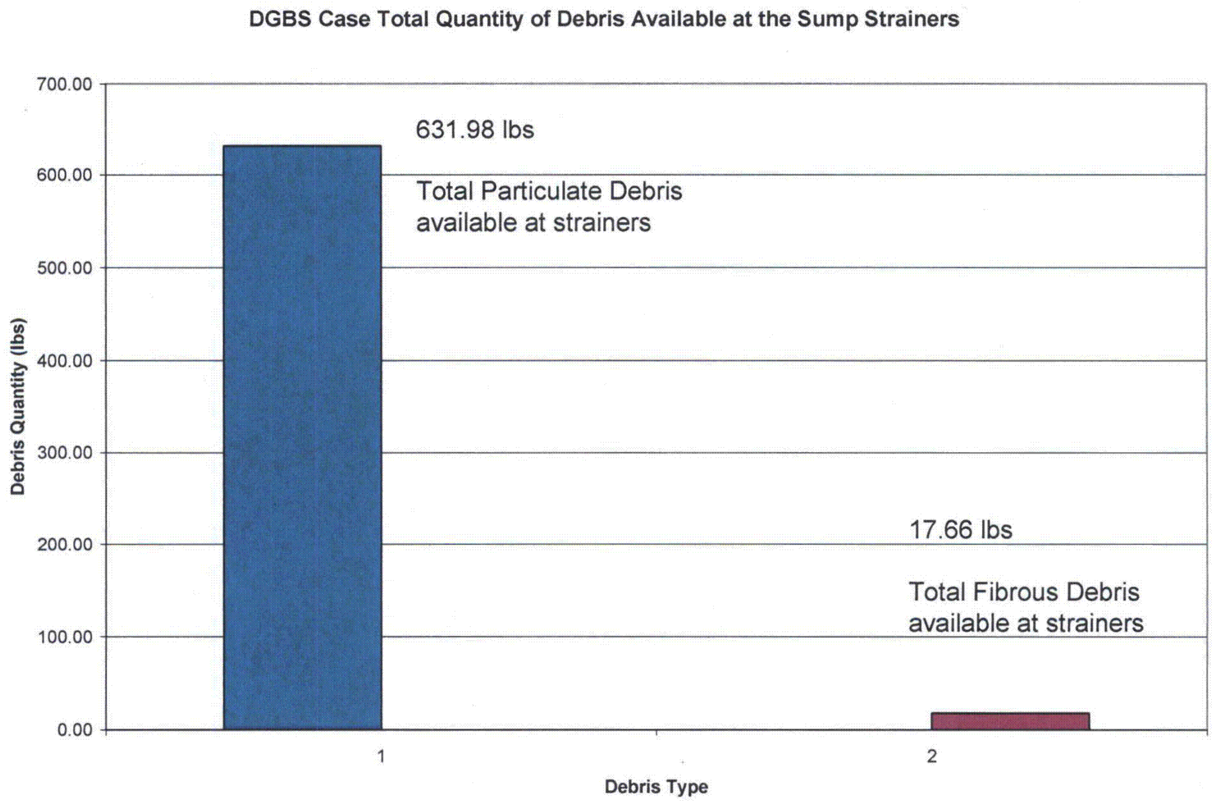

Figure 5-4: DGBS Total Quantity of Debris Available at the Sump Strainers

The particulate debris quantity predicted to reach both strainers is then compared to the quantity utilized in testing as shown in Figure 5-5.

Appendix 3

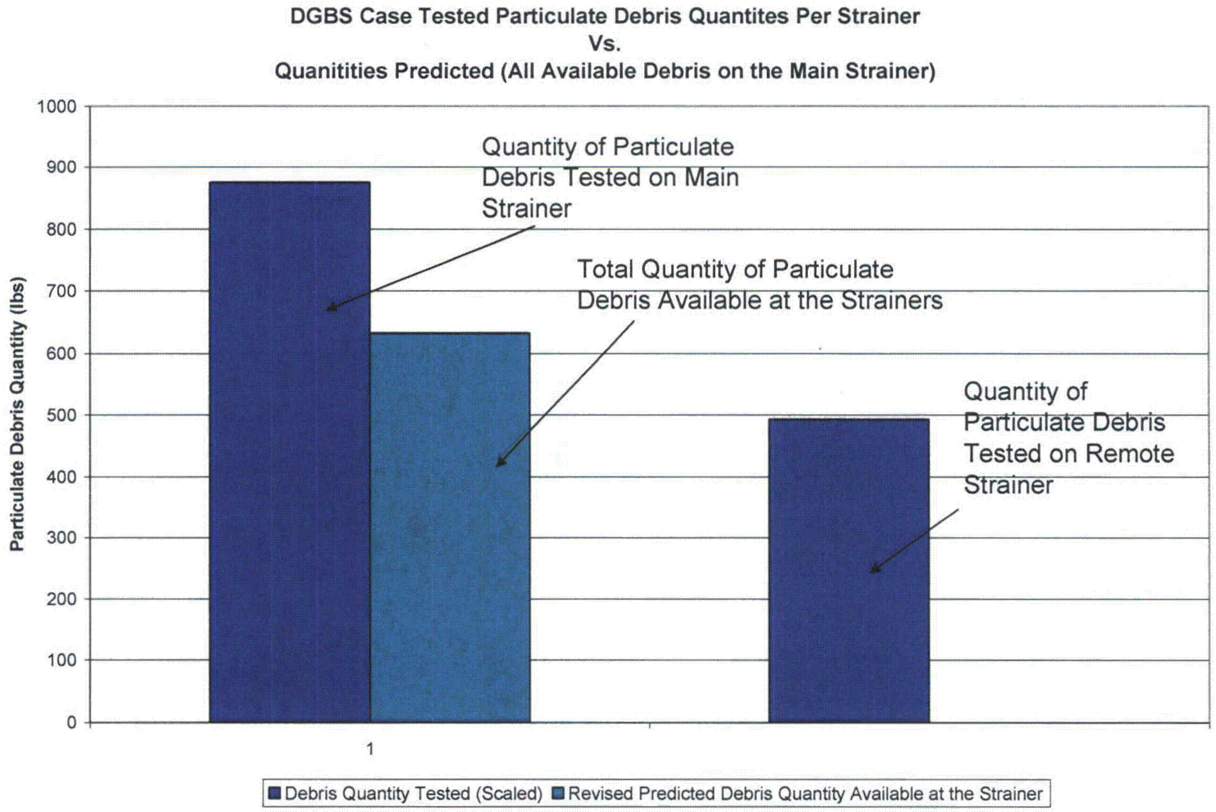

Figure 5-5: DGBS Case Tested Particulate Debris Quantities per Strainer Vs. Quantities Predicted (All Available Debris on the Main Strainer)

From this comparison it is apparent that the particulate quantity of debris tested on the main strainer alone exceeds the total particulate quantity of debris predicted to reach both strainers.

Similarly, the quantity of fibrous debris tested on the main strainer alone exceeds the total quantity of fibrous debris predicted to reach both strainers, as illustrated in Figure 5-6.

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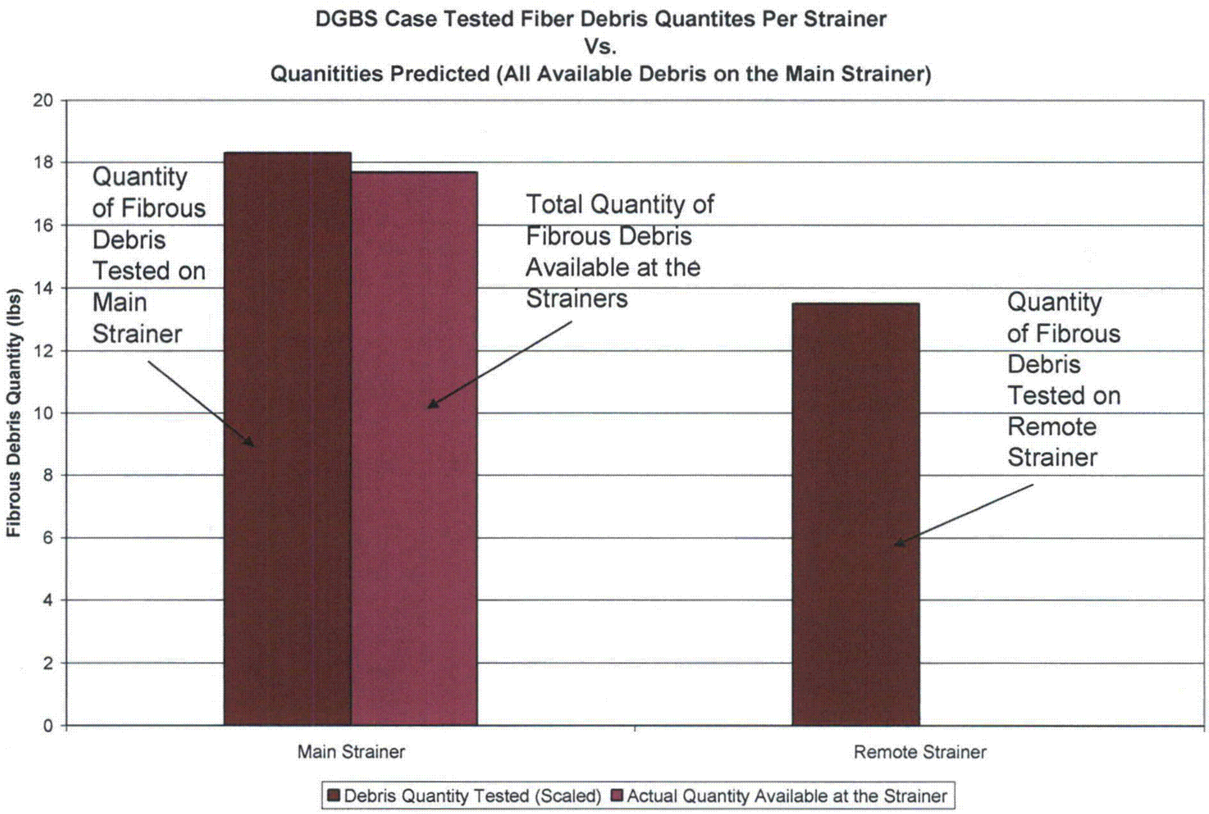

Figure 5-6: DGBS Case Tested Fiber Debris Quantities Per Strainer Vs. Quantities Predicted (All Available Debris on the Main Strainer)

Thus, the total quantity of debris tested on the main strainer alone during the head loss testing exceeds and bounds the total quantity of debris predicted to reach both strainers for both particulate and fibrous debris. This is illustrated in Figures 5-5 and 5-6. To this quantity of debris, additional significant quantities of debris were tested on the remote strainer.

The debris split displayed in Figures 5-5 and 5-6 for the "tested debris" quantities was determined by utilizing the ratio of debris applied to the main strainer as compared to that applied to the remote strainer for the scaled debris quantities used in testing.

Utilizing the results of a main strainer only DGBS test that was performed, a determination as to the effect of varied debris and flow rates on the head loss produced by the strainer modules was performed. As the remote and main strainer arrays are identical save in their total screen area and their plenum arrangement, the analytical correlations calculated between debris loading, flow rate, and head loss was applied to both the main and remote strainers. This is possible because the head losses produced due to the plenum arrangement of the remote strainer are accounted for in the "waterway" losses, while the difference in screen area is accounted for within the calculations.

To avoid excessive use of multiple types of debris load percentages, it was useful to define all debris loads for the DGBS case in terms of the sum total of debris available at both strainers. This was accomplished by comparing the total amount of main strainer debris used in testing to the sum total of available testing debris, as tabulated in Table 5-4.

Table 5-4: Comparison of Main Strainer Testing Debris and Total Available Testing Debris

Debris Type	Main Strainer Testing Debris (lbs)	Total Available Testing Debris (lbs)	Percentage of Total Testing Debris Allotted to the Main Strainer
Fibrous	0.463	0.802	57.69%
Particulate	23.045	36.017	63.98%

As is displayed in Table 5-4, the main strainer testing debris constitutes 57.69% of the total fibrous testing debris, as well as 63.98% of the total particulate testing debris.

As a simplification, the main strainer testing debris is taken to constitute 60% of the total available debris load, both fibrous and particulate. Similarly the remote strainer testing debris is taken to constitute 40% of the total available debris load, both fibrous and particulate.

Further, as shown in Table 5-3, the quantity of particulate debris utilized in testing exceeds 200% of the sum total of particulate debris available at the strainers for the DGBS. The quantity of fibrous debris utilized is equivalent to 178% of the sum total of fibrous debris available at the strainers. Therefore, as another simplification, the quantities of debris are combined without regard to fibrous or particulate debris and the quantity of debris utilized in testing is expressed as 200% of the sum total of debris available at the strainers. These comparisons are summarized below in Table 5-5.

Table 5-5: Comparison of Testing Debris and Actual Available Debris

Debris Type	Quantity Tested (lbs)	Actual Quantity Available at the Strainers (lbs)	Percentage of Actual Quantity Available
Particulate	1367.23	631.98	216%
Fibrous	31.57	17.66	179%
Total Debris	1398.8	649.64	215%

Using these simplifications to provide a common reference, all debris quantities are quoted as percentages of total debris quantity available at the strainers. Thus for example, the point at which 100% of the DGBS main strainer debris was tested is referred to as 120% of the total available debris. 100% of the DGBS main strainer debris being roughly equivalent to 60% of the total tested DGBS debris, and 60% of the total tested DGBS debris being roughly equivalent

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to 120% of the debris actually available at the strainers.

To determine the analytical correlations between debris loading, flow rate, and head loss, the head loss test results of the main strainer only DGBS head loss test were plotted against percentage of flow rate to determine the effect of flow rate upon head loss for the distinct debris loads constituting 60%, 90%, and 120% of the total available debris load. The curves that are contained within this response provide analytical insight but do not establish design basis head loss values for the recirculation sump strainer system. The strainer system design basis head loss values are established in Attachment 3, Information Item 3.o.15.a). Those values are 2.78 ft H_2O for the DEGB, 2.63 ft H_2O for the DGBS, and 2.38 ft H_2O for the SBLOCA.

The test data from CCI Test 12 was chosen to use for this analysis due to the test being performed entirely with the main strainer only. The remote strainer was 100% blocked for the entire duration of the test and no flow was passed through the remote strainer side of the test apparatus. This allowed for the collection of data which illustrates the relationship between flow, debris quantity used in the formation of the debris bed, and head loss. The test results are summarized Table 5-6.

Table 5-6: Main Strainer Only DGBS Test Results Summary

Test Step	Percentage of Total Debris Load	Percentage of Total Flow Rate	Head Loss (in H_2O)
2	50%	25%	0.188
3	50%	50%	0.453
4	75%	50%	0.723
5	75%	75%	1.532
6	100%	75%	4.803
7	100%	100%	4.923

These results were then plotted, as shown in Figure 5-7.

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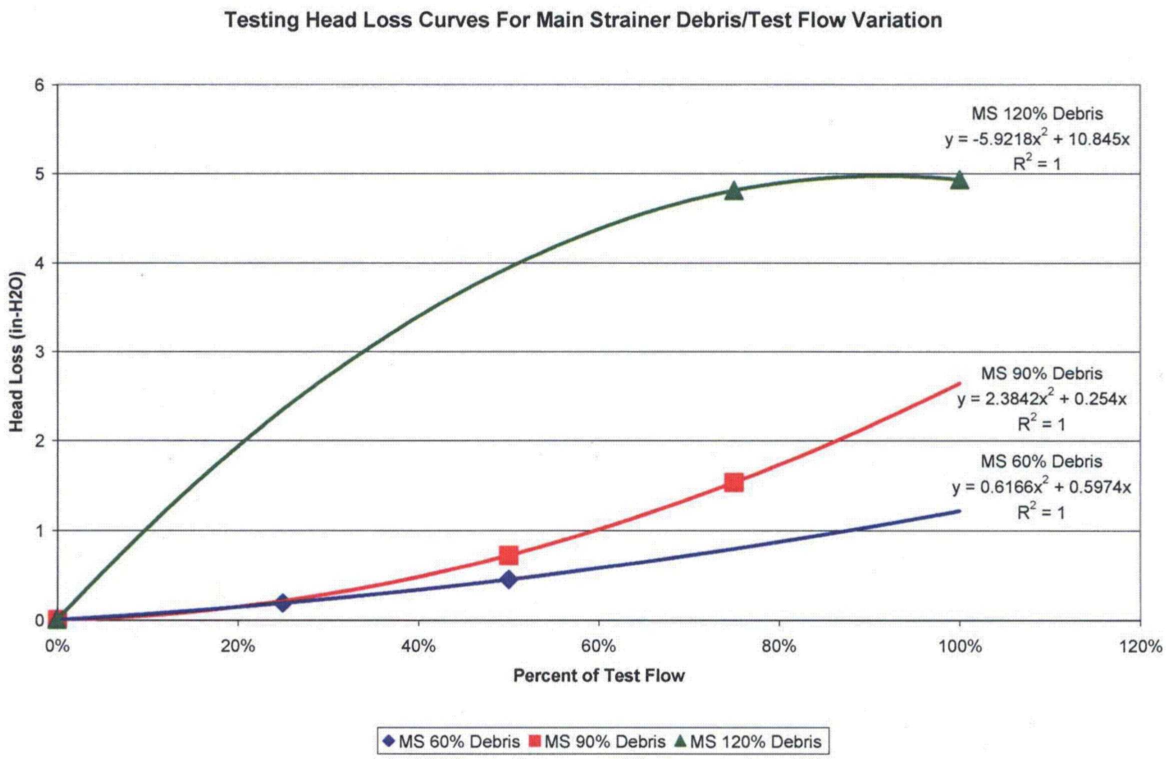

Figure 5-7: Testing Head Loss Curves for Main Strainer

For the 120% debris case the head loss curve appeared to be reaching a stabilization point in head loss with increasing flow rate near the 100% flow rates. It is most likely that this stabilization in head loss was due to the formation of bore holes in the debris bed at higher head losses. These bore holes in turn are most likely due to the very low quantity of fiber, which is insufficient to provide enough structure to the bed at higher head losses.

Because the main and remote strainers are identical except in their overall strainer area (number of pockets), the results determined for the main strainer were then applied to the remote strainer as well and the analysis combined to determine the effect of flow and debris split on the overall testing head loss. The curves were used to predict the head loss across the remote strainer at the same flow rate points used to create the curves for the main strainer, but the head loss points were determined using the adjusted approach velocity which corrects for the difference in strainer area between the main and remote strainers.

Utilizing the strainer areas for the remote and main strainers, where A_{ms}=20.089 and A_{rs}=24.106 it was found that the strainer area ratio is such that the main strainer has approximately 85% of the total area of the remote strainer. Thus, equivalent flow rate conditions through the remote strainer would result in approach velocities equal to 85% of those through the main strainer, which would cause a head loss equivalent to that of 85% of the flow rate through the main strainer. As the head loss curves for the main strainer were known as a function of test flow, the equivalent head loss curves for the remote strainer were determined by understanding that the head loss across the remote strainer is also known due to the known difference in approach velocity, which can be shown as a difference in head loss equivalent test flow due to the difference in strainer area. A summary of the points used to determine the remote strainer curves are shown in Table 5-7.

Table 5-7: Remote Strainer Head Loss Curve Data Points

Test Step Extrapolated	Percentage of Total Debris Load	Main Strainer Percentage of Total Flow Rate	Equivalent Remote Strainer Percentage of Total Flow Rate	Remote Strainer Head Loss (in H_2O)
2	50%	25%	22%	0.155
3	50%	50%	43%	0.365
4	75%	50%	43%	0.539
5	75%	75%	64%	1.131
6	100%	75%	64%	4.507
7	100%	100%	85%	4.940

The curves which are created for the remote strainer were then plotted against those previously created for the main strainer with the understanding that the total flow rate must be split between the two strainers. This is displayed in Figure 5-8.

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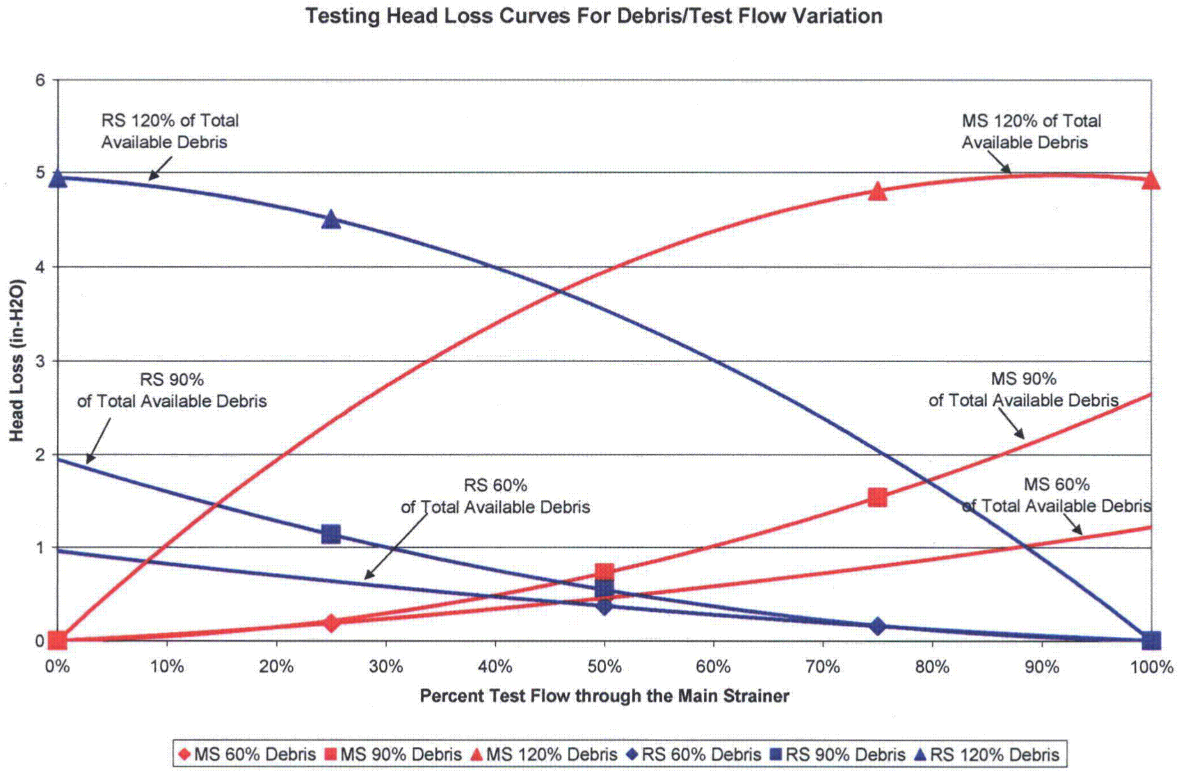

Figure 5-8: Combined Testing Head Loss Curves for Debris/Flow Variation

As can be seen from Figure 5-8, as the flow rate to the main strainer is increased the flow rate to the remote strainer is reduced, with the accompanying increase and decrease in head loss across the respective strainers. It is further understood that the head loss across the remote strainer in the test apparatus must be equal to the head loss across the main strainer. Due to this it can be seen that the intersections of the curves are the flow split that create the maximum achievable head loss for the debris split which is represented by the intersecting curves. By selecting paired curves which represent a constant debris quantity, the effect of the debris split between the main and remote strainers on the system head loss can be determined.

The most logical debris curve pairs to calculate system head losses are those which additively equal 180% of the total testing debris quantity. This is due to the fact that there are three of these points. Specifically the debris curves that represent 60% of the total available debris load on the main strainer and 120% on the remote strainer, the curves with 90% of the total available debris load on each strainer, and the curves which represents 120% of the total testing debris on the main strainer and 60% on the remote strainer. The head loss and flow rate split determined by the intersections of these three curve pairs were then used as inputs for the calculation of the plant system head loss, including waterway losses. These curves are illustrated in Figure 5-9 through Figure 5-11.

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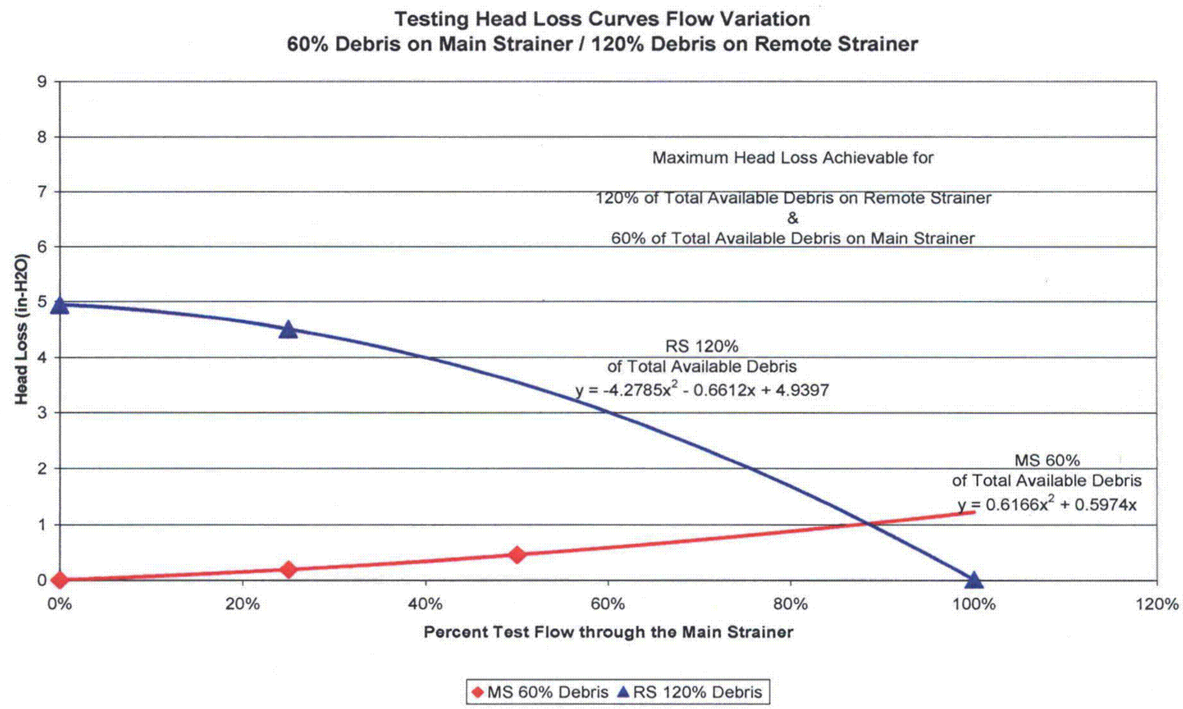

Figure 5-9: 180% Debris Load Curve Intersection for 60% Debris on the Main Strainer

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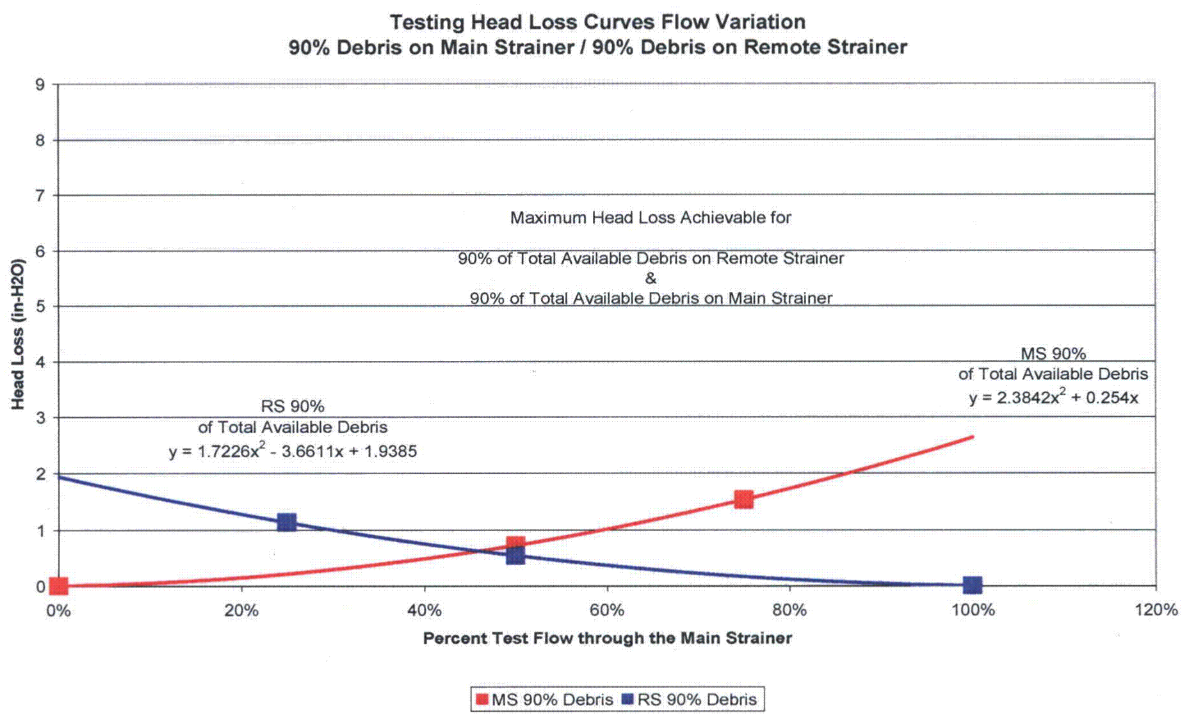

Figure 5-10: 180% Debris Load Curve Intersection for 90% Debris on the Main Strainer

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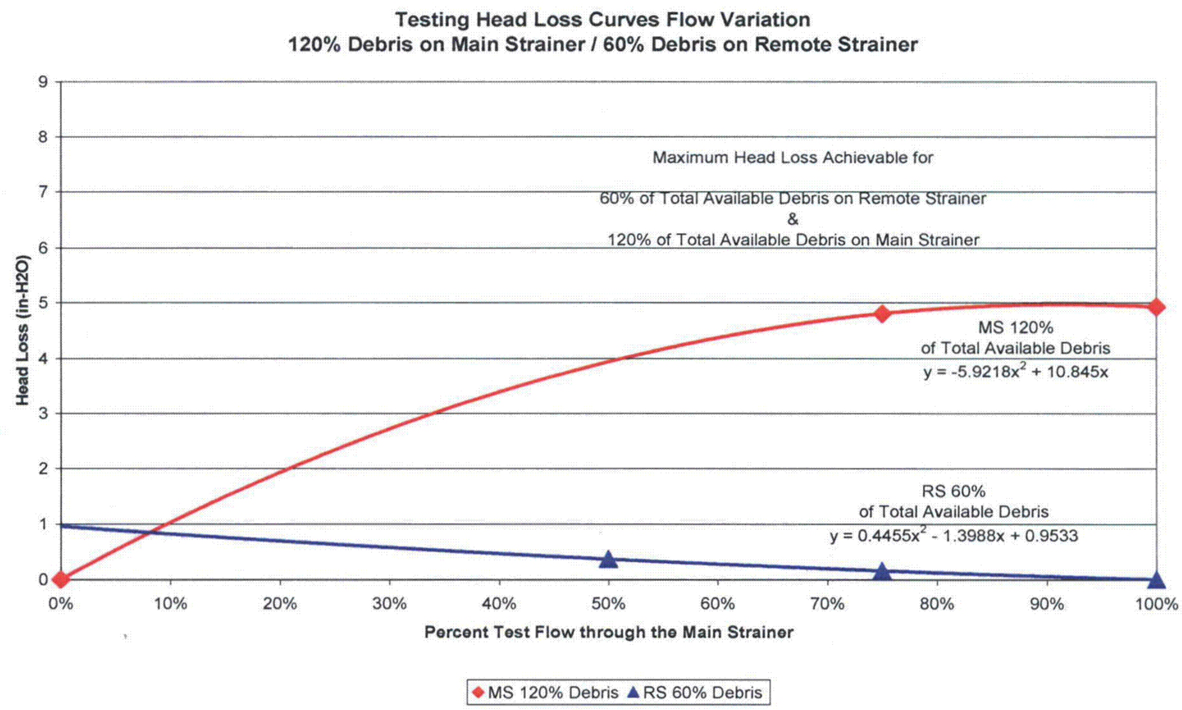

Figure 5-11: 180% Debris Load Curve Intersection for 120% Debris on the Main Strainer

The resultant value of the flow splits and head loss for the three debris case intersections were then determined by equating the equations of the head loss curves for each pair, as tabulated in Table 5-8.

Table 5-8: Intersection Figure Results

Figure Designation	Main Strainer Head Loss Equation	Remote Strainer Head Loss Equation	Equilibrium Head Loss Main Strainer Flow Rate	Equilibrium Head Loss (in H_2O)
Figure 5-9	$0.6166x^2+0.5974x$	$-4.2785x^2-0.6612x+4.9397$	88.42%	1.013
Figure 5-10	$2.3842x^2+0.254x$	$1.7226x^2-3.661x+1.9385$	45.95%	0.6201
Figure 5-11	$5.9218x^2+10.845x$	$0.445x^2-1.3988x+0.9533$	8.13%	0.8426

These results are summarized in Table 5-9. The "Equilibrium Head Loss" of Table 5-8 is represented as "Testing Head Loss" in Table 5-9, with a change of units from in H_2O to ft H_2O.

Table 5-9: Testing Head Loss and Flow Splits 180% Testing Debris Points

Main Strainer Testing Debris Fraction	Remote Strainer Testing Debris Fraction	Percent Flow Rate to Main Strainer	Testing Head Loss (ft H_2O)
60%	120%	88%	0.084
90%	90%	46%	0.052
120%	60%	8%	0.070

Finally, the duct head loss was then analytically appended to the analysis to determine the effect of flow and debris split on the plant system head loss. These results are summarized in Table 5-10.

Table 5-10: System Head Loss and Flow Splits 180% Testing Debris Points

Main Strainer Testing Debris Fraction	Remote Strainer Testing Debris Fraction	Percent Flow Rate to Main Strainer	System Head Loss (ft H_2O)
60%	120%	88%	0.086
90%	90%	46%	0.114
120%	60%	8%	0.598

As described earlier, the 120% debris case as shown in Figure 5-7 was considered to be potentially influenced by boreholes. To ensure conservatism was being exercised, it was determined that it would be useful to explore the possibility that the extrapolated curve for the 120% debris case was being influenced by a testing point which represents a statistical outlier and the extrapolated curve for this debris bed case should increase without limit as flow increases, similar to the other two curves.

To define the extrapolated curve which would describe the debris bed without the influence of boreholes, it was necessary to correct for the stabilization trend in the 120% debris load case head losses with flow rate. Physically, it is understood that head loss increases with flow rate, and that this correlation is proportional to the approach velocity (or flow rate) for laminar flows, and proportional to the square of approach velocity (or flow rate) for turbulent flows. It is also understood that beds which cause higher head loss tend to have more turbulent flows. Thus, to perform this correction, the flow through the 120% debris case bed was assumed to be 100% turbulent. It is known that for debris beds through which the flow regime is 100% turbulent, the head loss is a function of the square of the flow rate. This is conservative as turbulent flows produce higher head loss than laminar flows. The 100% flow data point was then discarded and the more conservative 75% flow point was used to determine the dependence of head loss on flow rate for the 120% debris load. This is displayed in Figure 5-12. Utilizing the 75% flow rate point was determined to be conservative as it produces higher extrapolated head losses than the 100% flow rate point.

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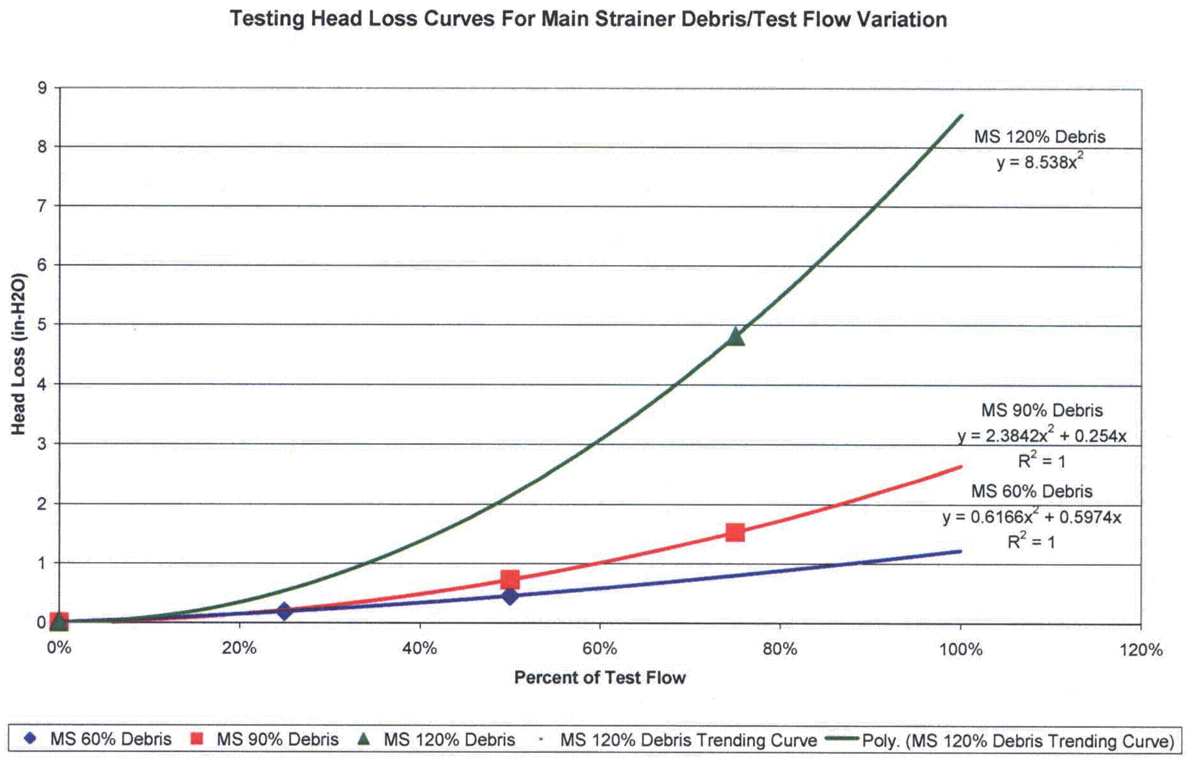

Figure 5-12: Alternate Testing Head Loss Curves for Main Strainer

These same curves were then applied to the remote strainer, similar to the original curves. The combined results are displayed in Figure 5-13.

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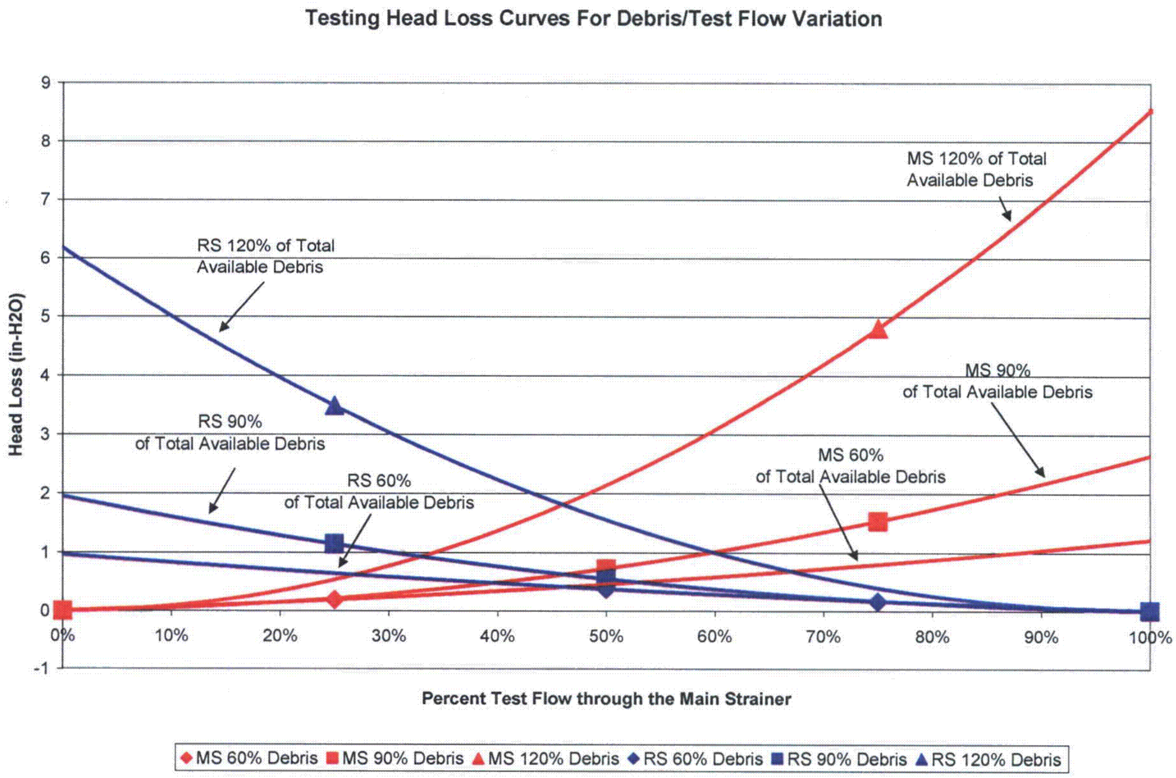

Figure 5-13: Alternate Combined Testing Head Loss Curves for Debris/Flow Variation

The change to the 120% of total available debris curves for both the main and remote strainer affects two of the cases chosen to determine the affect of varied flow and debris splits on head loss. These two cases are the paired curves for 60% of the available debris on the main strainer and 120% on the remote strainer, as well as the paired curves for 120% of the available debris on the main strainer and 60% on the remote strainer. The intersections of the alternate pairs of curves for these two cases are shown in Figure 5-14 and Figure 5-15.

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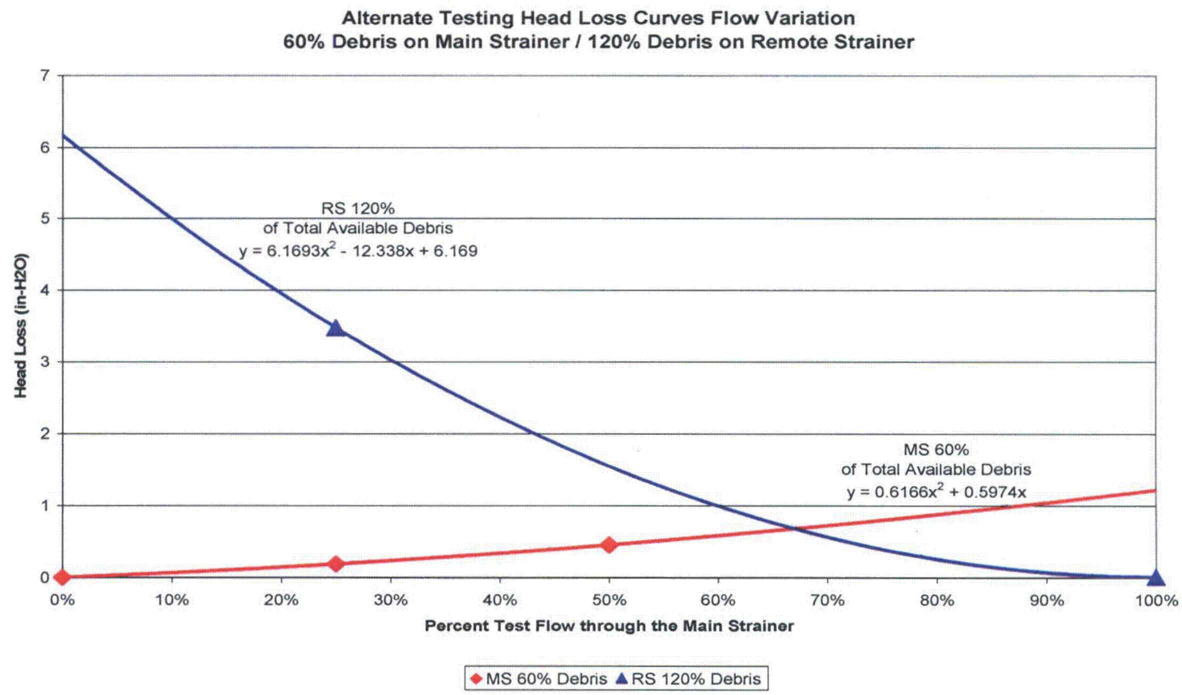

Figure 5-14: Alternate 180% debris Load Curve Intersection for 60% Debris on the Main Strainer

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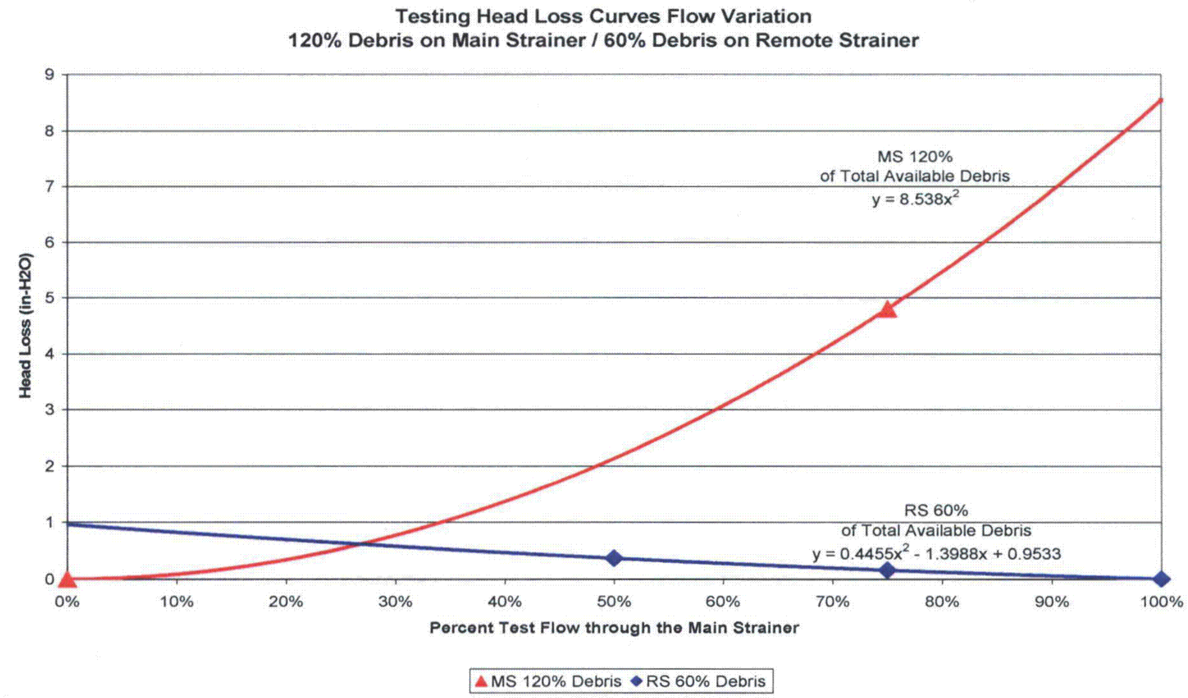

Figure 5-15: 180% Debris Load Curve Intersection for 120% Debris on the Main Strainer

The resultant value of the flow splits and head losses for the two alternate debris case intersections were then determined by equating the equations of the head loss curves for each pair, as tabulated in Table 5-11.

Table 5-11: Intersection Figure Results

Figure Designation	Main Strainer Head Loss Equation	Remote Strainer Head Loss Equation	Equilibrium Head Loss Main Strainer Flow Rate	Equilibrium Head Loss (in H_2O)
Figure 5-9	$0.6166x^2+0.5974x$	$6.1693x^2-12.338x+6.169$	66.91%	0.6758
Figure 5-10	$8.538x^2$	$0.445x^2-1.3988x+0.9533$	26.75%	0.6110

These results are summarized in Table 5-12.

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Table 5-12: Testing Head Loss and Flow Splits 180% Testing Debris Points

Main Strainer Testing Debris Fraction	Remote Strainer Testing Debris Fraction	Percent Flow Rate to Main Strainer	Testing Head Loss (ft H_2O)
60%	120%	67%	0.056
120%	60%	27%	0.051

Finally, the duct head loss was then analytically appended to the analysis to determine the effect of flow and debris split on the plant system head loss.

The results of the system head loss calculations which append the duct head loss to testing data for the three 180% debris load splits as well as the results for the debris splits incorporating 60% of the debris on the main strainer and 120% on the main strainer with the alternate testing curves are tabulated in Table 5-13.

Table 5-13: Head Loss for Varied Debris Splits

Main Strainer Debris Load (As a Percentage of Available Debris)	Remote Strainer Debris Load (As a Percentage of Available Debris)	System Head Loss (ft H_2O)
Original Testing Curves		
60%	120%	0.086
90%	90%	0.114
120%	60%	0.598
Alternate Testing Curves		
60%	120%	0.075
120%	60%	0.211

This data was then used to show how head loss changes with the debris split between the main and remote strainer. This relationship is presented in Figure 5-16. Note also that the data points which constitute this figure incorporate the appropriate flow rate split predicted for the debris split at each point.

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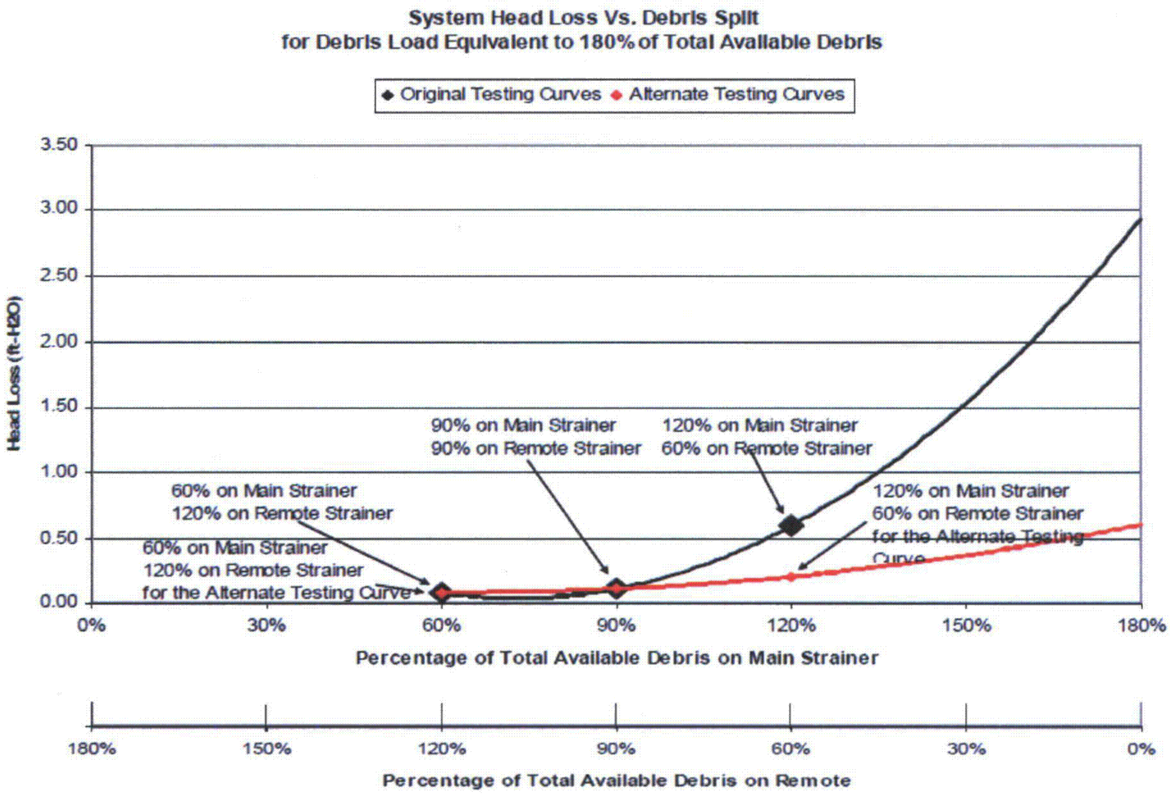

Figure 5-16: System Head Loss Vs. Debris Split

In Figure 5-16 it is apparent that at the point representing 60% of the total available debris on the main strainer (and a corresponding 120% of the total available debris on the remote strainer) that the use of the alternate head loss extrapolation curve with head loss as described earlier yielded a final system head loss roughly equivalent to the final system head loss yielded by the original head loss extrapolation testing curve. The primary difference between the use of the original testing curves and the alternate testing curves is at the point representing 120% of the total available debris on the main strainer (and a corresponding 60% of the total available debris on the remote strainer). However, though the alternate curves resulted in a lower head loss, the overall trend of head loss as a function of the debris split remained the same using the results of either the original *or* alternate curves.

Specifically, it is clear from Figure 5-16 from both the alternate and original curve points that the head loss trend is increasing as the debris split shifts debris from the remote strainer to the main strainer. The reason this occurs is due to the waterway losses as illustrated in Figure 5-2, reprinted as Figure 5-17 here for convenience.

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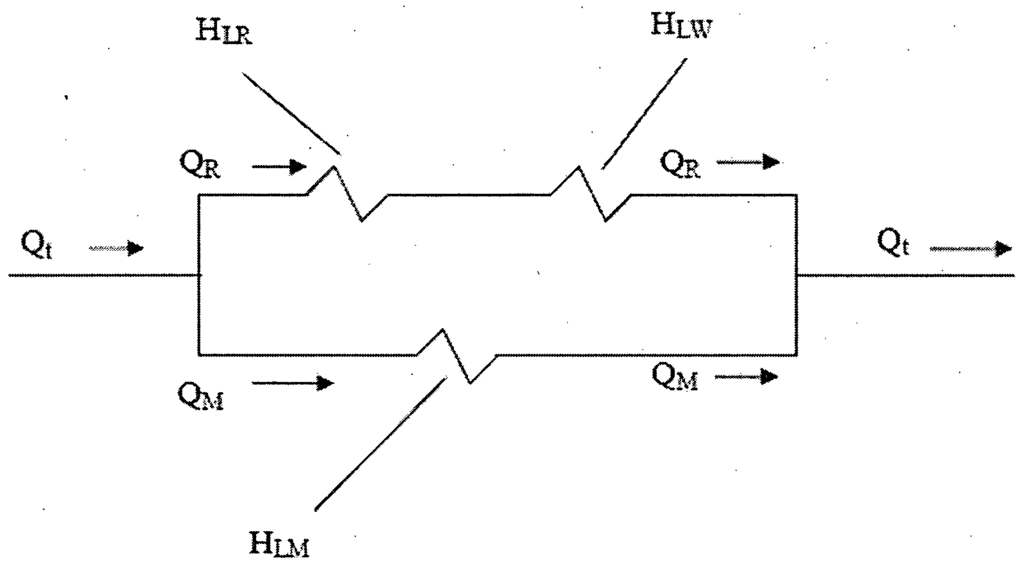

Figure 5-17: Sump Strainer Resistances Diagram

It can be seen that as the debris split favors the main strainer, the active resistance of the strainer would increase, and the active resistance of the remote strainer would decrease. As this occurs the flow rate will balance to ensure that the head loss across the two pathways remains the same by physical necessity. To accomplish this, the flow split will increase across the remote strainer pathway, and decrease across the main strainer pathway. As this occurs the head loss caused by the waterway losses increases, driving the overall system head loss upward.

Based on the discussions provided, the Loop 4 break is bounding due to its generation of greater quantities of problematic debris, and the postulated condition of uniform debris distribution per total unit strainer surface area results in a lower overall system head loss.

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.*

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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 0.33 in H_2O. For the DGBS, the head loss was even lower, approximately 0.08 in H_2O. Comparing these values to the clean screen head loss value of 0.065 in H_2O, it can be seen that the pool fill debris quantities result in a very low head loss across the main strainer. When these head loss values are analyzed to determine the total equivalent reduction of the clean strainer area at 100% flow, the results are less than 1% for the DGBS and 52% 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.

It should also be noted that during the period of pool fill, approximately 20 minutes for the DEGB large break LOCA (LBLOCA), the water level increases to approximately 7.7 ft in containment, providing substantial driving head for flow through the strainer.

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:

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 94.9%, 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 95.9%. As discussed in the response to RAI 5, a more heavily debris laden main strainer results in a greater overall system head loss due to the head loss associated with the waterway connecting the remote strainer to the sump pit. From a debris transport perspective, 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. In addition, also as discussed in the response to RAI 5, there is significant margin between the as-tested and actual available quantities of debris resident within containment. These factors provide reasonable assurance that the debris transport and testing methodologies utilized substantially bound the actual conditions that could develop following a LOCA.

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:

It is acknowledged that there are some important differences in debris transport for different accident scenarios that would affect time dependent transport during the pool fill phase. For example, an LBLOCA would result in more rapid ice melt than a MBLOCA or SBLOCA, the pool would rise faster, the break flow may be higher, etc. However, the quantity of debris generated and transported to the strainers for a LBLOCA far outweighs any potential differences in the time dependent transport that would be associated with a MBLOCA or SBLOCA.

During the blowdown phase, a large portion of the debris that is generated would be blown into the ice condenser where it would be captured by the ice baskets. The ice condenser is designed so that all of the steam blown into it will be condensed. This means that the debris that is blown into the ice condenser will be captured by the ice baskets rather than being blown all the way to upper containment. The tremendous transfer of heat from the steam blowdown to the ice condenser for a LBLOCA would result in a large quantity of ice melting immediately and approximately 80,000 gal of water washing back into the pool in less than 15 seconds (Reference 28 of the February 29, 2008, supplemental response. Since the debris blown into the ice condenser would be trapped on the outside of the ice, as the ice melts the debris would be washed back down to the loop compartment. Therefore, essentially all of the debris that is blown into the ice condenser would immediately be washed back into the pool. Therefore, it is reasonable to assume that the debris blown into the ice condenser would be in the containment pool at the beginning of the pool fill phase, and the additional ice melt flow draining into the pool is essentially clean.

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The unqualified coatings are assumed to fail after the pool fill phase is over and therefore were treated as being washed into the containment pool in the appropriate locations during the recirculation phase. Also, the latent debris, and other miscellaneous debris sources in upper containment were treated as being washed down more gradually by the containment sprays during the recirculation phase.

Although it is acknowledged that the water entering the containment pool during the pool fill phase would not actually be perfectly clean, the physical phenomena that affect debris transport during the blowdown, washdown, pool fill, and recirculation phases were reasonably accounted for to ensure that the overall transport fractions to both the main and remote strainers are conservative.

> *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.*

<u>Response:</u>

Refer to the responses provided to the individual items for this RAI and RAI 5, the combination of which adequately addresses this RAI.

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.*

<u>Response:</u>

ALION-REP-AEP-4462-02, "D. C. Cook Material Transport, Erosion and Dissolution Report", a CNP specific report, summarizes the results of the testing performed by Alion to measure the erosion and dissolution of Cal-Sil insulation material and the erosion of Marinite I insulation

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material as described in detail in the following Alion proprietary reports:

1. ALION-REP-LAB-2352-101, "Flow Erosion Testing of Cal-Sil Insulation Debris":
This testing used Alion obtained Thermo-12™ Gold from the Industrial Insulation Group (IIG) as the standard and tested four other types of plant provided Cal-Sil samples. Approximately 3 in x3 in x1 in pieces of Cal-Sil insulation, each weighing approximately 35 to 40 grams were tested for erosion at a constant flow velocity of 0.4 ft/s.

2. ALION-REP-LAB-2352-218, "Marinite I Flow Erosion Testing Report":
This report documents the Marinite I flow erosion testing and provides the test results as a percent weight loss for the tested samples.

3. ALION-REP-LAB-2352-76, "Calcium Silicate Insulation Debris Dissolution Report":
This report describes the dissolution testing of Thermo-12™ Gold Calcium Silicate insulation manufactured by IIG and aged Thermo-12® Gold Calcium Silicate insulation manufactured by Johns Manville (CNP specific material).

The data collected during Thermo-12™ Gold flow erosion testing was analyzed in the Cal-Sil Flow Erosion Testing Report. The data in Figure 7-1 represents the rate of erosion of Thermo-12™ Gold Cal-Sil as presented in Figure 3.2-3 of Cal-Sil Flow Erosion Testing Report. The equation from 3.2-3 (i.e. $y = 1.3286x^{-0.816}$) is used to calculate the cumulative % weight loss data and the curve generated from this data is presented in Figure 7-1 as well.

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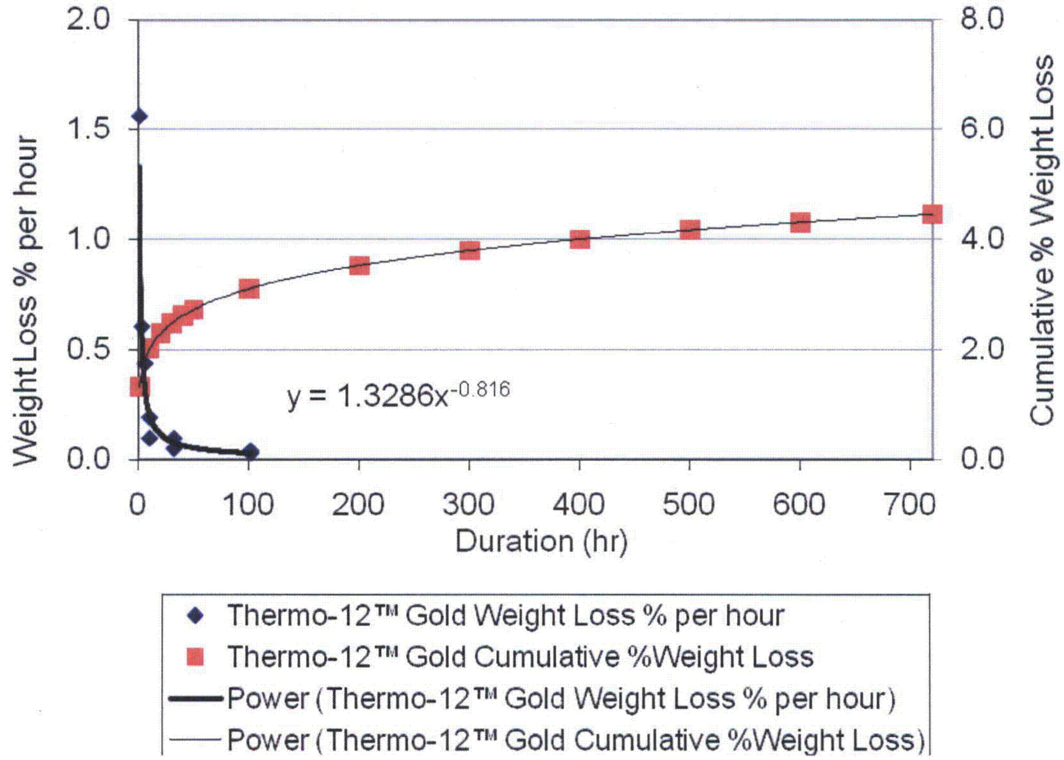

Figure 7-1: Data Erosion Rate and Predicted Cumulative % Weight Loss Curve (Thermo-12™ Gold)

During the conduct of the testing, one of the overall observations made was that during the initial stages of all tests, small amounts of particles detached from the samples. This behavior is most likely due to the washing of loosely attached pieces. The graph above shows the behavior that the majority of flow erosion occurs in the initial hours and then the rate of erosion continuously declines as time increases.

Extending the curve for cumulative % weight loss, the weight loss at 720 hours is 4.46%. Although the data plotted above indicates that the erosion rate may decrease with time, a linear curve fit was applied to the data as a more conservative method of extrapolation due to its application of a constant erosion rate as opposed to a power curve fit. Figure 3.2-2 of Cal-Sil Flow Erosion Testing Report (Figure 7-2) represents the linear curve fit. In addition to Thermo-12™ Gold Cal-Sil cumulative erosion, also displayed are values for four types of plant provided Cal-Sil cumulative erosion.

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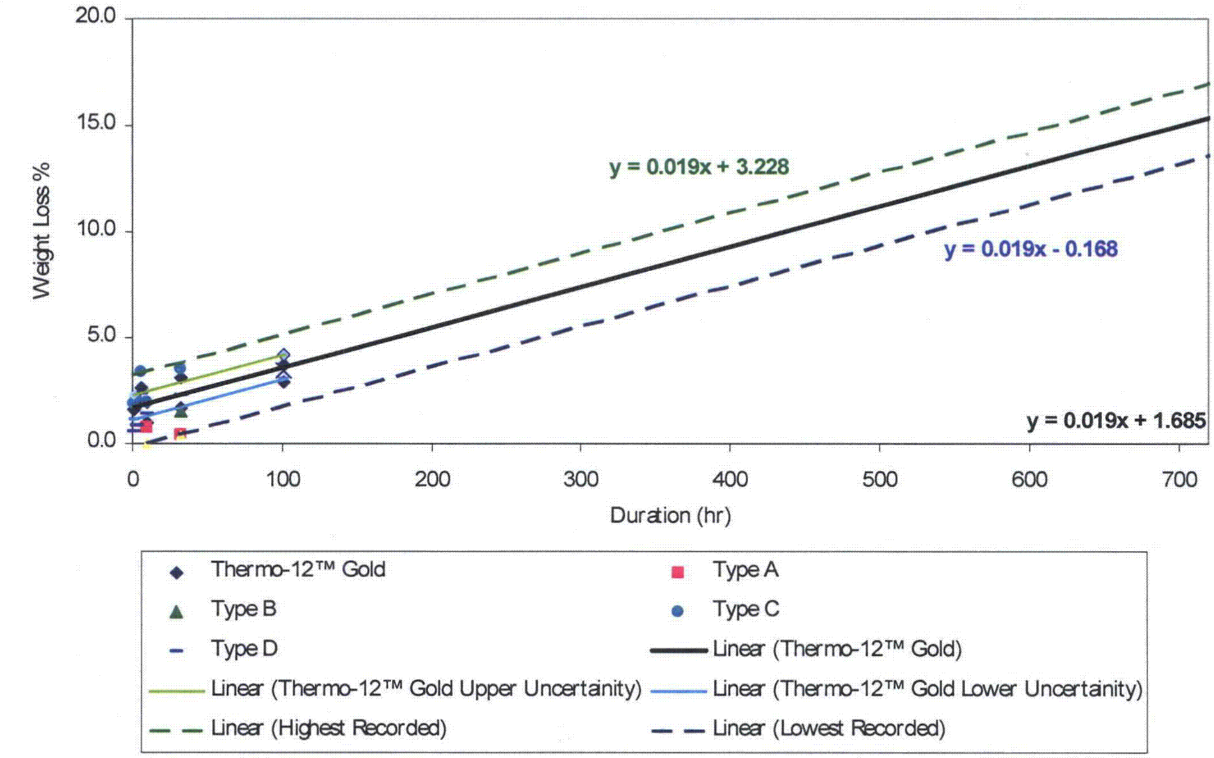

Figure 7-2: RMS Error and Bounding Curves for Cal-Sil Flow Erosion

The curve fit of Thermo-12™ Gold was used to determine the total Thermo-12™ Gold erosion at the recirculation mission time of 30 days (720 hours) as obtained by extrapolation. The total weight loss of Thermo-12™ Gold Cal-Sil samples at 30 days is (15.37 ± 0.59)% (using the equation y= 0.019x + 1.6854).

The upper and lower bounds of the weight loss as a function of time are calculated by sliding the linear curve fits up and down to the points that have the greatest difference between the measured value and the linear curve fit. These upper and lower bounding curve fits are used to determine the upper and lower bounding values of total Cal-Sil erosion at the recirculation mission time of 30 days (720 hours) i.e. 13.512% to 16.91% of initial mass.

Dissolution testing as discussed in the Alion Cal-Sil Dissolution Report 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 concluded 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. It was Alion's observation that Cal-Sil appears to gain weight when subjected to tap water or chemistry. Therefore, any long term test that requires material that could be absorbed by Cal-Sil would be non-conservative. Since this mechanism in not applicable to 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 dissolution testing in post-LOCA chemical conditions has concluded that large scale dissolution will not occur.

The Marinite I Flow Erosion Testing Report shows that Thermo-12™ Gold weight loss test results bound the weight loss test results obtained under similar conditions for Marinite I (See Table 7-1).

Table 7-1: Marinite I and Thermo-12™ Gold Cal-Sil Flow Erosion Results

Material	Test Duration (hrs)	Sample Weight Loss Average (%)
Thermo-12™ Gold	10	1.44
Marinite I	10	0.43
Thermo-12™ Gold	32	2.35
Marinite I	32	1.18

Thus, the value of 16.91% can be used conservatively as the maximum flow erosion for Marinite I as well.

The following is a summary of bases (as discussed above) for not accounting for erosion and dissolution effects in combination:

1. Cal-Sil insulation and Marinite board dissolution testing in post-LOCA chemical conditions concluded that the large scale dissolution of Cal-Sil will not occur.

2. The method of calculating the Cal-Sil and Marinite flow erosion at 30 days is highly conservative:

   a. Extending the curve for cumulative weight loss, the weight loss at 30 days for Thermo-12™ Gold is 4.46% (As shown in Figure 7-1).

   b. Although the data plotted in Figure 7-1 indicates that the erosion rate may decrease with time, a linear curve fit that was applied to the data as a more conservative method of extrapolation due to its application of a constant erosion rate as opposed to a power curve fit (As shown in Figure 7-2). The total weight loss of Cal-Sil samples calculated in this manner at 30 days is (15.37 ± 0.59)%.

   c. These upper and lower bounding curve fits are used to determine the upper and lower bounding values of total Cal-Sil erosion at the recirculation mission time of 30 days i.e. 13.512% to 16.91% of initial mass.

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d. Therefore, approximately 17% of the initial mass is used conservatively as the maximum flow erosion for the long term recirculation mission time of 720 hours for both CNP specific Cal-Sil and Marinite I insulation debris. This assures that all types of Cal-Sil represented are conservatively bounded.

3. The percentage erosion data that appears in the results of flow erosion testing was conservatively obtained from the differential sample weight. However, a portion of the erosion would have been in particulate form and another portion of it would have dissolved. The small portion of dissolved Cal-Sil / Marinite I would be considered to combine with other materials to form chemical precipitate and would not be available for direct input for debris only head loss across the strainer. The percentage erosion data obtained from the differential sample weight conservatively includes this portion of dissolved material.

4. There are additional conservatisms associated with Cal-Sil flow erosion testing:

   a. During testing it was observed that approximately 30% of the flow screen area exposed to flow velocity was blocked by the test samples. At a constant flow rate, this means that the local velocity around the test samples is 30% greater than the flow velocity. This increases conservatism of testing since this effect would not be possible in the containment pool due to the large volume of water.

   b. It is possible that local flow acceleration occurs due to the partially closed area of the screen on which the test material is placed. This means that the local velocity around the test samples is greater than the intended flow velocity which increases conservatism of testing.

Therefore, because of conservatisms associated with the established 17% as the maximum flow erosion for the long term recirculation mission time of 720 hours for both CNP specific Cal-Sil and Marinite I insulation debris and the negligible dissolution values, effects of erosion and dissolution were not considered to be additive.

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). 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:

The tumbling velocity that was used for small pieces of Cal-Sil and Marinite debris is 0.33 ft/s, and the tumbling velocity that was used for large pieces of Marinite debris is 0.52 ft/s. Since these pieces of debris would transport in any regions of the pool where the velocities are higher, the erosion would apply to debris that does not transport in the lower velocity regions. The recirculation pool CFD results from the limiting break case (Loop 4) were analyzed to determine the average velocity in the non-transport regions. As shown in Figure 7-3 and Figure 7-4, the average velocity in the non-transport regions was determined to be 0.11 ft/s for small pieces of Cal-Sil and Marinite, and 0.18 ft/s for large pieces of Marinite. Since these velocities are significantly lower than the 0.4 ft/s velocity used for the erosion tests, the erosion testing can be conservatively used for both the small and large pieces of Cal-Sil and Marinite at CNP.

Appendix 3

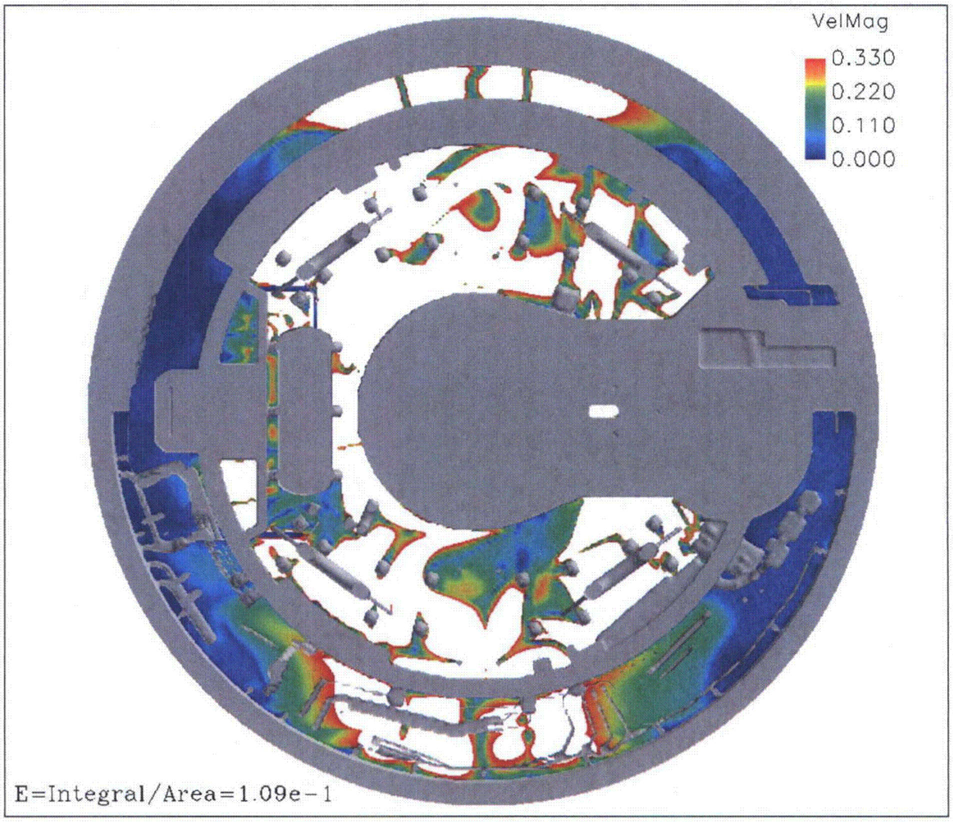

Figure 7-3: Average Velocity in Non-transport Regions for Small Pieces of Cal-Sil and Marinite

Appendix 3

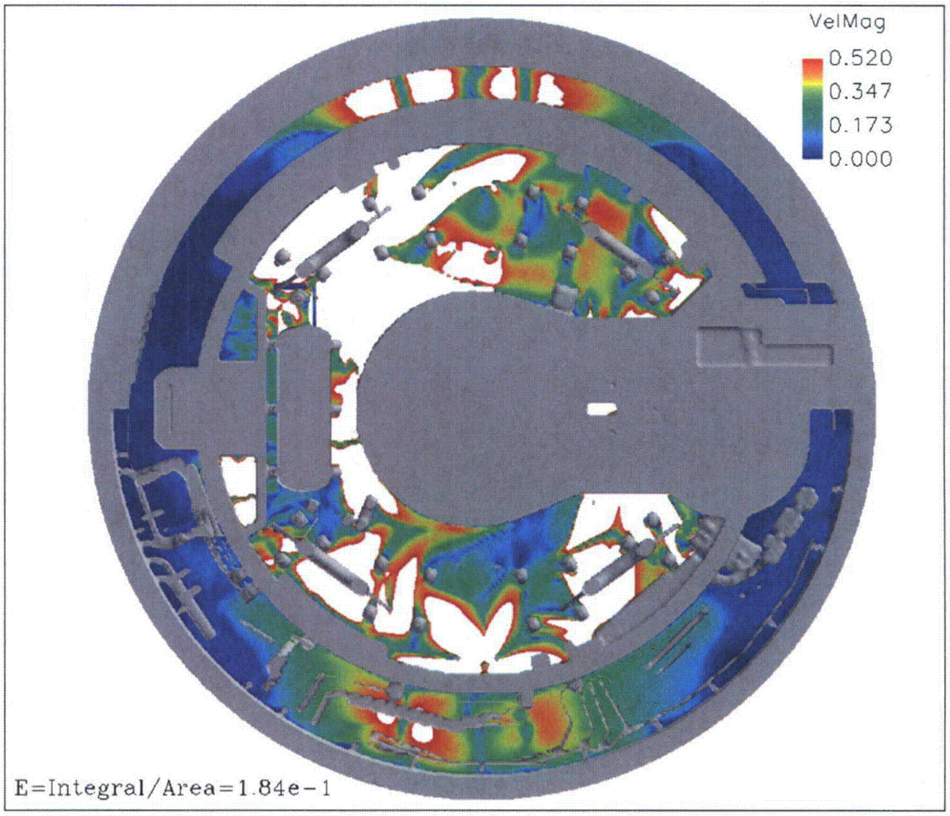

Figure 7-4: Average Velocity in Non-transport Regions for Large Pieces of Cal-Sil and Marinite

To further support acceptability of the flow rate used during erosion testing, there were no pieces of Cal-Sil or Marinite larger than 3 in (large pieces) used during the testing.

> *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:

The tumbling velocities used for the small and large pieces are based on flume testing performed by Alion. These velocities are incipient tumbling velocities. Table 8-1 shows the various incipient and bulk tumbling velocities that were measured.

Table 8-1 – Cal-Sil Tumbling Velocity Test Results

Sample Size	Incipient Tumbling Velocity (ft/s)	Bulk Tumbling Velocity (ft/s)
< 1 in	0.23	0.35
1 in - 3 in	0.33	0.45
>3 in	0.52	0.68

The incipient tumbling velocity is the flow velocity at which a piece first starts to move, and the bulk tumbling velocity is the velocity that causes continuous tumbling or sliding of the debris to the end of the flume.

The size distribution for the Cal-Sil at CNP is based on the OPG destruction testing described in NUREG/CR-6808. Based on this testing, the pieces of Cal-Sil range in size from chunks smaller than 1 in to chunks larger than 3 in with the majority of the pieces being in the 1 to 3 in range or larger than 3 in. The three categories of pieces from the OPG testing were combined together as small pieces in the CNP debris generation calculation. Since most of the debris classified as small pieces is larger than 1 in, using the 1 in - 3 in incipient tumbling velocity metric is reasonable. Note also that the incipient tumbling velocity for this category is lower than the bulk tumbling velocity for pieces smaller than 1 in. Since the bulk tumbling velocity is representative of the velocity required to transport debris all the way to the strainer, the velocity metric that was used for small pieces is also reasonably considered to be appropriate for the small portion of Cal-Sil debris that is smaller than 1 in.

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The debris transport metrics for Cal-Sil were assumed to be applicable to the Marinite debris also. This is a conservative assumption since the Marinite debris at CNP is more dense than Cal-Sil (36-46 lb_m/ft^3 for Marinite versus 14.5 lb_m/ft^3 for Cal-Sil), and therefore would be less likely to transport in the containment pool.

The tumbling velocity cited in NUREG/CR-6772 for small pieces of Cal-Sil is for chunks that were about 1 in in size. As shown in Table C.19(a) in this NUREG, the incipient tumbling velocity was determined to be 0.25 ft/s and the bulk tumbling velocity was determined to be 0.35 ft/s. These results are very similar to the results for the <1 in samples in the Alion testing (see Table 8-1).

As stated in the response to RAI 7c, there were no pieces of Cal-Sil or Marinite larger than 3 in (large pieces) used during the erosion testing.

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).*

<u>Response:</u>

It is acknowledged 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.

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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, 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 is included with the response to RAI 12.

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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 multifunctional test loop (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. Also, 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 Appendix 4 to this attachment. Figure 4-5 of Appendix 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 Appendix 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 initial review of industry data to support the response to this RAI was focused on those plants that have installed the CCI strainer design. Of the plants reviewed (seven plants total), it was determined that three of the plants had utilized RMI within their testing strategy. Plant 1, a high fiber plant, had used the RMI in a method similar to CNP. Plants 2 and 3 added RMI to essentially cover the full face of the test strainer following the addition of the chemical solutions to form the precipitates. Plants 2 and 3, being low fiber plants, saw a reduction of head loss in one test, and an increase in head loss in another test. The high fiber plant saw a significant increase in head loss as a result of chemical additions. Refer to the response to RAI 16 for additional discussion on increase in head loss as a result of chemical additions to the test loop.

The chemical effects testing that was performed for CNP did not introduce the debris in the same method as was done for the large scale event sequence testing which did introduce RMI as part of the pool fill sequence. For the MFTL chemical effects testing, the fibrous and particulate debris sources were added prior to the addition of RMI to the test loop. Based on available information, it is acknowledged that generally, the inclusion of RMI into testing will result in a lower head loss across the strainer. I&M acknowledges that the buildup of the RMI as observed within the photographs provided in Section 3.o of the February 29, 2008, supplemental is not what would be expected to exist in the plant following a LOCA. However, since this test was not attempting to establish a design basis bounding head loss value for the CNP strainer system, but rather determine a conservative increase in head loss across the most heavily debris loaded strainer in the CNP system, the specific configuration of the RMI with relation to the strainer is judged to be non-consequential for the following reasons:

- As can be seen in Figures 3o1-9 and 3o1-11 (Pages 291 and 293) of the February 29, 2008, supplemental response, the chemical precipitate had fully penetrated through the RMI layer to interact with the non-metallic debris bed within the strainer pockets. Figure 3o1-11 does show one pocket where it appears that little of the precipitant was present in the pocket. Figure 3o1-11 does show one pocket where it appears that there was significant blockage due to the way the RMI had placed itself in that particular strainer pocket. Upon closer examination of the actual photograph, it was determined that there was some of the precipitant within the pocket and the pocket was not completely blocked by the RMI. The photograph provided as Figure 4-7 in Appendix 4 of this attachment shows that the chemical precipitant had fully penetrated the RMI debris bed to interact with the fiber and particulate debris bed that had formed.

- Anything that reduces the quantity of debris sources from transporting to the strainer will result in an overall reduction of strainer head loss. Based on the assumption that not all of this RMI would stack up in front of the strainer in the plant does not mean that this RMI would be unavailable to filter fibrous, particulate, and chemical effects debris within the containment sump pool.

- Since these tests were performed with both fibrous and particulate debris significantly in excess of the quantities of the debris sources that are expected to exist within the plant, as described in the response to RAI 5, the resulting head loss values provide a correspondingly significant increase in magnitude over what would be expected.

- As provided in the North Anna final supplemental response (ML090641038), the type, quantity, and timing of the development of the chemical precipitates following an event are overly conservative when utilizing the WCAP-16530-NP criteria.

- As provided in the Ginna third supplemental response (ML091590265), evaluation of the CCI methodology for determination of the quantity of chemical precipitates to be formed was found to be significantly over-conservative resulting in the introduction of chemicals far in excess of reasonably conservative values. This is also applicable to CNP since the same chemical effects testing methodology that the Ginna supplemental response is referring to was during the same time frame that CNP was performing its testing (Fall 2007).

Further evaluation of the test configuration has determined the method by which the increased height RMI debris bed was formed. In an attempt to mimic the plant installation for the main strainer which has an approximate 4 in elevation from the containment floor to the bottom row of pockets, the bottom row of pockets were blocked off in the test strainer and a false floor was added. This false floor included a ramp on the leading edge which caused the water flow approaching the strainer to turn towards the vertical. As a result of this, the RMI debris bed that was initially at the lower pockets of the strainer following its addition to the test loop (expected condition for the plant) redistributed during the extended debris only head loss stabilization period. This did not happen instantaneously which provided sufficient time for the particulate and fibrous debris beds to form within the strainer pockets as would be expected to occur within the plant.

In conclusion, I&M judges that the presence of the RMI, in the configuration depicted in the photographs (figures) in Section 3.o of the February 29, 2008, supplemental response did not adversely impact the determination of the main strainer head loss increase attributable to chemical effects.

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, 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 the CNP strainers cannot form a complete fiber bed upon which compression effects are the most pronounced. Therefore, it is judged 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 is the most conservative, but not necessarily the most prototypical.

As described in the response to RAI 5, significant margin exists between the as-tested debris values and the actual quantity of debris available within containment to interact with the recirculation sump strainers, and the resultant head loss. This significant margin bounds any uncertainty with the test results.

Appendix 3

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:

There are multiple factors that can affect strainer head loss during test sequences. One of these factors is based on the recirculation transport of debris that initially bypasses the strainer during the debris additions. During the large scale testing, as described in the February 29, 2008, supplemental response to Information Item 3.f.4, Figure 3f4-1, the recirculation return path deposited the pumped water (with entrained bypass debris) into the common area. This water would then preferentially flow to the side of the test strainer module that had the least head loss, with some going to both sides of the strainer module. Since the test strainer module had different strainer areas between the main and remote strainer side, the remote strainer side would be predicted to have the greater flow once the main strainer side was substantially loaded. This was evidenced by the difference in propeller flow measurements that were obtained following achievement of stable 100% debris, 100% flow head loss across the test strainer module.

Another factor that can affect the difference in head loss is the degree of compaction of a debris bed that is formed. Small differences in debris accumulation within the pockets of the strainer can impact the magnitude of debris bed compaction that can occur. Also contributing to debris bed compaction is the quantity of fibrous debris available. With very little fibrous debris, as is the case for CNP, slight variations in the distribution of fibers within the pockets will have an impact on debris bed compaction.

Consideration of these types of effects is one of the reasons that regardless of the test scenario, the one that provided the highest head loss was the one that was chosen to represent the maximum head loss for a given break size.

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:

A review of the chemical effects testing within the industry has been performed. The initial focus of this review was on those plants that utilized the CCI strainer design. To date, this review has determined that the impact of chemical effects on the debris bed is principally a function of the fibrous material available within the debris bed, i.e., can a fibrous thin bed form. Based on a review of the test results, the greater the quantity of fiber, the greater the resulting head loss. Several of the plants that utilized the CCI strainer have significant quantities of fiber within their transported debris. For these plants, the increase in head loss as a function of chemical precipitate varied from a factor of 2 to a factor of 10, with the majority of the published results indicating a higher post-chemical precipitate head loss commensurate with the quantity of fibrous debris at the strainer.

The other CCI strainer plants reviewed were latent fiber debris only plants. These plants had an increase in head loss of approximately 30 percent above the debris only head loss values. These plants determined that the theoretical fibrous debris thickness that could develop was approximately 0.053 in thick.

Based on these reviews, a determination was made that the CNP chemical increase above the debris only head loss value of 53% was consistent with the increases seen with other CCI strainer plants since CNP has a theoretical fibrous debris thickness of 0.081 in thick.

For the plants reviewed, Table 16-1 identifies the debris only head loss and post-chemical precipitate head loss for the plants that were reviewed. These values are based on the latest published supplemental responses that could be found in the NRC document database, ADAMS, as of September 2009. It is possible that there could be additional letters that have modified some of these results.

Appendix 3

Table 16-1 CCI Strainer Testing Comparison

Plant	Strainer Opening Size (in)	Tested Fiber Bed Thickness (in)	Tested Flow Rate per Unit Strainer Area (gpm/ft^2)	Debris Only Head Loss (in H_2O)	Post 100% Chem. Add Head Loss (in H_2O)	Chemical Precipitate Added to / Injected in Test Loop	Increase Factor (Bump-up)
A	0.083	0.053	4.72	20.9	26.9	2100 ppm Al 480 ppm Ca 220 ppm Si	1.3
B	0.083	0.091	2.41	7.2	20.1	1.138 kg $NaAlSi_3O_8$ 0.566 kg AlOOH 0.477 kg $Ca_3(PO_4)_2$	2.8
CNP (DEGB)	0.083	0.10	10.5	32.04	45.96	1600 ppm Al 2700 ppm Ca 3800 ppm Si	1.43
CNP (DGBS)	0.083	0.10	10.5	53.16	81.6	1600 ppm Al 2700 ppm Ca 3800 ppm Si	1.53
C	0.083	0.3	2.16	97.23	117.43	2.577 kg $NaAlSi_3O_8$ 0.749 kg AlOOH	1.21
D	0.083	0.9	2.07	13.05	57.0	2.961 kg $NaAlSi_3O_8$ 0.599 kg AlOOH	4.37
E	0.063	0.069	4.70	19.2	38.4	5.058 kg $NaAlSi_3O_8$ 7.779 kg AlOOH	2.0
F	0.063	0.134	4.15	10.68	< 96 (1)	> 4.29 kg $NaAlSi_3O_8$	< 8.99
G	0.063	0.03	1.56	< 12.0	< 42	2.96 kg $NaAlSi_3O_8$	3.5
H	0.063	0.238	0.58	4.01	40.1	1.398 kg $NaAlSi_3O_8$	10
I	0.063	Information not readily available					

(1) Predicted Maximum Head Loss

To further demonstrate the conservatism and margin available to the CNP strainer design, Table 16-2 provides the overall system head loss increase factor available for the DEGB, DGBS, and SBLOCA based on the debris only system head loss values.

Table 16-2 Strainer System Head Loss

Test	Tested System Head Loss ($ft\ H_2O$) (1)	Allowable System Head Loss ($ft\ H_2O$)	Total Available Increase Factor
DEGB	1.129	2.8	2.48
DGBS	1.114	2.65	2.38
SBLOCA	1.114 (2)	2.4	2.15

(1) The stated head loss values are the 68°F normalized values
(2) Testing was not performed with SBLOCA debris quantities, thus use of DGBS test results are conservative

Furthermore, based on the reviews completed, a lower initial debris only head loss does not necessarily correlate to a greater increase in head loss as a result of chemical precipitate addition. A highly compacted bed, as was developed during the 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 CNP is 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, as described in the response to RAI 5. If testing had been performed with those reduced quantities, I&M fully expects that the debris bed 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 the 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 to weave the debris bed together for interacting with the chemical precipitate.

As identified in Table 16-2 above, the system head loss values have changed from those previously provided in the February 29, 2008, supplemental response. During the effort to address the June 18, 2009 RAI, it was determined that a non-conservative K-factor had been used for the waterway resistance and that the use of a more conservative temperature normalization methodology resulted in an increase in total system head loss based on the large scale testing results.

For the K-factor, the original analysis used a temperature of 190°F for the fluid in the waterway which is the maximum expected sump temperature following a LBLOCA. The current analysis uses a temperature of 68°F. The original temperature normalization did not use a dynamic methodology, but rather used a ratio of density for the given temperatures. The current methodology determines the flow regime that exists within the elements (laminar or turbulent or both) and then determines the change in head loss based on the change in density and viscosity of the water as a function of the turbulent and laminar flow contributions to overall system head loss. These changes are described, with the results, in Sections 3.f and 3.o of Attachment 4, Updated Supplemental Response, and the results are provided in Appendix 5 of this attachment. As can be seen, the margins to allowable head loss have been slightly reduced, but still provide substantial margin to account for uncertainties and increase in debris only head loss as a result of chemical effects.

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, I&M chose not to use the results of that testing as a direct input to the strainer system head loss evaluation. I&M 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:

Refer to the response to RAI 5.

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. As noted in the response to RAI 16.b), the system head loss values have increased as a result of use of more conservative inputs and methodologies. Table 16-2 provides the margin to allowable head loss for the DEGB, DGBS, and SBLOCA scenarios. As a result of the calculated system head loss changes previously described, CNP will no longer be using a 50% increase factor for determination of design basis head loss. The current methodology includes the clean strainer head loss within its determination of debris-only head loss.

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 maximum debris only head loss for the DGBS was 1.114 ft H_20 (as shown in Table 16-2), and the maximum head loss with chemicals is 1.89 ft H_20 (assuming a 70% increase in head loss), the head loss value is below the allowable head loss for the SBLOCA of 2.4 ft.

21. *Please provide justification that the flow rate assumed at the main strainer during the chemical effects testing was bounding with respect to the condition that could occur in the plant. Because of the amount of debris assumed at the main strainer, the corresponding flow assumed during testing may have been lower than could occur in the plant. A lower flow rate can affect the head loss value attained during testing and thus affect the bump up factor determined by the chemical effects head loss test.*

Response:

The flow rate used for the chemical effects head loss testing of the main strainer equivalent was equal to the flow rate assumed with the main strainer having an equivalent 90% blockage, 9720 gpm. Since the chemical precipitate interaction with the strainers will not occur until significantly later in the event, and as evidenced by the flow distribution between the main and remote strainer during the large scale testing, this flow rate should be at, or near, the maximum that the main strainer would see during the event, with this maximum debris load. The other factor that needs to be considered is that the head loss increase from the main strainer only was applied across the entire strainer system which includes the main and remote strainers and waterway connecting them. With this flow rate through the main strainer, the flow rate through the remote strainer will be about 4680 gpm, less than half of the flow through the main strainer. The head loss increase across the remote strainer due to the chemical effects will be substantially lower due to the lower flow rate through that strainer. Based on the high flow rate used and application of the chemical effects head loss increase factor across the entire strainer system, there is reasonable assurance that a maximum bump-up factor was determined through this 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. I&M fully expects 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. The Non-OEM alkyd coatings represent less than 0.4% of the total coatings debris that was used for testing for both the DEGB and DGBS. This quantity is judged to be insignificant when compared to the total coatings debris quantities that were used for testing which were in excess of the quantity of material determined to be available with the CNP containments.

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 epoxy 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. Since the epoxy coatings have fully developed bond strength within the coatings material itself, it is reasonable to conclude that the failure mechanism of loss of adhesion to the substrate material would result in relatively large chips of this material. Due to the expected size of these chips, there would be less of this material that would transport to the strainers as compared to what was used for strainer testing. It was conservatively decided to have the majority of the chips smaller than the strainer openings for the strainer testing. Due to the relatively small quantity of this coatings debris source as compared to the other coatings that are included in the head loss testing (< 0.8%), it was judged that it was not unreasonable to include coating chips of this size in the strainer head loss testing. The Non-OEM alkyd coatings represent less than 0.4% of the total coatings debris that was used for testing for both the DEGB and DGBS. Since the coatings debris quantities that were used for testing were significantly greater than the quantity that would be expected to be available, it is judged that the use of the chips did not significantly alter the head loss test results.

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. I&M believes 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, by procedure, 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. Utilizing more realistic inputs for the containment maximum water level analysis in the areas of available ice in the ice condenser, volume of water available and the expected temperature for the RWST, the expected temperature of the accumulators water, the quantity of core voiding that would be expected to exist at this later stage in the event, and the reduction in containment pool temperature to the expected temperature resulted in a significant decrease in maximum water level. The estimated maximum water level considering more realistic inputs is approximately 612.3 ft. For the 29 in inside diameter hot leg, this places the water level approximately 6 in below the opening of the pipe. 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 combination of conditions would prevent debris in the sump pool from entering the reactor vessel.

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

<u>Response:</u>

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. For other break locations that are below the expected maximum pool water level (as described in the response to RAI 24.a), the blowdown of the RCS that occurs from this break location would remove water from upper levels of RCS piping which would result in the loss of capability to form a siphon to pull debris laden water into the reactor vessel. The expected water level would not produce a driving head sufficient to force sump pool water into the reactor vessel.

<u>NPSH</u>

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 CNP RCS 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 includes a Double-Ended Cold Leg 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 CNP 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 reach rods. In addition to the physical arrangement of the CNP 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:

The debris that would be generated from a break near the top of the pressurizer was determined to be bounded by the debris that is generated for the DGBS. Additionally, the significant breaks that can occur at the top of the pressurizer are a 6 in single ended guillotine break at the supply piping for the pressurizer power operated relief valves and safety valves, or a double-ended guillotine break of the 4 in pressurizer spray piping. These break sizes are bounded by the 2 in SBLOCA minimum water level (5.1 ft) since these breaks will result in increased ice melt. The minimum water level for a 6 in break is approximately 5.3 ft at 9.2 hours following the break. The 6 in break assumes that RCS refill is somewhat effective resulting in reduced water inventory for the containment sump. The 4 in break results in more holdup of water in the RCS resulting in a minimum water level of approximately 5.1 ft at 9.7 hours following the break.

The 6 in break generates the greatest quantity of RMI and the 4 in break generates the greatest quantity of Cal-Sil. Table 25-1 provides the quantities of debris generated.

Appendix 3

Table 25-1 Pressurizer Enclosure Break Debris Generation

Break Size	Insulation Type	Amount Destroyed	Large Pieces	Small Pieces	Fines
6 in	RMI	892.2 ft^2	223.0 ft^2	669.1 ft^2	0 ft^2
4 in	Calcium Silicate	5.8 lbs	0 lbs	2.36 lbs	3.41 lbs

As can be seen from Table 25-1, the quantities of insulation debris generated is significantly below the quantities generated for the bounding DGBS break, Unit 2 Loop 4. As a result of these reduced quantities of materials, the strainer head loss values associated with the bounding DGBS testing that was performed also bound a break in this enclosure. An additional conservatism is that due to the extreme congestion that exists within the pressurizer enclosure, a large portion of this debris would be held up within the enclosure.

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:

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 containment equalization/hydrogen skimmer 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.

A pH level of 8.9 is justified for the testing based on the assumptions utilized in the CNP containment spray and recirculation sump pH calculation, MD-12-CTS-118-N. Within this calculation, there are three key assumptions that limit the quantity of sodium tetraborate (STB) within the recirculation sump fluid. These key assumptions and their basis are provided below:

1. The minimum concentration of STB in the ice per Technical Specifications (1800 to 2300 ppm) is used.

   Basis: Since the STB in the melted ice will buffer the sump solution pH, minimizing the amount of STB is conservative for predicting pH.

2. The minimum amount of ice melt is credited at various stages of the event regardless of the total available ice per Technical Specifications.

   Basis: Since the STB in the melted ice will buffer the sump solution pH, minimizing the ice melt (and thus STB) is conservative for predicting pH.

3. Any flow from the containment sump to isolated volumes of containment, such as to the reactor cavity via the nuclear instrumentation system penetrations in the primary shield wall, is conservatively neglected.

   Basis: If the boric acid, sodium hydroxide, and STB solution were to flow from the containment sump pool, the incoming STB from the ice condenser would be a larger fraction of the fluid in the sump. Since the STB in the melted ice will buffer the sump solution, minimizing the influence of the ice melt with this assumption is conservative.

The pH calculation establishes pH values for LBLOCA conditions which utilizes these assumptions, among others that either minimize or maximize pH values. For the LBLOCA case that establishes the maximum pH values for the case where both trains of ECCS and CTS operate throughout the event, the calculated pH values range between 8.79 and 8.91. This case is representative of the pH value that was used for the chemical effects testing.

As provided in the February 29, 2008, supplemental response, Section 3.o.4, to ensure that the maximum quantity of aluminum was generated to support formation of aluminum based precipitates, the pH value of the spray was maximized during the injection period (9.74 to 12.76) and then allowed to follow the expected trend toward the maximum expected pH of 8.9 during the following 8 hours. At that time the pH was held constant for both the sump pool and spray until the 48 hour point. At that time, the sprays were assumed to be secured. This is conservative since the containment sprays would be expected to be secured at some time after 8 hours following the event, but in all cases before 24 hours into the event. This maximized the aluminum generation since the quantity of aluminum exposed to spray was determined to be 1,184.85 lbs (8013.39 ft^2) and the quantity of aluminum determined to be submerged was 22.25 lbs (10.93 ft^2).

Based on the conservative application of the quantity of aluminum exposed to extended duration spray, the pH values calculated for determination of the corrosion of aluminum, the pH value used for testing, and the use of the sodium aluminate in the test loop, the addition of sodium hydroxide to the test loop was not necessary for establishing the required test conditions.

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.*

<u>Response:</u>

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.

The additions of chemicals beyond the 100% value were determined, through analysis to have formed the necessary precipitates since the aluminum solubility at the test conditions was approximately 115 ppm and the predicted concentration was approximately 2319 ppm. Approximately 808 ppm of the aluminum combined with the sodium and silicate within the solution to form sodium aluminum silicate until such time the available silica was consumed. The remaining aluminum (1511 ppm) was available to form aluminum oxyhydroxide. The results reported here were for the DEGB test. For the DGBS test, the aluminum solubility was the same as the DEGB test, 115 ppm. Approximately 577 ppm of the aluminum combined with the sodium and silicate to form sodium aluminum silicate. With the available silicate depleted, the remaining aluminum (1742 ppm) was available to form aluminum oxyhydroxide.

Due to bed morphology at the time of these additions, sufficient flow areas existed through the bed to not result in a significant increase in head loss. As previously stated in response to these RAIs, the debris bed formed with CNP debris loads does not have sufficient fiber to completely interlace the primarily particulate debris bed. In other words, a thin bed condition will not develop. For the additions up to and including the 100% chemical additions, the head loss did increase significantly. At these additions, existing flow paths through the primarily particulate debris bed were blocked resulting in the increased head loss. The results observed for chemical precipitate interaction with a primarily particulate based debris bed are consistent with those reported in NUREG/CR-6913. The test results reported within this NUREG determined that for a particulate only (Cal-Sil) bed, the head loss was minimal since there was insufficient fiber to effectively bind the bed together to provide for the continued filtration of particulate within solution. For CNP, the maximum fiber bed that could theoretically be formed is approximately 5/64 in thick which assumes that all of the fiber is retained by the strainer surfaces and not captured by other components within the recirculation loop or containment, and that the fiber is evenly distributed to all available strainer surfaces.

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%

Appendix 3

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

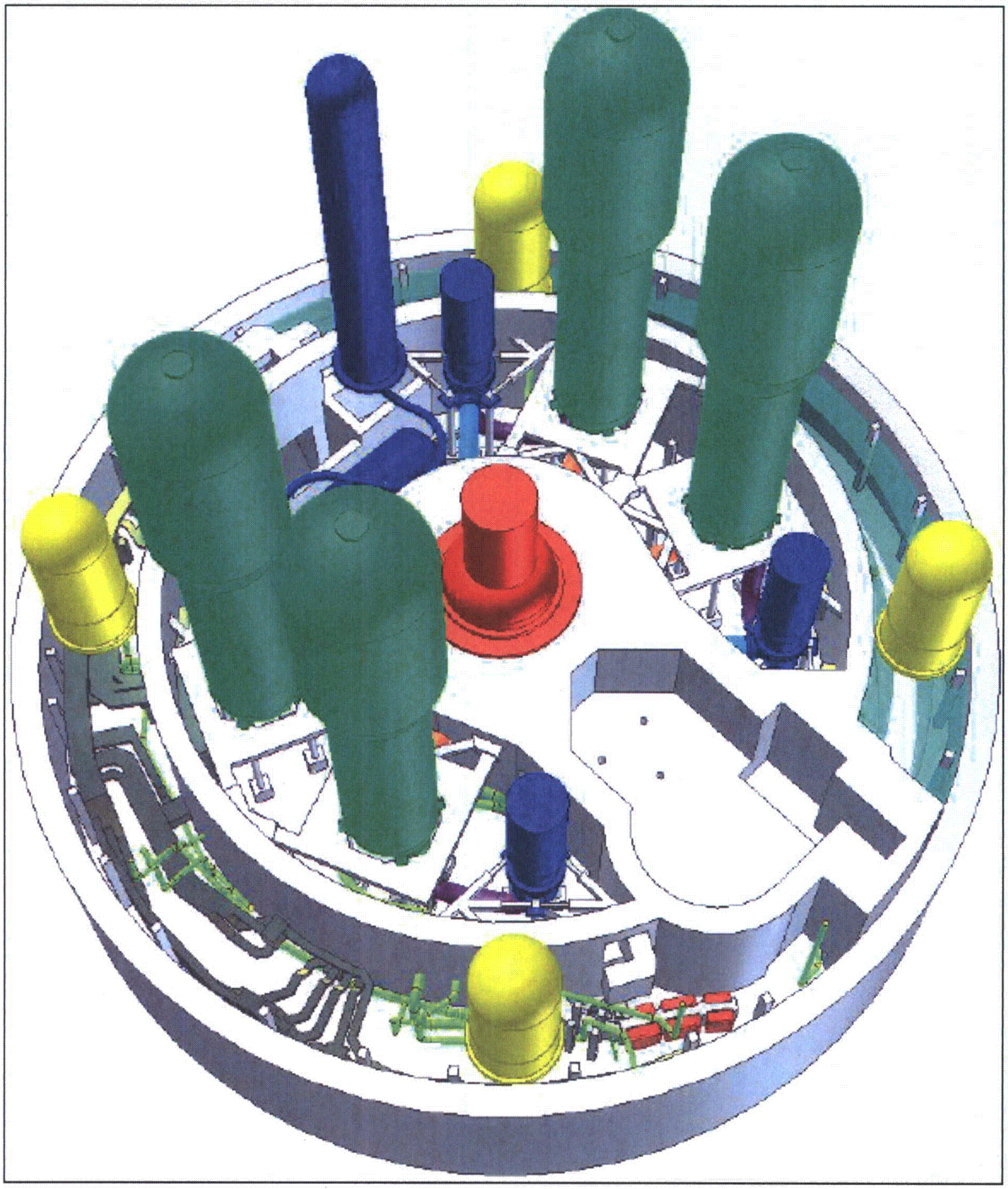
34. *Please explain why the head loss increased early in the head loss test to a fraction of a kPa (see figure 7.2-14) before the official start of the test.*

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.*

ATTACHMENT 3 TO AEP-NRC-2010-39

APPENDIX 4
FIGURES AND PHOTOGRAPHS SUPPORTING RAI RESPONSES

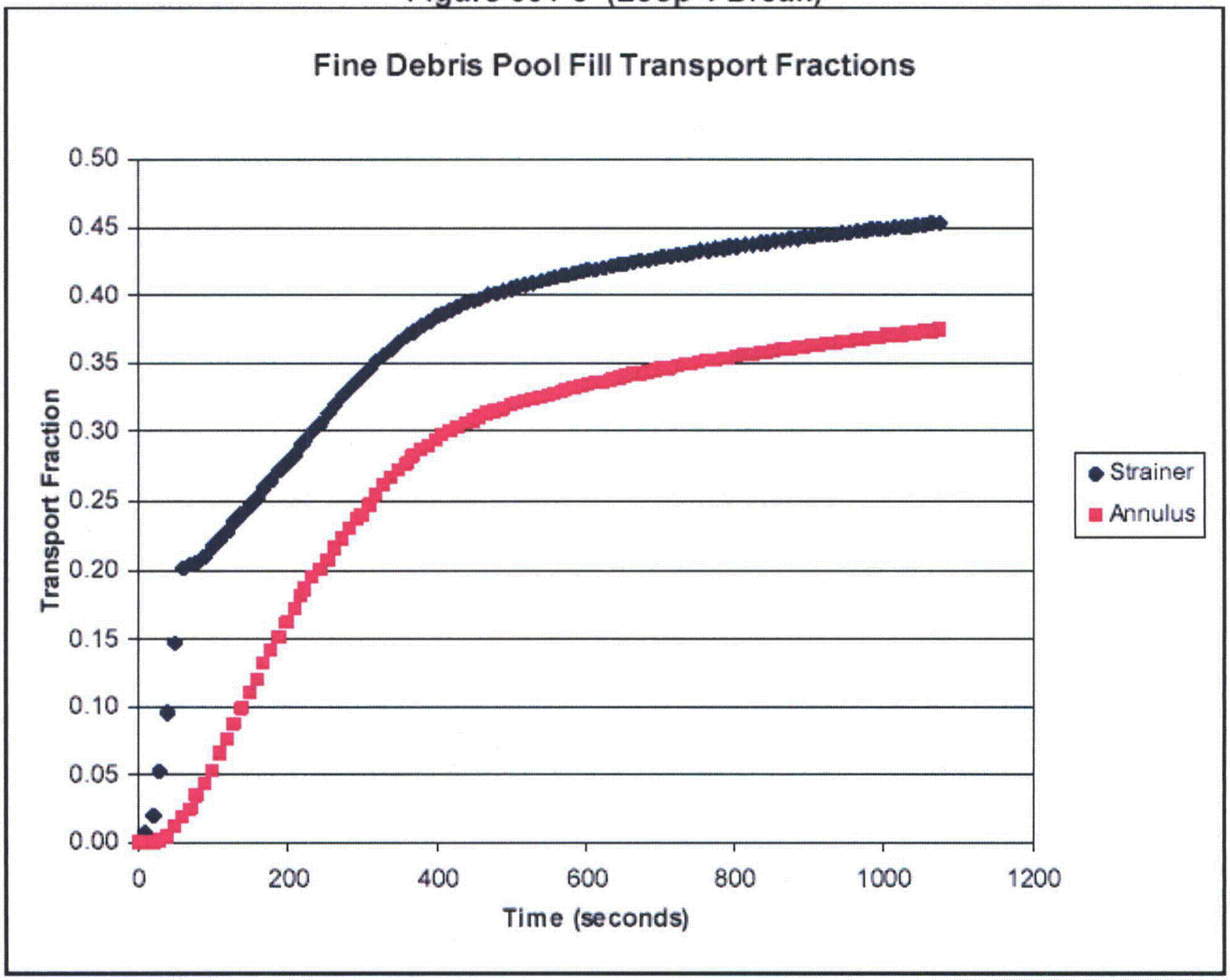
Figure 4-1



Appendix 4

Figure 4-2

Figure 3e1-8 (Loop 4 Break)



Appendix 4

Figure 4-3

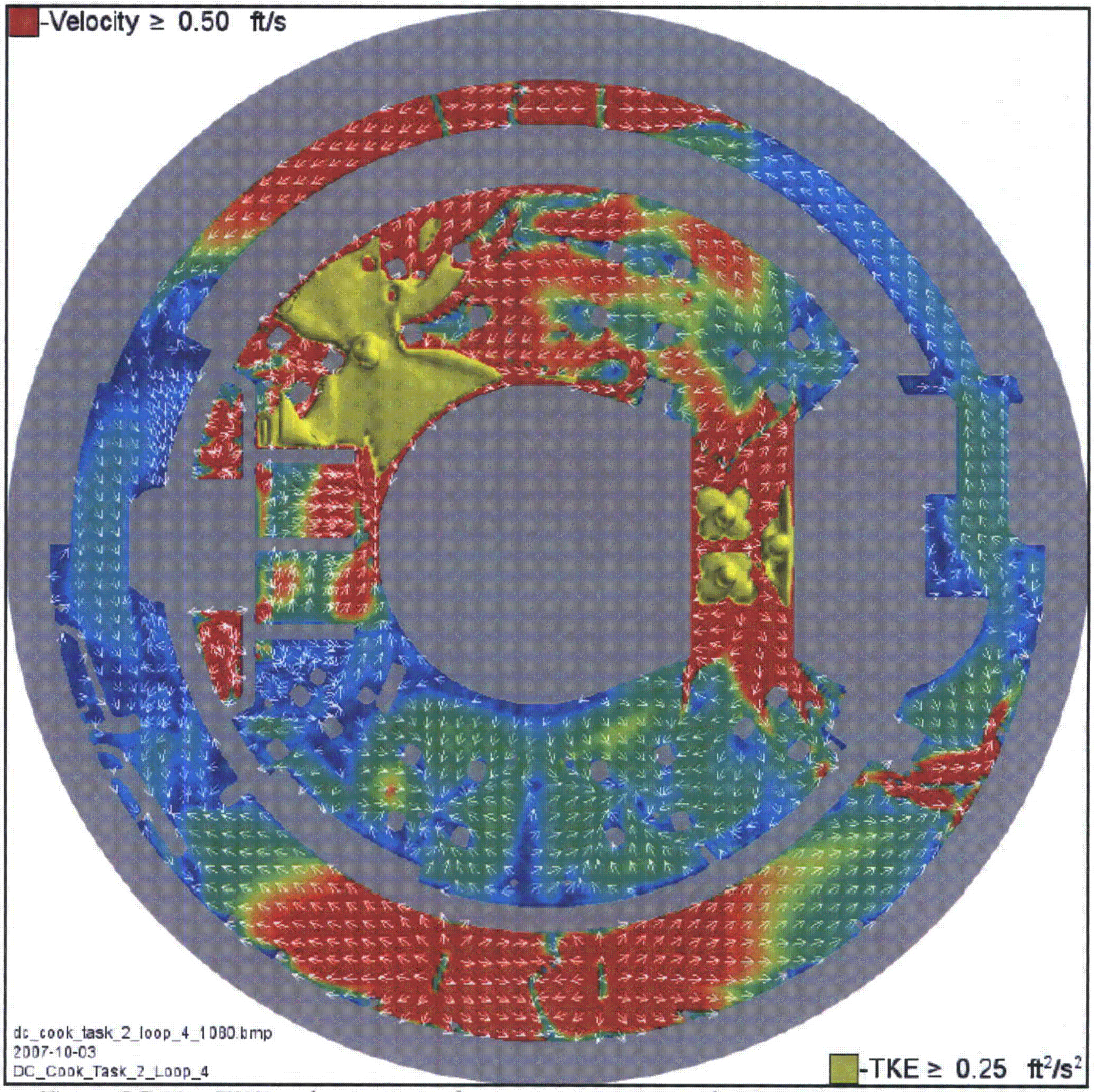


Figure 5.7.90 – TKE and velocity in the pool at 1,080 seconds (Pool Fill Loop 4 CFD Run)

Appendix 4

Figure 4-4

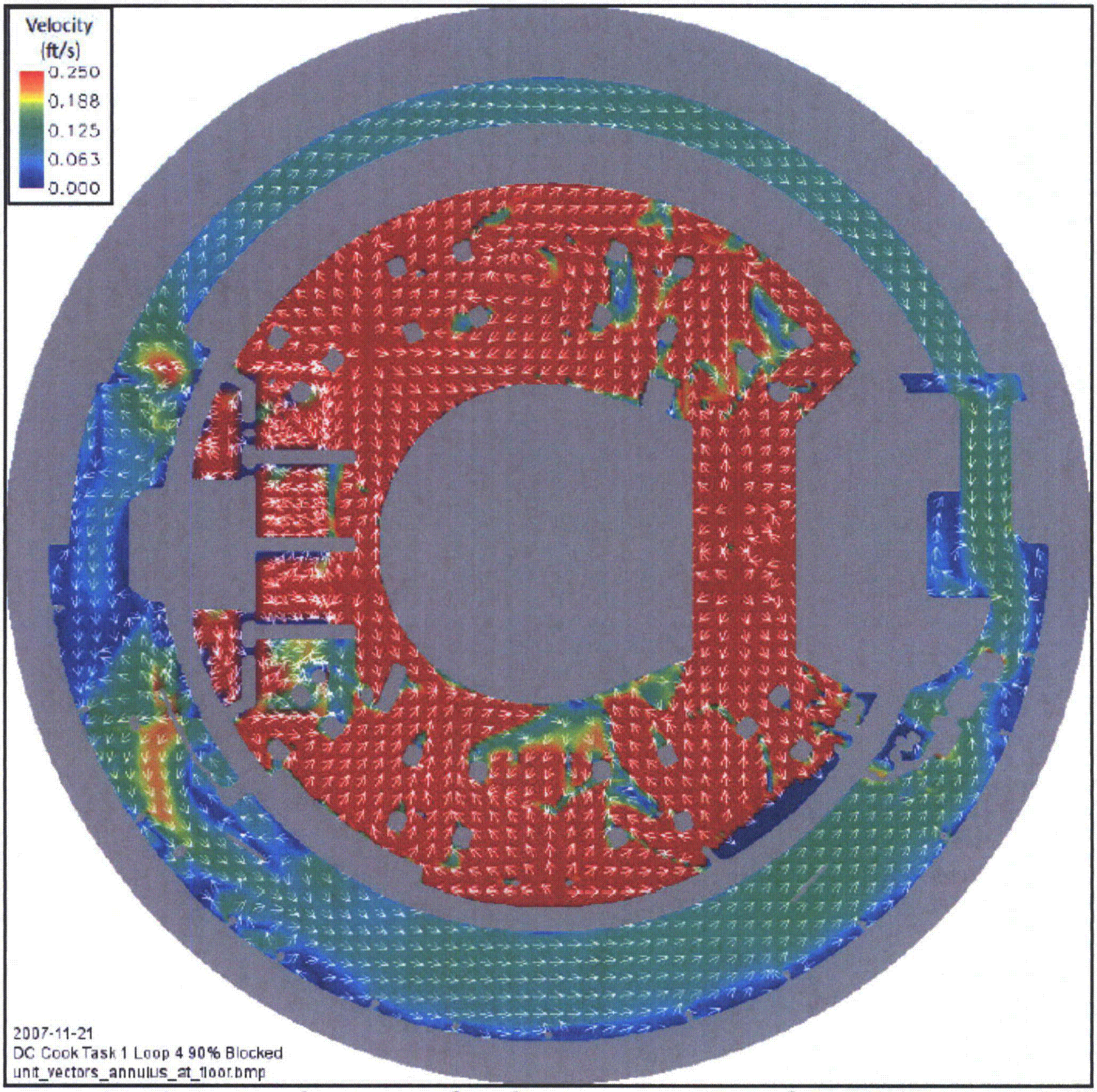


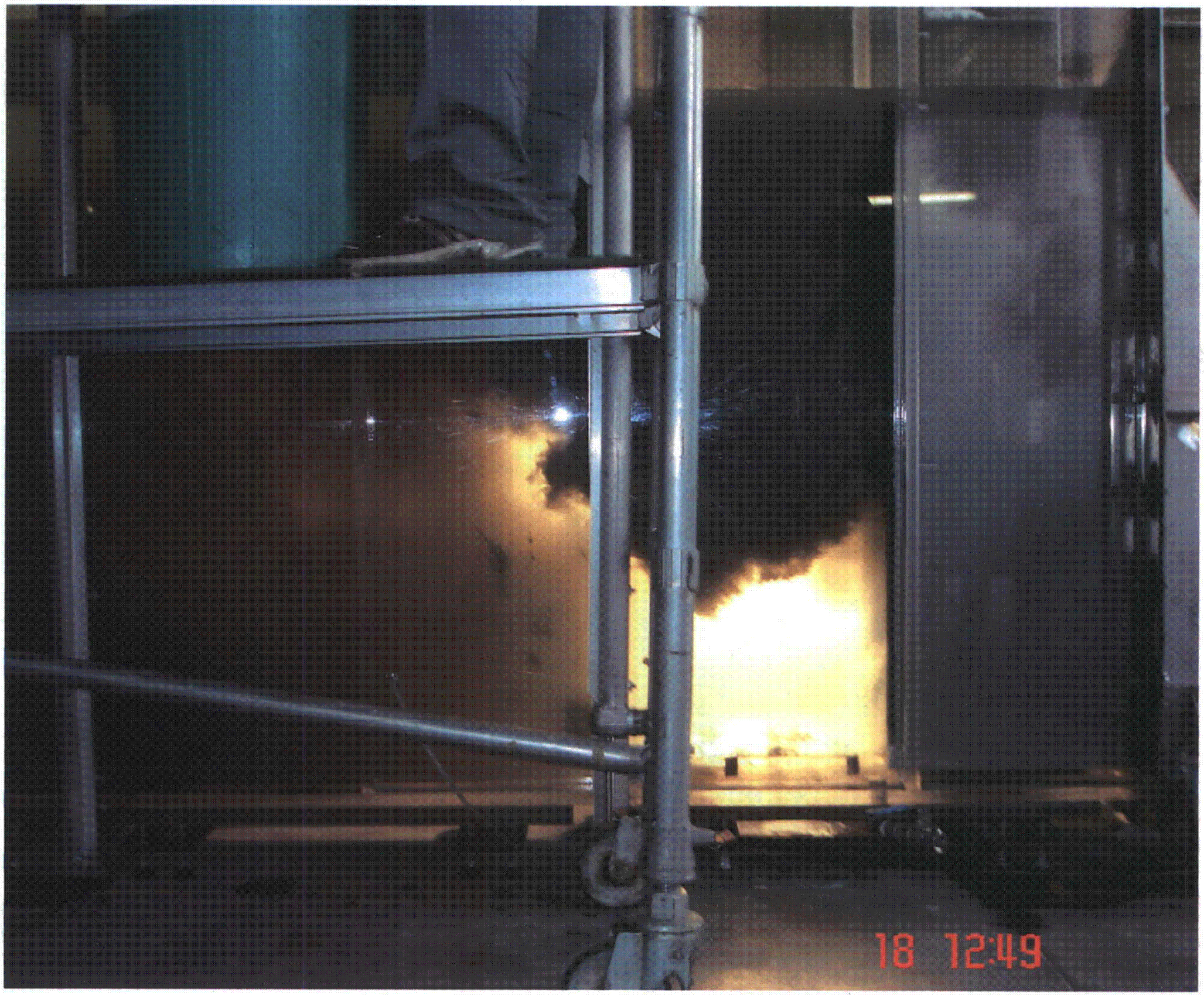
Figure 5.8.46 – Vectors showing pool flow direction, color scale set for annulus (Recirculation Pool Loop 4 90% Blocked Main Strainer CFD Run)

Appendix 4

Figure 4-5

Appendix 4

Figure 4-6



Appendix 4

Figure 4-7

APPENDIX 5
TABLE SUMMARIZING THE STRAINER TESTING PERFORMED AND RESULTS

Type of Test	Flow Rate(s) (% of 14,400)	Debris Additions (%)	Head Loss (ft H_2O)	System Head Loss (ft H_2O)	Temp for Head Loss (°F)	Comments
DEGB Standard	60, 80, 100, 76.4, 52.8	60, 80, 100 (Homogeneous)	0.925	1.129	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)	0.751	1.091	68	
DEGB Debris Sequence	100	1. Fiber: 40, 40, 20 2. Cal-Sil, Marinite: 40, 40, 20 3. Particulate: 40, 40, 20 4. RMI: 50, 50	0.4	Not Calculated	59	
DGBS Standard	60, 80, 100, 76.4, 52.8	60, 80, 100 (Homogeneous)	0.446	0.547	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)	0.682	1.114	68	
DGBS Debris Sequence	100	1. Fiber: 40, 40, 20 2. Cal-Sil, Marinite: 40, 40, 20 3. Particulate: 40, 40, 20 4. RMI: 50, 50	0.133	Not Calculated	60	
MFTL DEGB Debris Only	67.5	100 (Homogeneous, for main strainer only)	2.12	Not Calculated	87	
MFTL DEGB Debris + Chem	67.5, 51.6, 33.8	Chemicals	2.81	Not Calculated	103	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)	3.38	Not Calculated	90	
MFTL DGBS Debris + Chem	67.5, 51.6, 33.8	Chemicals	4.75	Not Calculated	102	Reductions in flow resulted in reductions in head loss of 40% and 73%

ATTACHMENT 4 TO AEP-NRC-2010-39

UPDATED FINAL RESPONSE TO GL 2004-02

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This attachment provides I&M's updated final response to GL 2004-02 in the form of a supplement to Attachment 3 to Reference 1 and Attachment 3 to Reference 2. Consistent with Attachment 3 to References 1 and 2, this attachment follows the format and guidance provided by the NRC in Reference 3. This attachment addresses all sections of Attachments 3 to References 1 and 2. Each section of this attachment indicates whether the section constitutes a revision that supersedes the corresponding section of Attachments 3 to References 1 or 2, or whether the section provides information that is in addition to that provided in the corresponding section of Attachments 3 to References 1 and 2. The text from the NRC guidance provided by Reference 3 is presented in italic script.

NRC Request, Summary-Level Description

The GL supplemental response should begin with a summary-level description of the approach chosen. This summary should identify key aspects of design modifications, process changes, and supporting analyses that the licensee believes are relevant or important to the NRC staff's verification that corrective actions to address the GL are adequate. The summary should address significant conservatisms and margins that are used to provide high confidence the issue has been addressed even with uncertainties remaining. Licensees should address commitments and/or descriptions of plant programs that support conclusions.

Summary-Level Description for CNP

The key aspects of the approach chosen by I&M to resolve the concerns identified in GL 2004-02 remain unchanged from those stated in Reference 2 Attachment 3, but are restated below for clarity. The key aspects are:

- Extensive design modifications to significantly reduce the potential effects of post-accident debris and latent material on the functions of the ECCS and CTS during the recirculation phase of accident mitigation.

- Extensive testing and analysis to determine break locations, identify and quantify debris sources, quantify debris transport, determine upstream and downstream effects, and confirm the recirculation function.

- Use of the Alternate Evaluation methodology as described in Chapter 6 of the GR and SER.

- Changes to the CNP licensing basis, including TS changes, to reflect the plant modifications, and the change to a mechanistic sump strainer blockage evaluation.

- Extensive changes to plant programs, processes, and procedures to limit the introduction of materials into containment that could adversely impact the recirculation function, and establish monitoring programs to ensure containment conditions will continue to support the recirculation function.

- Application of conservative measures to assure adequate margins throughout the actions taken to address the GL 2004-02 concerns.

The following information consolidates and updates that which was provided in the References 1 and 2 Attachment 3 Summary Level Description under the headings, Analyses, Changes to the Licensing Basis, Improvements in Processes and Programs, and Conservatisms and Margins.

Analyses

I&M has had the debris generation analysis re-performed since it was determined that the original analysis did not credit the removal of Cal-Sil insulation from the pressurizer safety and relief valve discharge line to the pressurizer relief tank, and had not completely incorporated the walkdown information from the insulation validation walkdowns. A review of the original analysis also determined that excessive conservatism existed in the methodology used to determine the quantity of material that could be liberated following a break. The use of more accurate CAD modeling resulted in a significant reduction in the quantity of Cal-Sil generated following a break. Additional discussion of these changes is provided in the updated response to Information Item 3.b.

As a result of the issues identified with the Wyle jet impingement testing, the ZOI values originally determined from that testing were non-conservative. To address this non-conservatism, the ZOI for both the Marinite and fire barrier tape were established at 17D. Additional discussion of this testing is provided in the updated response to Information Item 3.b.

I&M has also re-performed the system head loss analysis to more conservatively reflect the overall strainer system head loss. This effort has resulted in the calculated debris-only overall system head loss increasing from the previous values, but still providing substantial margin to account for chemical effects. Additional discussion of this change is provided in the updated response to Information Items 3.f and 3.o.

The in-vessel blockage effects analysis (WCAP-16793-NP) has not yet been finalized and the SE has not been issued by the NRC. Due to the very low fibrous debris quantity that exists at CNP (latent debris only), it is not expected that this will be a concern since both units use Westinghouse fuel. Following receipt of the NRC SE on WCAP-16793-NP, the approved methodology will be used to perform the calculation which will document the design basis results.

Changes to the Licensing Basis

I&M had previously completed changes to the CNP UFSAR to recognize the mechanistic evaluation of the effect of post-accident debris on the ECCS and CTS recirculation function, as described in this letter and Reference 2. As a result of the reanalysis described above, additional updates to the CNP UFSAR will be made following receipt of the NRC letter documenting closure of GL 2004-02 for CNP. This UFSAR update will also identify those margins that are within licensee control and those that are under regulatory control. Additional discussion of these planned UFSAR changes is provided in the updated response to Information Item 3.p. I&M has also completed changes to the UFSAR to reflect the physical changes to the plant, and those programmatic and process changes that support the adoption of, and maintenance of, the mechanistic methodology.

I&M has obtained NRC approval of TS changes that reflect the GL 2004-02 related plant modifications and provide new TS Surveillance Requirements as necessary to assure that important components are operable to support the recirculation function. These new TS requirements have been implemented in both Unit 1 and Unit 2.

Improvements in Processes and Programs

I&M has completed the review of plant procedures, processes, and programs and has updated those procedures and design specifications or standards that will ensure the analysis inputs and assumptions can be maintained. The changes to those programs and processes determined to be necessary to support the transition to the mechanistic evaluation methodology licensing basis were in place prior to, or at the time of the change to the licensing basis. The other changes completed since Reference 2 was submitted consisted principally of changes to plant implementing procedures and engineering documents to prevent the introduction of debris sources that could reduce the available sacrificial strainer margin.

Conservatisms and Margins

I&M applied conservative measures to assure adequate margins throughout the actions taken to address the GL 2004-02 concerns. The key areas in which these conservative measures were applied are discussed in Appendix 2 of Attachment 3 of this letter.

NRC Request - 2006 RAI

Licensees should ensure that GL supplemental response information fully address issues identified in the RAIs provided to each licensee in early 2006. A separate response to the RAIs is not necessary if they are appropriately addressed in the GL supplemental response.

I&M Response to 2006 RAI

References 1 and 2 fully addressed the 2006 RAI (Reference 4).

NRC Information Item 1 - Overall Compliance:

Provide information requested in GL 2004-02 Requested Information Item 2(a) regarding compliance with regulations.

GL 2004-02 Requested Information Item 2(a)
Confirmation that the ECCS and CSS [CTS at CNP] recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this GL. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis has been updated to reflect the results of the analysis described above.

I&M Response to Information Item 1

The confirmation statement provided below reflects the status of the in-vessel blockage analysis and supersedes that provided in Reference 2.

Confirmation

I&M has completed all necessary analyses, with the exception of in-vessel blockage, and has updated the CNP licensing basis to reflect that the ECCS and CTS recirculation functions under debris loading conditions are in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL 2004-02. I&M will further update the CNP licensing basis to reflect the analysis changes described in this attachment. I&M has completed all associated plant modifications in Unit 1 and Unit 2.

Applicable Regulatory Requirements

The applicable regulatory requirements identified in GL 2004-02 are:

10 CFR 50.46	"Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors"
10 CFR 50.67	"Accident Source Term"
10 CFR 100	"Reactor Site Criteria"

For plants not licensed to the GDC in 10 CFR 50, Appendix A, such as CNP, the applicable regulatory requirements include plant specific design criteria in their licensing basis similar to the following: Criterion 35, "Emergency Core Cooling," Criterion 38, "Containment Heat Removal," Criterion 41, "Containment Atmosphere Cleanup."

Plant Configuration

The plant modifications that have been completed in Unit 1 and Unit 2 include: replacement of recirculation sump trash racks and screens with a main pocket-style strainer, installation of a remote pocket-style strainer assembly, creation of a waterway between the remote strainer and the recirculation sump, installation of level instruments in the recirculation sump, reconfiguration of sump vents, installation of debris interceptors at key locations, modification of various flowpaths, and removal of significant debris sources.

NRC Information Item 2 - General Description of and Schedule for Corrective Actions:

Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per Requested Information Item 2(b). (Note: All requests for extension should be submitted to the NRC as soon as the need becomes clear, preferably not later than October 1, 2007.)

GL 2004-02 Requested Information Item 2(b)
A general description of and implementation schedule for all corrective actions, including any plant modifications that you identified while responding to this GL. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1, 2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

I&M Response to Information Item 2

The corrective actions to address the concerns identified in GL 2004-02 at CNP consisted of plant modifications, testing and analysis, changes to plant programs and processes, and changes to the licensing basis. These actions have been completed in accordance with I&M's regulatory commitments and NRC-approved extensions. The completion dates for these actions are provided below.

Plant Modifications

The plant modifications needed to address the GL 2004-02 concerns were completed in Unit 2 during the Fall 2007 RFO, which ended November 6, 2007. Except as approved by References 5 and 6, these modifications were completed in Unit 1 during the Fall 2006 RFO. As approved by References 5 and 6, certain Unit 1 modifications were completed prior to entry into Mode 4 at the end of the Spring 2008 RFO.

Testing and analyses

Except as approved by Reference 6, the testing and analyses needed to address GL 2004-02 concerns were completed by December 31, 2007. As approved by Reference 6, certain analyses were completed prior to May 31, 2008. The in-vessel blockage analysis, previously performed as a simplified analysis as reported in Reference 2, will be re-performed using an NRC approved methodology. This is expected to be complete by the end of the 3rd quarter of 2010, pending issuance of the NRC SE on WCAP-16793-NP.

Plant Programs and Processes

Significant program and process changes necessary to address the GL 2004-02 concerns were completed by December 31, 2007, and additional changes were completed by May 31, 2008.

Licensing Basis

The licensing basis changes needed to address the GL 2004-02 concerns consist of UFSAR changes related to the plant modifications implemented to resolve the concerns identified in GL 2004-02, TS changes related to those plant modifications, and licensing basis changes to reflect the mechanistic evaluation of the effect of post-accident debris on the ECCS and CTS recirculation functions.

The UFSAR changes related to the Unit 2 GL 2004-02 plant modifications were made effective during the Fall 2007 RFO. Except as approved by Reference 6, the UFSAR changes related to the Unit 1 GL 2004-02 plant modifications were made effective during the Fall 2006 RFO. As approved by Reference 6, the UFSAR changes related to certain Unit 1 GL 2004-02 modifications were made effective prior to entry into Mode 4 at the end of the Spring 2008 RFO.

The TS changes related to the GL 2004-02 plant modifications were implemented for Unit 2 prior to entry into Mode 4 during the Fall 2007 RFO. In accordance with Reference 7 and Reference 6 the TS changes related to the GL 2004-02 plant modifications were implemented for Unit 1 prior to entry into Mode 4 at the end of the Spring 2008 Unit 1 RFO.

In accordance with Reference 6, the CNP licensing basis was changed to reflect the mechanistic evaluation of the effect of post-accident debris on the ECCS and CTS recirculation function by May 31, 2008. An update to the CNP licensing basis will be completed following receipt of the NRC letter documenting closure of GL 2004-02 for CNP, which is expected following completion of the in-vessel blockage analysis. I&M anticipates that completion of the in-vessel blockage analysis, receipt of the NRC closure letter, and update of the licensing basis will be completed by December 31, 2010.

3. Specific Information Regarding Methodology for Demonstrating Compliance:

NRC Information Item 3.a - Break Selection

The objective of the break selection process is to identify the break size and location that present the greatest challenge to post-accident sump performance.

1. *Describe and provide the basis for the break selection criteria used in the evaluation.*
2. *State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines) and briefly explain why or why not.*
3. *Discuss the basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance.*

Updated responses to Information Items 3.a.1 and 3.a.3 are provided below.

I&M Response to Information Item 3.a.1

The break selection process consisted of determining the size and location of the HELBs that would produce debris and potentially challenge the performance of the recirculation sump strainer. The break selection process required evaluating a number of potential break locations in order to identify the location that would be likely to present the greatest challenge to post-accident sump performance. The debris inventory and the transport path were both considered when making this determination.

Section 3.3.4.1 in the GR recommends that a sufficient number of breaks in each high-pressure system that rely on recirculation be considered to ensure that the breaks that bound variations in debris generation by the size, quantity, and type of debris are identified. The following break locations were considered:

Break No. 1: Breaks in the RCS with the largest potential for debris.
Break No. 2: Large breaks (with two or more different types of debris). Large breaks are defined in CNP UFSAR Section 14.3 as breaks with greater than a 1.0 ft^2 cross sectional area. This equates to a guillotine break of a 14 in or greater ID pipe.
Break No. 3: Breaks in the most direct path to the sump.
Break No. 4: Large breaks with the largest potential particulate debris to insulation ratio by weight.
Break No. 5: Breaks that generate a "thin bed" – i.e., high particulate with 1/8 in fiber bed.

Only those line breaks that require the recirculation sump function were evaluated. A review of accident analyses and operational procedures was performed to determine the scenarios that require the recirculation sump function. This review determined that LBLOCAs and certain SBLOCAs require the sump function.

A review of the flow diagrams associated with the RCS was performed to identify those large bore lines directly attached to the RCS (up to the first normally closed manual isolation valve, second automatic isolation valve, and first check valve). The LBLOCA lines to be evaluated for debris generation were determined to be (See Attachment 4, Figure A4-11):

- 31 in RCS crossover line from the bottom of the RCPs down to the 603 ft 8 1/4 in elevation and up to the SG cold leg nozzles.
- 29 in RCS hot leg at the 614 ft elevation.
- 27 1/2 in RCS cold leg at the 614 ft elevation.
- 14 in PZR surge line from RCS loop 3 hot leg piping at the 614 ft elevation to the bottom of the PZR at the 625 ft 9 in elevation.
- 14 in RHR suction line from RCS loop No. 2 hot leg piping connection up to the first isolation valve which is closed with motive power removed except when on shutdown cooling.

The CNP UFSAR classifies SBLOCAs as the break of any RCS piping in excess of the capacity of a CCP (approximately 0.375 in diameter hole) but less than 1.0 ft^2 total cross sectional area. An SBLOCA must be considered for debris generation because it may not be isolable and may lead to recirculation. In accordance with Section 3.3.4.1, Item 7, of the GR and the SER, only SBLOCA lines 2 in diameter and larger (but less than 14 in diameter) up to the first isolation point were included in the evaluation. The isolation point was defined as a single passive component (such as a normally closed manual isolation valve or a check valve) or two active automatic isolation valves. Consistent with the CNP single failure criteria, check valves were considered as passive components. A review showed that all SBLOCA locations that required evaluation were inside the crane wall. The SBLOCA lines to be evaluated for debris generation were determined to be (see Reference 2, Attachment 4, Figures A4-11 through A4-13):

- 10 in diameter RHR lines from the RCS cold legs to the accumulator check valves SI-170-L1, SI-170-L2, SI-170-L3, and SI-170-L4. This piping runs from the cold leg injection location inside the crane wall to the first check valve at each of the four RCS loops. A break at these lines would be enveloped by the LBLOCA break.
- 10 in diameter SI lines from the accumulator injection lines to the check valves. This is a short run of piping just off of the accumulator injection line near the cold leg. A break at these lines would be enveloped by the LBLOCA break.
- 6 in diameter SI lines from the RCS hot legs to check valves SI-158-L1, SI-158-L2, SI-158-L3, and SI-158-L4. These lines run from the hot legs inside the crane wall to the check valves near the loop piping. A break at these lines would be enveloped by the LBLOCA break.
- 6 in diameter PZR safety relief line to safety valves SV-45A, SV-45B, and SV-45C. These valves are located at the top of the PZR inside the PZR enclosure area. A break at these lines would be enveloped by the LBLOCA break.
- 6 in diameter PZR PORV line to valves NRV-151, NRV-152 and NRV-153. These valves are located at the top of the PZR inside the PZR enclosure area. A break at these lines would be enveloped by the LBLOCA break.
- 4 in diameter PZR spray line from cold leg loops No. 3 and No. 4. These lines run from the top of the pressurizer to the cold leg piping inside the crane wall. A break at these lines would be enveloped by the LBLOCA break.
- 3 in diameter CVCS letdown and charging lines from cold leg loops 1 and 4 to valves CS-329-L1, CS-329-L4, and QRV-112. This piping runs from the RCS loops 1 and 4 cold legs inside the crane wall to the isolation valves inside the crane wall. A break at these lines would be enveloped by the LBLOCA break.

Break locations were evaluated to identify the breaks that produce the maximum amount of debris and also the worst combination of debris with the possibility of being transported to the recirculation sump strainers. In addition to the customary DEGB locations, DGBS break locations were also evaluated. These break locations, as identified above, utilized the equivalent area of a double-ended guillotine break of the largest pipe connected to the RCS loop piping. In this case, this is the PZR surge line. These breaks are further discussed in the response to NRC Information Item 3.b.

Section 3.3.5.2 of the SER states that break selection at 5 ft intervals along a pipe in question is acceptable, with the clarification that "...the concept of equal increments is only a reminder to be systematic and thorough." The SER provides further clarification by stating that "For the purpose of identifying limiting break conditions, a more discrete approach driven by the comparison of debris source term and transport potential can be effective at placing postulated breaks. The key difference between many breaks (especially large breaks) will not be the exact location along the pipe, but rather the envelope of containment material targets that is affected."

Due to the size of the RMI ZOI assumed in the debris generation analysis, and the consequential volume of debris generated, it was not necessary to evaluate pipe breaks at 5 ft increments. The ZOI for RMI encompassed several areas in the loop compartment for a LBLOCA. Similar to RMI, it was not necessary to evaluate 5 ft increments due to the size of the Min-K insulation ZOI. For other insulation types (Cal-Sil and Marinite), break locations were selected by plotting the ZOI along the RCS piping (hot leg, cold leg, and crossover leg) to maximize the major targets that fell within the perimeter of the ZOI sphere. The ZOI was assumed to be located in the area of the largest concentration of problematic debris source material. Specific break locations were selected by plotting the ZOI along the crossover leg to maximize the major targets that fell within the ZOI sphere. This methodology is consistent with the GR, which states that a sufficient number of breaks in each high-pressure system that rely on recirculation should be evaluated to ensure the most limiting quantity of debris is generated and transported to the sump.

I&M Response to Information Item 3.a.2

The information provided in the Reference 2 response to Information Item 3.a.2 remains applicable.

I&M Response to Information Item 3.a.3

The information provided below supersedes the information provided in Reference 2, except that the methodology for determination of the worst case break locations is as described in Reference 2 and is not repeated here.

As a result of re-performing the debris generation analysis, it was determined that a crossover leg break in Unit 1 Loop 4 results in the worst case DEGB break, and a crossover leg break in Unit 2 Loop 4 results in the worst case DGBS break. The DGBS break location remains the same as was reported in Reference 2. Tables 3a3-3 through 3a3-24 from Reference 2 have been updated to reflect the new debris generation values for Unit 2. Tables 3a3-25 through 3a3-46 have been added to provide the debris quantities predicted at the main and remote strainers for Unit 1 for the same break cases as provided for Unit 2.

For the debris generation reanalysis, the debris generated for Loops 1 and 4, and Pressurizer Surge Line breaks was determined utilizing the CAD model of containment and piping systems similar to the methodology used for determination of coatings debris generated within an associated ZOI. For the Loops 2 and 3 breaks, the debris quantities reflect the use of Excel spreadsheets via pivot tables as was previously performed. For the fire barrier tape and Marinite, a ZOI of 17D was applied to the location of these materials for determination of debris quantities generated.

Table 3a3-3 Unit 2 Loop 1 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	48734	0.63	30702.42
RMI Large Pieces, ft^2	16245	0.43	6985.35
Cal-Sil Fines, lbs	9	0.45	4.05
Erosion of Cal-Sil Small Pieces to fines, lbs	13.8	0.1	1.38
Cal-Sil Small Pieces, lbs	13.8	0.38	5.244
Marinite I fines, lbs	0.6	0.45	0.27
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.1	0.02
Marinite I Small Pieces, lbs	0.2	0.38	0.076
Erosion of Marinite I Large Pieces to fines, lbs	1.3	0.11	0.143
Marinite I Large Pieces, lbs	1.3	0.35	0.455
Marinite 36 fines, lbs	0.5	0.45	0.225
Erosion of Marinite 36 Small Pieces to fines, lbs	0.2	0.1	0.02
Marinite 36 Small Pieces, lbs	0.2	0.38	0.076
Erosion of Marinite 36 Large Pieces to fines, lbs	1	0.11	0.11
Marinite 36 Large Pieces, lbs	1	0.35	0.35
Min-K, lbs	3.6	0.45	1.62
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	2.8	0.45	1.26
Fire Proof Tape Small Pieces, ft^2	6.5	0.63	4.095
Fire Proof Tape Large Pieces, ft^2	24.5	0.63	15.435
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.7	0.63	0.441
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-4 Unit 2 Loop 1 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	48734	0	0
RMI Large Pieces, ft^2	16245	0	0
Cal-Sil Fines, lbs	9	0.52	4.68
Erosion of Cal-Sil Small Pieces to fines, lbs	13.8	0.08	1.104
Cal-Sil Small Pieces, lbs	13.8	0	0
Marinite I fines, lbs	0.6	0.52	0.312
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.08	0.016
Marinite I Small Pieces, lbs	0.2	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.3	0.06	0.078
Marinite I Large Pieces, lbs	1.3	0	0
Marinite 36 fines, lbs	0.5	0.52	0.26
Erosion of Marinite 36 Small Pieces to fines, lbs	0.2	0.08	0.016
Marinite 36 Small Pieces, lbs	0.2	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	1	0.06	0.06
Marinite 36 Large Pieces, lbs	1	0	0
Min-K, lbs	3.6	0.52	1.872
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	2.8	0.52	1.456
Fire Proof Tape Small Pieces, ft^2	6.5	0	0
Fire Proof Tape Large Pieces, ft^2	24.5	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-5 Unit 2 Loop 2 RCS Crossover Leg Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	52533	0.4	21013.2
RMI Large Pieces, ft^2	17511	0.38	6654.18
Cal-Sil Fines, lbs	20.3	0.33	6.699
Erosion of Cal-Sil Small Pieces to fines, lbs	13.1	0	0
Cal-Sil Small Pieces, lbs	13.1	0.31	4.061
Marinite I fines, lbs	1.4	0.33	0.462
Erosion of Marinite I Small Pieces to fines, lbs	0.5	0	0
Marinite I Small Pieces, lbs	0.5	0.31	0.155
Erosion of Marinite I Large Pieces to fines, lbs	2.9	0	0
Marinite I Large Pieces, lbs	2.9	0.3	0.87
Marinite 36 fines, lbs	3.5	0.33	1.155
Erosion of Marinite 36 Small Pieces to fines, lbs	1.3	0	0
Marinite 36 Small Pieces, lbs	1.3	0.31	0.403
Erosion of Marinite 36 Large Pieces to fines, lbs	7.2	0	0
Marinite 36 Large Pieces, lbs	7.2	0.3	2.16
Min-K, lbs	5.2	0.33	1.716
Epoxy Paint (inside ZOI), lbs	216	0.33	71.28
Alkyd Paint (inside ZOI), lbs	1.9	0.33	0.627
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.25	42.5
Latent Fiber, ft^3	12.5	0.25	3.125
Fire Proof Tape Fines, lbs	3.2	0.33	1.056
Fire Proof Tape Small Pieces, ft^2	7.4	0.4	2.96
Fire Proof Tape Large Pieces, ft^2	27.8	0.4	11.12
Ice Storage Bag Fibers, ft^3	0.026	0.47	0.01222
Ice Storage Bag Liner Shards, ft^3	0.00022	0.47	0.0001034
Pieces of Work Platform Rubber, ft^3	0.002	0.47	0.00094
Electromark Label (inside ZOI), ft^2	0.6	0.4	0.24
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-6 Unit 2 Loop 2 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	52533	0.63	33095.79
RMI Large Pieces, ft^2	17511	0.43	7529.73
Cal-Sil Fines, lbs	20.3	0.45	9.135
Erosion of Cal-Sil Small Pieces to fines, lbs	13.1	0.1	1.31
Cal-Sil Small Pieces, lbs	13.1	0.38	4.978
Marinite I fines, lbs	1.4	0.45	0.63
Erosion of Marinite I Small Pieces to fines, lbs	0.5	0.1	0.05
Marinite I Small Pieces, lbs	0.5	0.38	0.19
Erosion of Marinite I Large Pieces to fines, lbs	2.9	0.11	0.319
Marinite I Large Pieces, lbs	2.9	0.35	1.015
Marinite 36 fines, lbs	3.5	0.45	1.575
Erosion of Marinite 36 Small Pieces to fines, lbs	1.3	0.1	0.13
Marinite 36 Small Pieces, lbs	1.3	0.38	0.494
Erosion of Marinite 36 Large Pieces to fines, lbs	7.2	0.11	0.792
Marinite 36 Large Pieces, lbs	7.2	0.35	2.52
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.39	12.09
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	3.2	0.45	1.44
Fire Proof Tape Small Pieces, ft^2	7.4	0.63	4.662
Fire Proof Tape Large Pieces, ft^2	27.8	0.63	17.514
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-7 Unit 2 Loop 2 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	52533	0	0
RMI Large Pieces, ft^2	17511	0	0
Cal-Sil Fines, lbs	20.3	0.51	10.353
Erosion of Cal-Sil Small Pieces to fines, lbs	13.1	0.04	0.524
Cal-Sil Small Pieces, lbs	13.1	0	0
Marinite I fines, lbs	1.4	0.51	0.714
Erosion of Marinite I Small Pieces to fines, lbs	0.5	0.04	0.02
Marinite I Small Pieces, lbs	0.5	0	0
Erosion of Marinite I Large Pieces to fines, lbs	2.9	0.04	0.116
Marinite I Large Pieces, lbs	2.9	0	0
Marinite 36 fines, lbs	3.5	0.51	1.785
Erosion of Marinite 36 Small Pieces to fines, lbs	1.3	0.04	0.052
Marinite 36 Small Pieces, lbs	1.3	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	7.2	0.04	0.288
Marinite 36 Large Pieces, lbs	7.2	0	0
Min-K, lbs	5.2	0.51	2.652
Epoxy Paint (inside ZOI), lbs	216	0.51	110.16
Alkyd Paint (inside ZOI), lbs	1.9	0.51	0.969
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	3.2	0.51	1.632
Fire Proof Tape Small Pieces, ft^2	7.4	0	0
Fire Proof Tape Large Pieces, ft^2	27.8	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.41	0.01066
Ice Storage Bag Liner Shards, ft^3	0.00022	0.41	0.0000902
Pieces of Work Platform Rubber, ft^3	0.002	0.41	0.00082
Electromark Label (inside ZOI), ft^2	0.6	0.05	0.03
Electromark Label (outside ZOI), ft^2	39.6	0.6	23.76
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-8 Unit 2 Loop 3 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	65080	0.63	41000.4
RMI Large Pieces, ft^2	21693	0.43	9327.99
Cal-Sil Fines, lbs	18.9	0.45	8.505
Erosion of Cal-Sil Small Pieces to fines, lbs	11.6	0.1	1.16
Cal-Sil Small Pieces, lbs	11.6	0.38	4.408
Marinite I fines, lbs	0.9	0.45	0.405
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite I Large Pieces to fines, lbs	1.9	0.11	0.209
Marinite I Large Pieces, lbs	1.9	0.35	0.665
Marinite 36 fines, lbs	4.1	0.45	1.845
Erosion of Marinite 36 Small Pieces to fines, lbs	1.6	0.1	0.16
Marinite 36 Small Pieces, lbs	1.6	0.38	0.608
Erosion of Marinite 36 Large Pieces to fines, lbs	8.5	0.11	0.935
Marinite 36 Large Pieces, lbs	8.5	0.35	2.975
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	9.3	0.45	4.185
Fire Proof Tape Small Pieces, ft^2	21.8	0.63	13.734
Fire Proof Tape Large Pieces, ft^2	81.9	0.63	51.597
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-9 Unit 2 Loop 3 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	65080	0	0
RMI Large Pieces, ft^2	21693	0	0
Cal-Sil Fines, lbs	18.9	0.52	9.828
Erosion of Cal-Sil Small Pieces to fines, lbs	11.6	0.08	0.928
Cal-Sil Small Pieces, lbs	11.6	0	0
Marinite I fines, lbs	0.9	0.52	0.468
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.08	0.024
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.9	0.06	0.114
Marinite I Large Pieces, lbs	1.9	0	0
Marinite 36 fines, lbs	4.1	0.52	2.132
Erosion of Marinite 36 Small Pieces to fines, lbs	1.6	0.08	0.128
Marinite 36 Small Pieces, lbs	1.6	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	8.5	0.06	0.51
Marinite 36 Large Pieces, lbs	8.5	0	0
Min-K, lbs	5.2	0.52	2.704
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	9.3	0.52	4.836
Fire Proof Tape Small Pieces, ft^2	21.8	0	0
Fire Proof Tape Large Pieces, ft^2	81.9	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.6	0.47	0.282
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-10 Unit 2 Loop 4 RCS Crossover Leg Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	53874	0.09	4848.66
RMI Large Pieces, ft^2	17958	0.05	897.9
Cal-Sil Fines, lbs	29.1	0.32	9.312
Erosion of Cal-Sil Small Pieces to fines, lbs	18.9	0	0
Cal-Sil Small Pieces, lbs	18.9	0.05	0.945
Marinite I fines, lbs	2.4	0.32	0.768
Erosion of Marinite I Small Pieces to fines, lbs	0.4	0	0
Marinite I Small Pieces, lbs	0.4	0.05	0.02
Erosion of Marinite I Large Pieces to fines, lbs	1.1	0	0
Marinite I Large Pieces, lbs	1.1	0.04	0.044
Marinite 36 fines, lbs	4.6	0.32	1.472
Erosion of Marinite 36 Small Pieces to fines, lbs	1.8	0	0
Marinite 36 Small Pieces, lbs	1.8	0.05	0.09
Erosion of Marinite 36 Large Pieces to fines, lbs	9.5	0	0
Marinite 36 Large Pieces, lbs	9.5	0.04	0.38
Min-K, lbs	1.6	0.32	0.512
Epoxy Paint (inside ZOI), lbs	216	0.32	69.12
Alkyd Paint (inside ZOI), lbs	1.9	0.32	0.608
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.24	40.8
Latent Fiber, ft^3	12.5	0.24	3
Fire Proof Tape Fines, lbs	11.9	0.32	3.808
Fire Proof Tape Small Pieces, ft^2	28.1	0.09	2.529
Fire Proof Tape Large Pieces, ft^2	105.3	0.09	9.477
Ice Storage Bag Fibers, ft^3	0.026	0.45	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.45	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.45	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.09	0.063
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-11 Unit 2 Loop 4 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	53874	0.13	7003.62
RMI Large Pieces, ft^2	17958	0.08	1436.64
Cal-Sil Fines, lbs	29.1	0.44	12.804
Erosion of Cal-Sil Small Pieces to fines, lbs	18.9	0.1	1.89
Cal-Sil Small Pieces, lbs	18.9	0.1	1.89
Marinite I fines, lbs	2.4	0.44	1.056
Erosion of Marinite I Small Pieces to fines, lbs	0.4	0.1	0.04
Marinite I Small Pieces, lbs	0.4	0.1	0.04
Erosion of Marinite I Large Pieces to fines, lbs	1.1	0.14	0.154
Marinite I Large Pieces, lbs	1.1	0.07	0.077
Marinite 36 fines, lbs	4.6	0.44	2.024
Erosion of Marinite 36 Small Pieces to fines, lbs	1.8	0.1	0.18
Marinite 36 Small Pieces, lbs	1.8	0.1	0.18
Erosion of Marinite 36 Large Pieces to fines, lbs	9.5	0.14	1.33
Marinite 36 Large Pieces, lbs	9.5	0.07	0.665
Min-K, lbs	1.6	0.44	0.704
Epoxy Paint (inside ZOI), lbs	216	0.44	95.04
Alkyd Paint (inside ZOI), lbs	1.9	0.44	0.836
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	11.9	0.44	5.236
Fire Proof Tape Small Pieces, ft^2	28.1	0.13	3.653
Fire Proof Tape Large Pieces, ft^2	105.3	0.13	13.689
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-12 Unit 2 Loop 4 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	53874	0	0
RMI Large Pieces, ft^2	17958	0	0
Cal-Sil Fines, lbs	29.1	0.52	15.132
Erosion of Cal-Sil Small Pieces to fines, lbs	18.9	0.08	1.512
Cal-Sil Small Pieces, lbs	18.9	0	0
Marinite I fines, lbs	2.4	0.52	1.248
Erosion of Marinite I Small Pieces to fines, lbs	0.4	0.08	0.032
Marinite I Small Pieces, lbs	0.4	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.1	0.06	0.066
Marinite I Large Pieces, lbs	1.1	0	0
Marinite 36 fines, lbs	4.6	0.52	2.392
Erosion of Marinite 36 Small Pieces to fines, lbs	1.8	0.08	0.144
Marinite 36 Small Pieces, lbs	1.8	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	9.5	0.06	0.57
Marinite 36 Large Pieces, lbs	9.5	0	0
Min-K, lbs	1.6	0.52	0.832
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	11.9	0.52	6.188
Fire Proof Tape Small Pieces, ft^2	28.1	0	0
Fire Proof Tape Large Pieces, ft^2	105.3	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-13 Unit 2 Pressurizer Surge Line Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	24646	0.13	3203.98
RMI Large Pieces, ft^2	8215	0.08	657.2
Cal-Sil Fines, lbs	0	0.44	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.1	0
Cal-Sil Small Pieces, lbs	0	0.1	0
Marinite I fines, lbs	0.3	0.44	0.132
Erosion of Marinite I Small Pieces to fines, lbs	0.1	0.1	0.01
Marinite I Small Pieces, lbs	0.1	0.1	0.01
Erosion of Marinite I Large Pieces to fines, lbs	0.7	0.14	0.098
Marinite I Large Pieces, lbs	0.7	0.07	0.049
Marinite 36 fines, lbs	2.7	0.44	1.188
Erosion of Marinite 36 Small Pieces to fines, lbs	1	0.1	0.1
Marinite 36 Small Pieces, lbs	1	0.1	0.1
Erosion of Marinite 36 Large Pieces to fines, lbs	5.6	0.14	0.784
Marinite 36 Large Pieces, lbs	5.6	0.07	0.392
Min-K, lbs	1.6	0.44	0.704
Epoxy Paint (inside ZOI), lbs	13.7	0.44	6.028
Alkyd Paint (inside ZOI), lbs	0.2	0.44	0.088
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	9.2	0.44	4.048
Fire Proof Tape Small Pieces, ft^2	21.6	0.13	2.808
Fire Proof Tape Large Pieces, ft^2	81	0.13	10.53
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-14 Unit 2 Pressurizer Surge Line Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	24646	0	0
RMI Large Pieces, ft^2	8215	0	0
Cal-Sil Fines, lbs	0	0.52	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.08	0
Cal-Sil Small Pieces, lbs	0	0	0
Marinite I fines, lbs	0.3	0.52	0.156
Erosion of Marinite I Small Pieces to fines, lbs	0.1	0.08	0.008
Marinite I Small Pieces, lbs	0.1	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0.7	0.06	0.042
Marinite I Large Pieces, lbs	0.7	0	0
Marinite 36 fines, lbs	2.7	0.52	1.404
Erosion of Marinite 36 Small Pieces to fines, lbs	1	0.08	0.08
Marinite 36 Small Pieces, lbs	1	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	5.6	0.06	0.336
Marinite 36 Large Pieces, lbs	5.6	0	0
Min-K, lbs	1.6	0.52	0.832
Epoxy Paint (inside ZOI), lbs	13.7	0.52	7.124
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	9.2	0.52	4.784
Fire Proof Tape Small Pieces, ft^2	21.6	0	0
Fire Proof Tape Large Pieces, ft^2	81	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-15 Unit 2 Loop 1 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	34736	0.63	21883.68
RMI Large Pieces, ft^2	11579	0.43	4978.97
Cal-Sil Fines, lbs	6.4	0.45	2.88
Erosion of Cal-Sil Small Pieces to fines, lbs	4.2	0.1	0.42
Cal-Sil Small Pieces, lbs	4.2	0.38	1.596
Marinite I fines, lbs	0.2	0.45	0.09
Erosion of Marinite I Small Pieces to fines, lbs	0.1	0.1	0.01
Marinite I Small Pieces, lbs	0.1	0.38	0.038
Erosion of Marinite I Large Pieces to fines, lbs	0.4	0.11	0.044
Marinite I Large Pieces, lbs	0.4	0.35	0.14
Marinite 36 fines, lbs	0	0.45	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.1	0
Marinite 36 Small Pieces, lbs	0	0.38	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.11	0
Marinite 36 Large Pieces, lbs	0	0.35	0
Min-K, lbs	0	0.45	0
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	2.4	0.45	1.08
Fire Proof Tape Small Pieces, ft^2	5.5	0.63	3.465
Fire Proof Tape Large Pieces, ft^2	20.7	0.63	13.041
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.7	0.63	0.441
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-16 Unit 2 Loop 1 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	34736	0	0
RMI Large Pieces, ft^2	11579	0	0
Cal-Sil Fines, lbs	6.4	0.52	3.328
Erosion of Cal-Sil Small Pieces to fines, lbs	4.2	0.08	0.336
Cal-Sil Small Pieces, lbs	4.2	0	0
Marinite I fines, lbs	0.2	0.52	0.104
Erosion of Marinite I Small Pieces to fines, lbs	0.1	0.08	0.008
Marinite I Small Pieces, lbs	0.1	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0.4	0.06	0.024
Marinite I Large Pieces, lbs	0.4	0	0
Marinite 36 fines, lbs	0	0.52	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.08	0
Marinite 36 Small Pieces, lbs	0	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.06	0
Marinite 36 Large Pieces, lbs	0	0	0
Min-K, lbs	0	0.52	0
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	2.4	0.52	1.248
Fire Proof Tape Small Pieces, ft^2	5.5	0	0
Fire Proof Tape Large Pieces, ft^2	20.7	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-17 Unit 2 Loop 2 Alternate RCS loop Piping Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	32808	0.4	13123.2
RMI Large Pieces, ft^2	10936	0.38	4155.68
Cal-Sil Fines, lbs	0	0.33	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0	0
Cal-Sil Small Pieces, lbs	0	0.31	0
Marinite I fines, lbs	0.5	0.33	0.165
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0	0
Marinite I Small Pieces, lbs	0.2	0.31	0.062
Erosion of Marinite I Large Pieces to fines, lbs	1	0	0
Marinite I Large Pieces, lbs	1	0.3	0.3
Marinite 36 fines, lbs	0.7	0.33	0.231
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0	0
Marinite 36 Small Pieces, lbs	0.3	0.31	0.093
Erosion of Marinite 36 Large Pieces to fines, lbs	1.5	0	0
Marinite 36 Large Pieces, lbs	1.5	0.3	0.45
Min-K, lbs	5.2	0.33	1.716
Epoxy Paint (inside ZOI), lbs	2.7	0.33	0.891
Alkyd Paint (inside ZOI), lbs	0.2	0.33	0.066
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.25	42.5
Latent Fiber, ft^3	12.5	0.25	3.125
Fire Proof Tape Fines, lbs	3.2	0.33	1.056
Fire Proof Tape Small Pieces, ft^2	7.4	0.4	2.96
Fire Proof Tape Large Pieces, ft^2	27.8	0.4	11.12
Ice Storage Bag Fibers, ft^3	0.026	0.47	0.01222
Ice Storage Bag Liner Shards, ft^3	0.00022	0.47	0.0001034
Pieces of Work Platform Rubber, ft^3	0.002	0.47	0.00094
Electromark Label (inside ZOI), ft^2	0.6	0.4	0.24
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-18 Unit 2 Loop 2 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	32808	0.63	20669.04
RMI Large Pieces, ft^2	10936	0.43	4702.48
Cal-Sil Fines, lbs	0	0.45	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.1	0
Cal-Sil Small Pieces, lbs	0	0.38	0
Marinite I fines, lbs	0.5	0.45	0.225
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.1	0.02
Marinite I Small Pieces, lbs	0.2	0.38	0.076
Erosion of Marinite I Large Pieces to fines, lbs	1	0.11	0.11
Marinite I Large Pieces, lbs	1	0.35	0.35
Marinite 36 fines, lbs	0.7	0.45	0.315
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite 36 Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite 36 Large Pieces to fines, lbs	1.5	0.11	0.165
Marinite 36 Large Pieces, lbs	1.5	0.35	0.525
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.39	12.09
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	3.2	0.45	1.44
Fire Proof Tape Small Pieces, ft^2	7.4	0.63	4.662
Fire Proof Tape Large Pieces, ft^2	27.8	0.63	17.514
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-19 Unit 2 Loop 2 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	32808	0	0
RMI Large Pieces, ft^2	10936	0	0
Cal-Sil Fines, lbs	0	0.51	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.04	0
Cal-Sil Small Pieces, lbs	0	0	0
Marinite I fines, lbs	0.5	0.51	0.255
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.04	0.008
Marinite I Small Pieces, lbs	0.2	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1	0.04	0.04
Marinite I Large Pieces, lbs	1	0	0
Marinite 36 fines, lbs	0.7	0.51	0.357
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0.04	0.012
Marinite 36 Small Pieces, lbs	0.3	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	1.5	0.04	0.06
Marinite 36 Large Pieces, lbs	1.5	0	0
Min-K, lbs	5.2	0.51	2.652
Epoxy Paint (inside ZOI), lbs	2.7	0.51	1.377
Alkyd Paint (inside ZOI), lbs	0.2	0.51	0.102
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	3.2	0.51	1.632
Fire Proof Tape Small Pieces, ft^2	7.4	0	0
Fire Proof Tape Large Pieces, ft^2	27.8	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.41	0.01066
Ice Storage Bag Liner Shards, ft^3	0.00022	0.41	0.0000902
Pieces of Work Platform Rubber, ft^3	0.002	0.41	0.00082
Electromark Label (inside ZOI), ft^2	0.6	0.05	0.03
Electromark Label (outside ZOI), ft^2	39.6	0.6	23.76
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-20 Unit 2 Loop 3 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	41936	0.63	26419.68
RMI Large Pieces, ft^2	13978	0.43	6010.54
Cal-Sil Fines, lbs	0	0.45	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.1	0
Cal-Sil Small Pieces, lbs	0	0.38	0
Marinite I fines, lbs	0.6	0.45	0.27
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.1	0.02
Marinite I Small Pieces, lbs	0.2	0.38	0.076
Erosion of Marinite I Large Pieces to fines, lbs	1.2	0.11	0.132
Marinite I Large Pieces, lbs	1.2	0.35	0.42
Marinite 36 fines, lbs	2	0.45	0.9
Erosion of Marinite 36 Small Pieces to fines, lbs	0.8	0.1	0.08
Marinite 36 Small Pieces, lbs	0.8	0.38	0.304
Erosion of Marinite 36 Large Pieces to fines, lbs	4.2	0.11	0.462
Marinite 36 Large Pieces, lbs	4.2	0.35	1.47
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	9.3	0.45	4.185
Fire Proof Tape Small Pieces, ft^2	21.8	0.63	13.797
Fire Proof Tape Large Pieces, ft^2	81.9	0.63	51.597
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-21 Unit 2 Loop 3 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	41936	0	0
RMI Large Pieces, ft^2	13978	0	0
Cal-Sil Fines, lbs	0	0.52	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.08	0
Cal-Sil Small Pieces, lbs	0	0	0
Marinite I fines, lbs	0.6	0.52	0.312
Erosion of Marinite I Small Pieces to fines, lbs	0.2	0.08	0.016
Marinite I Small Pieces, lbs	0.2	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.2	0.06	0.072
Marinite I Large Pieces, lbs	1.2	0	0
Marinite 36 fines, lbs	2	0.52	1.04
Erosion of Marinite 36 Small Pieces to fines, lbs	0.8	0.08	0.064
Marinite 36 Small Pieces, lbs	0.8	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	4.2	0.06	0.252
Marinite 36 Large Pieces, lbs	4.2	0	0
Min-K, lbs	5.2	0.52	2.704
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	9.3	0.52	4.836
Fire Proof Tape Small Pieces, ft^2	21.9	0	0
Fire Proof Tape Large Pieces, ft^2	81.9	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.6	0.47	0.282
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-22 Unit 2 Loop 4 Alternate RCS loop Piping Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	59564	0.09	5360.76
RMI Large Pieces, ft^2	19855	0.05	992.75
Cal-Sil Fines, lbs	14.2	0.32	4.544
Erosion of Cal-Sil Small Pieces to fines, lbs	9.3	0	0
Cal-Sil Small Pieces, lbs	9.3	0.05	0.465
Marinite I fines, lbs	0.9	0.32	0.288
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0	0
Marinite I Small Pieces, lbs	0.3	0.05	0.015
Erosion of Marinite I Large Pieces to fines, lbs	1.8	0	0
Marinite I Large Pieces, lbs	1.8	0.04	0.072
Marinite 36 fines, lbs	2	0.32	0.64
Erosion of Marinite 36 Small Pieces to fines, lbs	0.8	0	0
Marinite 36 Small Pieces, lbs	0.8	0.05	0.04
Erosion of Marinite 36 Large Pieces to fines, lbs	4.2	0	0
Marinite 36 Large Pieces, lbs	4.2	0.04	0.168
Min-K, lbs	0	0.32	0
Epoxy Paint (inside ZOI), lbs	2.7	0.32	0.864
Alkyd Paint (inside ZOI), lbs	0.2	0.32	0.064
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.24	40.8
Latent Fiber, ft^3	12.5	0.24	3
Fire Proof Tape Fines, lbs	10.4	0.32	3.328
Fire Proof Tape Small Pieces, ft^2	24.4	0.09	2.196
Fire Proof Tape Large Pieces, ft^2	91.5	0.09	8.235
Ice Storage Bag Fibers, ft^3	0.026	0.45	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.45	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.45	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.09	0.063
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-23 Unit 2 Loop 4 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	59564	0.13	7743.32
RMI Large Pieces, ft^2	19855	0.08	1588.4
Cal-Sil Fines, lbs	14.2	0.44	6.248
Erosion of Cal-Sil Small Pieces to fines, lbs	9.3	0.1	0.93
Cal-Sil Small Pieces, lbs	9.3	0.1	0.93
Marinite I fines, lbs	0.9	0.44	0.396
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.1	0.03
Erosion of Marinite I Large Pieces to fines, lbs	1.8	0.14	0.252
Marinite I Large Pieces, lbs	1.8	0.07	0.126
Marinite 36 fines, lbs	2	0.44	0.88
Erosion of Marinite 36 Small Pieces to fines, lbs	0.8	0.1	0.08
Marinite 36 Small Pieces, lbs	0.8	0.1	0.08
Erosion of Marinite 36 Large Pieces to fines, lbs	4.2	0.14	0.588
Marinite 36 Large Pieces, lbs	4.2	0.07	0.294
Min-K, lbs	0	0.44	0
Epoxy Paint (inside ZOI), lbs	2.7	0.44	1.188
Alkyd Paint (inside ZOI), lbs	0.2	0.44	0.088
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	10.4	0.44	4.576
Fire Proof Tape Small Pieces, ft^2	24.4	0.13	3.172
Fire Proof Tape Large Pieces, ft^2	91.5	0.13	11.895
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-24 Unit 2 Loop 4 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	59564	0	0
RMI Large Pieces, ft^2	19855	0	0
Cal-Sil Fines, lbs	14.2	0.52	7.384
Erosion of Cal-Sil Small Pieces to fines, lbs	9.3	0.08	0.744
Cal-Sil Small Pieces, lbs	9.3	0	0
Marinite I fines, lbs	0.9	0.52	0.468
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.08	0.024
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.8	0.06	0.108
Marinite I Large Pieces, lbs	1.8	0	0
Marinite 36 fines, lbs	2	0.52	1.04
Erosion of Marinite 36 Small Pieces to fines, lbs	0.8	0.08	0.064
Marinite 36 Small Pieces, lbs	0.8	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	4.2	0.06	0.252
Marinite 36 Large Pieces, lbs	4.2	0	0
Min-K, lbs	0	0.52	0
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	10.4	0.52	5.408
Fire Proof Tape Small Pieces, ft^2	24.4	0	0
Fire Proof Tape Large Pieces, ft^2	91.5	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-25 Unit 1 Loop 1 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	34267	0.63	21588.21
RMI Large Pieces, ft^2	11422	0.43	4911.46
Cal-Sil Fines, lbs	11.2	0.45	5.04
Erosion of Cal-Sil Small Pieces to fines, lbs	7.4	0.1	0.74
Cal-Sil Small Pieces, lbs	7.4	0.38	2.812
Marinite I fines, lbs	0	0.45	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.1	0
Marinite I Small Pieces, lbs	0	0.38	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.11	0
Marinite I Large Pieces, lbs	0	0.35	0
Marinite 36 fines, lbs	0	0.45	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.1	0
Marinite 36 Small Pieces, lbs	0	0.38	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.11	0
Marinite 36 Large Pieces, lbs	0	0.35	0
Min-K, lbs	3.6	0.45	1.62
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	1.8	0.45	0.81
Fire Proof Tape Small Pieces, ft^2	4.1	0.63	2.583
Fire Proof Tape Large Pieces, ft^2	15.5	0.63	9.765
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.7	0.63	0.441
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-26 Unit 1 Loop 1 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	34267	0	0
RMI Large Pieces, ft^2	11422	0	0
Cal-Sil Fines, lbs	11.2	0.52	5.824
Erosion of Cal-Sil Small Pieces to fines, lbs	7.4	0.08	0.592
Cal-Sil Small Pieces, lbs	7.4	0	0
Marinite I fines, lbs	0	0.52	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.08	0
Marinite I Small Pieces, lbs	0	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.06	0
Marinite I Large Pieces, lbs	0	0	0
Marinite 36 fines, lbs	0	0.52	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.08	0
Marinite 36 Small Pieces, lbs	0	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.06	0
Marinite 36 Large Pieces, lbs	0	0	0
Min-K, lbs	3.6	0.52	1.872
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	1.8	0.52	0.936
Fire Proof Tape Small Pieces, ft^2	4.1	0	0
Fire Proof Tape Large Pieces, ft^2	15.5	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-27 Unit 1 Loop 2 RCS Crossover Leg Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	60312	0.4	24124.8
RMI Large Pieces, ft^2	20104	0.38	7639.52
Cal-Sil Fines, lbs	31.9	0.33	10.527
Erosion of Cal-Sil Small Pieces to fines, lbs	20.3	0	0
Cal-Sil Small Pieces, lbs	20.3	0.31	6.293
Marinite I fines, lbs	0.8	0.33	0.264
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0	0
Marinite I Small Pieces, lbs	0.3	0.31	0.093
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0	0
Marinite I Large Pieces, lbs	1.7	0.3	0.51
Marinite 36 fines, lbs	0.7	0.33	0.231
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0	0
Marinite 36 Small Pieces, lbs	0.3	0.31	0.093
Erosion of Marinite 36 Large Pieces to fines, lbs	1.4	0	0
Marinite 36 Large Pieces, lbs	1.4	0.3	0.42
Min-K, lbs	5.2	0.33	1.716
Epoxy Paint (inside ZOI), lbs	216	0.33	71.28
Alkyd Paint (inside ZOI), lbs	1.9	0.33	0.627
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.25	42.5
Latent Fiber, ft^3	12.5	0.25	3.125
Fire Proof Tape Fines, lbs	2.2	0.33	0.726
Fire Proof Tape Small Pieces, ft^2	5.2	0.4	2.08
Fire Proof Tape Large Pieces, ft^2	19.4	0.4	7.76
Ice Storage Bag Fibers, ft^3	0.026	0.47	0.01222
Ice Storage Bag Liner Shards, ft^3	0.00022	0.47	0.0001034
Pieces of Work Platform Rubber, ft^3	0.002	0.47	0
Electromark Label (inside ZOI), ft^2	0.6	0.4	0.24
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-28 Unit 1 Loop 2 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	60312	0.63	37996.56
RMI Large Pieces, ft^2	20104	0.43	8644.72
Cal-Sil Fines, lbs	31.9	0.45	14.355
Erosion of Cal-Sil Small Pieces to fines, lbs	20.3	0.1	2.03
Cal-Sil Small Pieces, lbs	20.3	0.38	7.714
Marinite I fines, lbs	0.8	0.45	0.36
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.11	0.187
Marinite I Large Pieces, lbs	1.7	0.35	0.595
Marinite 36 fines, lbs	0.7	0.45	0.315
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite 36 Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite 36 Large Pieces to fines, lbs	1.4	0.11	0.154
Marinite 36 Large Pieces, lbs	1.4	0.35	0.49
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.39	12.09
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	2.2	0.45	0.99
Fire Proof Tape Small Pieces, ft^2	5.2	0.63	3.276
Fire Proof Tape Large Pieces, ft^2	19.4	0.63	12.222
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-29 Unit 1 Loop 2 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	60312	0	0
RMI Large Pieces, ft^2	20104	0	0
Cal-Sil Fines, lbs	31.9	0.51	16.269
Erosion of Cal-Sil Small Pieces to fines, lbs	20.3	0.04	0.812
Cal-Sil Small Pieces, lbs	20.3	0	0
Marinite I fines, lbs	0.8	0.51	0.408
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.04	0.012
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.04	0.068
Marinite I Large Pieces, lbs	1.7	0	0
Marinite 36 fines, lbs	0.7	0.51	0.357
Erosion of Marinite 36 Small Pieces to fines, lbs	0.3	0.04	0.012
Marinite 36 Small Pieces, lbs	0.3	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	1.4	0.04	0.056
Marinite 36 Large Pieces, lbs	1.4	0	0
Min-K, lbs	5.2	0.51	2.652
Epoxy Paint (inside ZOI), lbs	216	0.51	110.16
Alkyd Paint (inside ZOI), lbs	1.9	0.51	0.969
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	2.2	0.51	1.122
Fire Proof Tape Small Pieces, ft^2	5.2	0	0
Fire Proof Tape Large Pieces, ft^2	19.4	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.41	0.01066
Ice Storage Bag Liner Shards, ft^3	0.00022	0.41	0.0000902
Pieces of Work Platform Rubber, ft^3	0.002	0.41	0.00082
Electromark Label (inside ZOI), ft^2	0.6	0.05	0.03
Electromark Label (outside ZOI), ft^2	39.6	0.6	23.76
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-30 Unit 1 Loop 3 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	59439	0.63	37446.57
RMI Large Pieces, ft^2	19813	0.43	8519.59
Cal-Sil Fines, lbs	16	0.45	7.2
Erosion of Cal-Sil Small Pieces to fines, lbs	10.1	0.1	1.01
Cal-Sil Small Pieces, lbs	10.1	0.38	3.838
Marinite I fines, lbs	0.8	0.45	0.36
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.11	0.187
Marinite I Large Pieces, lbs	1.7	0.35	0.595
Marinite 36 fines, lbs	1.9	0.45	0.855
Erosion of Marinite 36 Small Pieces to fines, lbs	0.7	0.1	0.07
Marinite 36 Small Pieces, lbs	0.7	0.38	0.266
Erosion of Marinite 36 Large Pieces to fines, lbs	3.9	0.11	0.429
Marinite 36 Large Pieces, lbs	3.9	0.35	1.365
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	216	0.45	97.2
Alkyd Paint (inside ZOI), lbs	1.9	0.45	0.855
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	2.3	0.45	1.035
Fire Proof Tape Small Pieces, ft^2	5.4	0.63	3.402
Fire Proof Tape Large Pieces, ft^2	20.3	0.63	12.789
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-31 Unit 1 Loop 3 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	59439	0	0
RMI Large Pieces, ft^2	19813	0	0
Cal-Sil Fines, lbs	16	0.52	8.32
Erosion of Cal-Sil Small Pieces to fines, lbs	10.1	0.08	0.808
Cal-Sil Small Pieces, lbs	10.1	0	0
Marinite I fines, lbs	0.8	0.52	0.416
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.08	0.024
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.06	0.102
Marinite I Large Pieces, lbs	1.7	0	0
Marinite 36 fines, lbs	1.9	0.52	0.988
Erosion of Marinite 36 Small Pieces to fines, lbs	0.7	0.08	0.056
Marinite 36 Small Pieces, lbs	0.7	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	3.9	0.06	0.234
Marinite 36 Large Pieces, lbs	3.9	0	0
Min-K, lbs	5.2	0.52	2.704
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	2.3	0.52	1.196
Fire Proof Tape Small Pieces, ft^2	5.4	0	0
Fire Proof Tape Large Pieces, ft^2	20.3	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.6	0.47	0.282
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-32 Unit 1 Loop 4 RCS Crossover Leg Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	70105	0.09	6309.45
RMI Large Pieces, ft^2	23368	0.05	1168.4
Cal-Sil Fines, lbs	40.7	0.32	13.024
Erosion of Cal-Sil Small Pieces to fines, lbs	26.5	0	0
Cal-Sil Small Pieces, lbs	26.5	0.05	1.325
Marinite I fines, lbs	0	0.32	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0	0
Marinite I Small Pieces, lbs	0	0.05	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0	0
Marinite I Large Pieces, lbs	0	0.04	0
Marinite 36 fines, lbs	1.5	0.32	0.48
Erosion of Marinite 36 Small Pieces to fines, lbs	0.6	0	0
Marinite 36 Small Pieces, lbs	0.6	0.05	0.03
Erosion of Marinite 36 Large Pieces to fines, lbs	3.1	0	0
Marinite 36 Large Pieces, lbs	3.1	0.04	0.124
Min-K, lbs	1.6	0.32	0.512
Epoxy Paint (inside ZOI), lbs	216	0.32	69.12
Alkyd Paint (inside ZOI), lbs	1.9	0.32	0.608
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.24	40.8
Latent Fiber, ft^3	12.5	0.24	3
Fire Proof Tape Fines, lbs	3.3	0.32	1.056
Fire Proof Tape Small Pieces, ft^2	7.8	0.09	0.702
Fire Proof Tape Large Pieces, ft^2	29.3	0.09	2.637
Ice Storage Bag Fibers, ft^3	0.026	0.45	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.45	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.45	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.09	0.063
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-33 Unit 1 Loop 4 RCS Crossover Leg Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	70105	0.13	9113.65
RMI Large Pieces, ft^2	23368	0.08	1869.44
Cal-Sil Fines, lbs	40.7	0.44	17.908
Erosion of Cal-Sil Small Pieces to fines, lbs	26.5	0.1	2.65
Cal-Sil Small Pieces, lbs	26.5	0.1	2.65
Marinite I fines, lbs	0	0.44	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.1	0
Marinite I Small Pieces, lbs	0	0.1	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.14	0
Marinite I Large Pieces, lbs	0	0.07	0
Marinite 36 fines, lbs	1.5	0.44	0.66
Erosion of Marinite 36 Small Pieces to fines, lbs	0.6	0.1	0.06
Marinite 36 Small Pieces, lbs	0.6	0.1	0.06
Erosion of Marinite 36 Large Pieces to fines, lbs	3.1	0.14	0.434
Marinite 36 Large Pieces, lbs	3.1	0.07	0.217
Min-K, lbs	1.6	0.44	0.704
Epoxy Paint (inside ZOI), lbs	216	0.44	95.04
Alkyd Paint (inside ZOI), lbs	1.9	0.44	0.836
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	3.3	0.44	1.452
Fire Proof Tape Small Pieces, ft^2	7.8	0.13	1.014
Fire Proof Tape Large Pieces, ft^2	29.3	0.13	3.809
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-34 Unit 1 Loop 4 RCS Crossover Leg Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	70105	0	0
RMI Large Pieces, ft^2	23368	0	0
Cal-Sil Fines, lbs	40.7	0.52	21.164
Erosion of Cal-Sil Small Pieces to fines, lbs	26.5	0.08	2.12
Cal-Sil Small Pieces, lbs	26.5	0	0
Marinite I fines, lbs	0	0.52	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.08	0
Marinite I Small Pieces, lbs	0	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.06	0
Marinite I Large Pieces, lbs	0	0	0
Marinite 36 fines, lbs	1.5	0.52	0.78
Erosion of Marinite 36 Small Pieces to fines, lbs	0.6	0.08	0.048
Marinite 36 Small Pieces, lbs	0.6	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	3.1	0.06	0.186
Marinite 36 Large Pieces, lbs	3.1	0	0
Min-K, lbs	1.6	0.52	0.832
Epoxy Paint (inside ZOI), lbs	216	0.52	112.32
Alkyd Paint (inside ZOI), lbs	1.9	0.52	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	3.3	0.52	1.716
Fire Proof Tape Small Pieces, ft^2	7.8	0	0
Fire Proof Tape Large Pieces, ft^2	29.3	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-35 Unit 1 Pressurizer Surge Line Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	15131	0.13	1967.03
RMI Large Pieces, ft^2	5044	0.08	403.52
Cal-Sil Fines, lbs	11.1	0.44	4.884
Erosion of Cal-Sil Small Pieces to fines, lbs	7.2	0.1	0.72
Cal-Sil Small Pieces, lbs	7.2	0.1	0.72
Marinite I fines, lbs	0	0.44	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.1	0
Marinite I Small Pieces, lbs	0	0.1	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.14	0
Marinite I Large Pieces, lbs	0	0.07	0
Marinite 36 fines, lbs	1.2	0.44	0.528
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.1	0.05
Marinite 36 Small Pieces, lbs	0.5	0.1	0.05
Erosion of Marinite 36 Large Pieces to fines, lbs	2.5	0.14	0.35
Marinite 36 Large Pieces, lbs	2.5	0.07	0.175
Min-K, lbs	1.6	0.44	0.704
Epoxy Paint (inside ZOI), lbs	13.7	0.44	6.028
Alkyd Paint (inside ZOI), lbs	0.2	0.44	0.088
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	0.8	0.44	0.352
Fire Proof Tape Small Pieces, ft^2	1.9	0.13	0.247
Fire Proof Tape Large Pieces, ft^2	7.1	0.13	0.923
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-36 Unit 1 Pressurizer Surge Line Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	15131	0	0
RMI Large Pieces, ft^2	5044	0	0
Cal-Sil Fines, lbs	11.1	0.52	5.772
Erosion of Cal-Sil Small Pieces to fines, lbs	7.2	0.08	0.576
Cal-Sil Small Pieces, lbs	7.2	0	0
Marinite I fines, lbs	0	0.52	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.08	0
Marinite I Small Pieces, lbs	0	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.06	0
Marinite I Large Pieces, lbs	0	0	0
Marinite 36 fines, lbs	1.2	0.52	0.624
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.08	0.04
Marinite 36 Small Pieces, lbs	0.5	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	2.5	0.06	0.15
Marinite 36 Large Pieces, lbs	2.5	0	0
Min-K, lbs	1.6	0.52	0.832
Epoxy Paint (inside ZOI), lbs	13.7	0.52	7.124
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	0.8	0.52	0.416
Fire Proof Tape Small Pieces, ft^2	1.9	0	0
Fire Proof Tape Large Pieces, ft^2	7.1	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-37 Unit 1 Loop 1 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	15817	0.63	9964.71
RMI Large Pieces, ft^2	5272	0.43	2266.96
Cal-Sil Fines, lbs	6.3	0.45	2.835
Erosion of Cal-Sil Small Pieces to fines, lbs	4.1	0.1	0.41
Cal-Sil Small Pieces, lbs	4.1	0.38	1.558
Marinite I fines, lbs	0	0.45	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.1	0
Marinite I Small Pieces, lbs	0	0.38	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.11	0
Marinite I Large Pieces, lbs	0	0.35	0
Marinite 36 fines, lbs	0	0.45	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.1	0
Marinite 36 Small Pieces, lbs	0	0.38	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.11	0
Marinite 36 Large Pieces, lbs	0	0.35	0
Min-K, lbs	0	0.45	0
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	1.8	0.45	0.81
Fire Proof Tape Small Pieces, ft^2	4.1	0.63	2.583
Fire Proof Tape Large Pieces, ft^2	15.5	0.63	9.765
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.7	0.63	0.441
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-38 Unit 1 Loop 1 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	15817	0	0
RMI Large Pieces, ft^2	5272	0	0
Cal-Sil Fines, lbs	6.3	0.52	3.276
Erosion of Cal-Sil Small Pieces to fines, lbs	4.1	0.08	0.328
Cal-Sil Small Pieces, lbs	4.1	0	0
Marinite I fines, lbs	0	0.52	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.08	0
Marinite I Small Pieces, lbs	0	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.06	0
Marinite I Large Pieces, lbs	0	0	0
Marinite 36 fines, lbs	0	0.52	0
Erosion of Marinite 36 Small Pieces to fines, lbs	0	0.08	0
Marinite 36 Small Pieces, lbs	0	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0	0.06	0
Marinite 36 Large Pieces, lbs	0	0	0
Min-K, lbs	0	0.52	0
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	1.8	0.52	0.936
Fire Proof Tape Small Pieces, ft^2	4.1	0	0
Fire Proof Tape Large Pieces, ft^2	15.5	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-39 Unit 1 Loop 2 Alternate RCS loop Piping Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	39852	0.4	15940.8
RMI Large Pieces, ft^2	13284	0.38	5047.92
Cal-Sil Fines, lbs	0	0.33	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0	0
Cal-Sil Small Pieces, lbs	0	0.31	0
Marinite I fines, lbs	0.8	0.33	0.264
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0	0
Marinite I Small Pieces, lbs	0.3	0.31	0.093
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0	0
Marinite I Large Pieces, lbs	1.7	0.3	0.51
Marinite 36 fines, lbs	0.2	0.33	0.066
Erosion of Marinite 36 Small Pieces to fines, lbs	0.1	0	0
Marinite 36 Small Pieces, lbs	0.1	0.31	0.031
Erosion of Marinite 36 Large Pieces to fines, lbs	0.4	0	0
Marinite 36 Large Pieces, lbs	0.4	0.3	0.12
Min-K, lbs	5.2	0.33	1.716
Epoxy Paint (inside ZOI), lbs	2.7	0.33	0.891
Alkyd Paint (inside ZOI), lbs	0.2	0.33	0.066
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.25	42.5
Latent Fiber, ft^3	12.5	0.25	3.125
Fire Proof Tape Fines, lbs	0.9	0.33	0.297
Fire Proof Tape Small Pieces, ft^2	2.2	0.4	0.88
Fire Proof Tape Large Pieces, ft^2	8.1	0.4	3.24
Ice Storage Bag Fibers, ft^3	0.026	0.47	0.01222
Ice Storage Bag Liner Shards, ft^3	0.00022	0.47	0.0001034
Pieces of Work Platform Rubber, ft^3	0.002	0.47	0.00094
Electromark Label (inside ZOI), ft^2	0.6	0.4	0.24
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-40 Unit 1 Loop 2 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	39852	0.63	25106.76
RMI Large Pieces, ft^2	13284	0.43	5712.12
Cal-Sil Fines, lbs	0	0.45	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.1	0
Cal-Sil Small Pieces, lbs	0	0.38	0
Marinite I fines, lbs	0.8	0.45	0.36
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.11	0.187
Marinite I Large Pieces, lbs	1.7	0.35	0.595
Marinite 36 fines, lbs	0.2	0.45	0.09
Erosion of Marinite 36 Small Pieces to fines, lbs	0.1	0.1	0.01
Marinite 36 Small Pieces, lbs	0.1	0.38	0.038
Erosion of Marinite 36 Large Pieces to fines, lbs	0.4	0.11	0.044
Marinite 36 Large Pieces, lbs	0.4	0.35	0.14
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.39	12.09
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	0.9	0.45	0.405
Fire Proof Tape Small Pieces, ft^2	2.2	0.63	1.386
Fire Proof Tape Large Pieces, ft^2	8.1	0.63	5.103
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-41 Unit 1 Loop 2 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	39852	0	0
RMI Large Pieces, ft^2	13284	0	0
Cal-Sil Fines, lbs	0	0.51	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.04	0
Cal-Sil Small Pieces, lbs	0	0	0
Marinite I fines, lbs	0.8	0.51	0.408
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.04	0.012
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.04	0.068
Marinite I Large Pieces, lbs	1.7	0	0
Marinite 36 fines, lbs	0.2	0.51	0.102
Erosion of Marinite 36 Small Pieces to fines, lbs	0.1	0.04	0.004
Marinite 36 Small Pieces, lbs	0.1	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	0.4	0.04	0.016
Marinite 36 Large Pieces, lbs	0.4	0	0
Min-K, lbs	5.2	0.51	2.652
Epoxy Paint (inside ZOI), lbs	2.7	0.51	1.377
Alkyd Paint (inside ZOI), lbs	0.2	0.51	0.102
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	0.9	0.51	0.459
Fire Proof Tape Small Pieces, ft^2	2.2	0	0
Fire Proof Tape Large Pieces, ft^2	8.1	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.41	0.01066
Ice Storage Bag Liner Shards, ft^3	0.00022	0.41	0.0000902
Pieces of Work Platform Rubber, ft^3	0.002	0.41	0.00082
Electromark Label (inside ZOI), ft^2	0.6	0.05	0.03
Electromark Label (outside ZOI), ft^2	39.6	0.6	23.76
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-42 Unit 1 Loop 3 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	27709	0.63	17456.67
RMI Large Pieces, ft^2	9236	0.43	3971.48
Cal-Sil Fines, lbs	0	0.45	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.1	0
Cal-Sil Small Pieces, lbs	0	0.38	0
Marinite I fines, lbs	0.8	0.45	0.36
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.1	0.03
Marinite I Small Pieces, lbs	0.3	0.38	0.114
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.11	0.187
Marinite I Large Pieces, lbs	1.7	0.35	0.595
Marinite 36 fines, lbs	1.4	0.45	0.63
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.1	0.05
Marinite 36 Small Pieces, lbs	0.5	0.38	0.19
Erosion of Marinite 36 Large Pieces to fines, lbs	2.9	0.11	0.319
Marinite 36 Large Pieces, lbs	2.9	0.35	1.015
Min-K, lbs	5.2	0.45	2.34
Epoxy Paint (inside ZOI), lbs	2.7	0.45	1.215
Alkyd Paint (inside ZOI), lbs	0.2	0.45	0.09
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	1	0.45	0.45
Fire Proof Tape Small Pieces, ft^2	2.4	0.63	1.512
Fire Proof Tape Large Pieces, ft^2	9	0.63	5.67
Ice Storage Bag Fibers, ft^3	0.026	0.64	0.01664
Ice Storage Bag Liner Shards, ft^3	0.00022	0.64	0.0001408
Pieces of Work Platform Rubber, ft^3	0.002	0.64	0.00128
Electromark Label (inside ZOI), ft^2	0.6	0.63	0.378
Electromark Label (outside ZOI), ft^2	39.6	0.17	6.732
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-43 Unit 1 Loop 3 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	27709	0	0
RMI Large Pieces, ft^2	9236	0	0
Cal-Sil Fines, lbs	0	0.52	0
Erosion of Cal-Sil Small Pieces to fines, lbs	0	0.08	0
Cal-Sil Small Pieces, lbs	0	0	0
Marinite I fines, lbs	0.8	0.52	0.416
Erosion of Marinite I Small Pieces to fines, lbs	0.3	0.08	0.024
Marinite I Small Pieces, lbs	0.3	0	0
Erosion of Marinite I Large Pieces to fines, lbs	1.7	0.06	0.102
Marinite I Large Pieces, lbs	1.7	0	0
Marinite 36 fines, lbs	1.4	0.52	0.728
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.08	0.04
Marinite 36 Small Pieces, lbs	0.5	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	2.9	0.06	0.174
Marinite 36 Large Pieces, lbs	2.9	0	0
Min-K, lbs	5.2	0.52	2.704
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	1	0.52	0.52
Fire Proof Tape Small Pieces, ft^2	2.4	0	0
Fire Proof Tape Large Pieces, ft^2	9	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.6	0.47	0.282
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

Table 3a3-44 Unit 1 Loop 4 Alternate RCS loop Piping Break Debris Transported to the Main Strainer during Pool Fill

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	38562	0.09	3470.58
RMI Large Pieces, ft^2	12854	0.05	642.7
Cal-Sil Fines, lbs	3.8	0.32	1.216
Erosion of Cal-Sil Small Pieces to fines, lbs	2.5	0	0
Cal-Sil Small Pieces, lbs	2.5	0.05	0.125
Marinite I fines, lbs	0	0.32	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0	0
Marinite I Small Pieces, lbs	0	0.05	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0	0
Marinite I Large Pieces, lbs	0	0.04	0
Marinite 36 fines, lbs	1.2	0.32	0.384
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0	0
Marinite 36 Small Pieces, lbs	0.5	0.05	0.025
Erosion of Marinite 36 Large Pieces to fines, lbs	2.6	0	0
Marinite 36 Large Pieces, lbs	2.6	0.04	0.104
Min-K, lbs	0	0.32	0
Epoxy Paint (inside ZOI), lbs	2.7	0.32	0.864
Alkyd Paint (inside ZOI), lbs	0.2	0.32	0.064
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0	0
Dirt/Dust, lbs	170	0.24	40.8
Latent Fiber, ft^3	12.5	0.24	3
Fire Proof Tape Fines, lbs	2.7	0.32	0.864
Fire Proof Tape Small Pieces, ft^2	6.3	0.09	0.567
Fire Proof Tape Large Pieces, ft^2	23.7	0.09	2.133
Ice Storage Bag Fibers, ft^3	0.026	0.45	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.45	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.45	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.09	0.063
Electromark Label (outside ZOI), ft^2	39.6	0	0
Unqualified Labels – Paper, ft^2	0.28	0	0
Unqualified Labels – Other, ft^2	25.66	0	0
Flex Conduit PVC Jacketing, ft^2	1.57	0	0

Table 3a3-45 Unit 1 Loop 4 Alternate RCS loop Break Debris at Main Strainer

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	38562	0.13	5013.06
RMI Large Pieces, ft^2	12854	0.08	1028.32
Cal-Sil Fines, lbs	3.8	0.44	1.672
Erosion of Cal-Sil Small Pieces to fines, lbs	2.5	0.1	0.25
Cal-Sil Small Pieces, lbs	2.5	0.1	0.25
Marinite I fines, lbs	0	0.44	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.1	0
Marinite I Small Pieces, lbs	0	0.1	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.14	0
Marinite I Large Pieces, lbs	0	0.07	0
Marinite 36 fines, lbs	1.2	0.44	0.528
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.1	0.05
Marinite 36 Small Pieces, lbs	0.5	0.1	0.05
Erosion of Marinite 36 Large Pieces to fines, lbs	2.6	0.14	0.364
Marinite 36 Large Pieces, lbs	2.6	0.07	0.182
Min-K, lbs	0	0.44	0
Epoxy Paint (inside ZOI), lbs	2.7	0.44	1.188
Alkyd Paint (inside ZOI), lbs	0.2	0.44	0.088
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.4	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.14	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0.52	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.58	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	0.93	361.5375
Dirt/Dust, lbs	170	0.52	88.4
Latent Fiber, ft^3	12.5	0.52	6.5
Fire Proof Tape Fines, lbs	2.7	0.44	1.188
Fire Proof Tape Small Pieces, ft^2	6.3	0.13	0.819
Fire Proof Tape Large Pieces, ft^2	23.7	0.13	3.081
Ice Storage Bag Fibers, ft^3	0.026	0.63	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.63	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.63	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Label (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels – Paper, ft^2	0.28	0.86	0.2408
Unqualified Labels – Other, ft^2	25.66	0.86	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1	1.57

Table 3a3-46 Unit 1 Loop 4 Alternate RCS loop Break Debris at Remote Strainer (90% Blocked Main)

Debris Type	Debris Generated	Transport Fraction	Predicted Debris at Strainer
RMI Small Pieces, ft^2	38562	0	0
RMI Large Pieces, ft^2	12854	0	0
Cal-Sil Fines, lbs	3.8	0.52	1.976
Erosion of Cal-Sil Small Pieces to fines, lbs	2.5	0.08	0.2
Cal-Sil Small Pieces, lbs	2.5	0	0
Marinite I fines, lbs	0	0.52	0
Erosion of Marinite I Small Pieces to fines, lbs	0	0.08	0
Marinite I Small Pieces, lbs	0	0	0
Erosion of Marinite I Large Pieces to fines, lbs	0	0.06	0
Marinite I Large Pieces, lbs	0	0	0
Marinite 36 fines, lbs	1.2	0.52	0.624
Erosion of Marinite 36 Small Pieces to fines, lbs	0.5	0.08	0.04
Marinite 36 Small Pieces, lbs	0.5	0	0
Erosion of Marinite 36 Large Pieces to fines, lbs	2.6	0.06	0.156
Marinite 36 Large Pieces, lbs	2.6	0	0
Min-K, lbs	0	0.52	0
Epoxy Paint (inside ZOI), lbs	2.7	0.52	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.52	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0.72	12.168
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0.9	66.96
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0.59	2.006
Unqualified Cold Galvanizing Compound, lbs	388.75	0.35	136.0625
Dirt/Dust, lbs	170	0.56	95.2
Latent Fiber, ft^3	12.5	0.56	7
Fire Proof Tape Fines, lbs	2.7	0.52	1.404
Fire Proof Tape Small Pieces, ft^2	6.3	0	0
Fire Proof Tape Large Pieces, ft^2	23.7	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.42	0.01092
Ice Storage Bag Liner Shards, ft^3	0.00022	0.42	0.0000924
Pieces of Work Platform Rubber, ft^3	0.002	0.42	0.00084
Electromark Label (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Label (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels – Paper, ft^2	0.28	0.4	0.112
Unqualified Labels – Other, ft^2	25.66	0.4	10.264
Flex Conduit PVC Jacketing, ft^2	1.57	0.3	0.471

(1) 8% of Cal-Sil fines transport to the reactor cavity (References 28 and 94 of Reference 2) and are subtracted from the debris generated value prior to determining the debris at the strainer and the amount available to transport.

NRC Information Item 3.b - Debris Generation/Zone of Influence (ZOI) (excluding coatings)

The objective of the debris generation/ZOI process is to determine, for each postulated break location: (1) the zone within which the break jet forces would be sufficient to damage materials and create debris; and (2) the amount of debris generated by the break jet forces.

1. *Describe the methodology used to determine the ZOIs for generating debris. Identify which debris analyses used approved methodology default values. For debris with ZOIs not defined in the guidance report/SE, or if using other than default values, discuss method(s) used to determine ZOI and the basis for each.*
2. *Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent.*
3. *Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the NRC for review or information, describe the test procedure and results with reference to the test report(s).*
4. *Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data only for the four most limiting locations.*
5. *Provide total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment.*

I&M Response to Information Items 3.b.1 and 3.b.2

The information previously provided in References 1 and 2 is supplemented by the following information.

Tables 3b1-1 and 3b1-2 have been updated to reflect the as-installed configuration of insulation in the Unit 1 and Unit 2 containments. Note that these tables reflect the insulation that is installed in lower containment and not just the quantity that could be within a potential ZOI.

Table 3b1-1 Insulation Quantities – Unit 1

	Transco RMI, ft^2	DP RMI, ft^2	Cal-Sil, ft^3	Fiberglass, ft^3	Marinite, ft^3	Min-K, ft^3
Lower Containment – Inside Crane Wall – Loop 1	37,726	9,968	211	--	--	--
Lower Containment – Inside Crane Wall – Loop 2	37,840	12,417	198	--	2.12	0.18
Lower Containment – Inside Crane Wall – Loop 3	37,674	13,684	213	--	0.68	0.08
Lower Containment – Inside Crane Wall – Loop 4	37,726	11,601	245	--	2.55	--
Lower Containment – Inside Crane Wall – PZR Vault area	520	20,438	30	--	--	--
Reactor Cavity	19,792	--	--	5	--	--
Total	**171278**	**68108**	**897**	**5**	**5.35**	**0.26**

Table 3b1-2 Insulation Quantities – Unit 2

	Transco RMI, ft^2	DP RMI, ft^2	Cal-Sil, ft^3	Fiberglass, ft^3	Marinite, ft^3	Min-K, ft^3
Lower Containment – Inside Crane Wall – Loop 1	--	39,543	337	--	2.09	--
Lower Containment – Inside Crane Wall – Loop 2	--	42,542	318	--	0.61	0.18
Lower Containment – Inside Crane Wall – Loop 3	--	43,828	345	--	7.05	0.08
Lower Containment – Inside Crane Wall – Loop 4	--	42,346	346	--	2.56	--
Lower Containment – Inside Crane Wall – PZR Vault area	--	18,003	18	--	--	--
Reactor Cavity	19,802	--	--	5	--	--
Total	**19,802**	**186,262**	**1,364**	**5**	**12.31**	**0.26**

The Wyle jet impingement testing that was previously used to establish ZOI values for Marinite, fire barrier tape, Electromark labels, and jacketed Armaflex insulation was determined to have a choke point upstream of the nozzle. As a result of this configuration, the previously calculated ZOI values were determined to be non-conservative. To account for this non-conservatism in L/D, the ZOI for Marinite and fire barrier tape were increased to 17D, the same as that used for low density fiberglass.

Determination of ZOI values based on the increased distance from the choke point, and reduced diameter at the choke point, resulted in ZOI values greater than previously reported but less than 17D. For Marinite, the recalculated ZOI values at which destruction occurred are 8.8D, 6.4D, and 5.2D. For fire barrier tape, the recalculated maximum ZOI was 13.7D. The debris distribution values from these tests were retained at the values determined during testing as reported in Reference 1. For the Electromark labels, the previous method of determining the quantity of labels potentially affected by the jet was not changed. One-half of the loop compartment volume was used to determine the quantity of labels that could be impacted in lieu of a specific ZOI. The majority of the labels that could reasonably be assumed to be impacted by a jet are below the maximum predicted flood elevation in containment following a LOCA.

Therefore, all labels below the minimum predicted flood elevation were assumed to undergo 100% failure. For the double jacketed Armaflex insulation, failure did not occur during testing. Conservatively assuming that failure could occur at the same ZOI as jacketed Cal-Sil (5.45D) the resulting quantity of debris would potentially result in 11.79 ft^2 of main strainer blockage. This material can only impact the main strainer during pool fill since it floats in water. After transfer to the recirculation mode of core and containment cooling, the water level remains above the top of the strainers.

Refer to Attachment 3 for additional discussion of jet impingement testing of CNP specific materials.

Table 3b1-5 of Reference 1 provided the ZOI values used for debris sources. This table is reproduced here and updated with new ZOI values for those materials for which debris was generated during jet impingement testing.

Table 3b1-5 ZOI Radii for Debris Sources

Debris Source Types	Destruction Pressure (psi)	ZOI Radius (Radius/Break Diameter) (ft)	Basis for Assumed ZOI
Transco RMI	114	2.0D	SER Table 3-2
Marinite I and Marinite 36	6	17D	SER Table 3-2
Cal-Sil	20	6.4D (2)	ALION
Low Density Transco Fiberglass (Owens Corning Type AU 300)	114	2.0D (3)	SER Table 3-2
DP RMI	2.4	28.6D	SER Table 3-2
Min-K	2.4	28.6D	SER Table 3-2
Fire-Proof Tape	6	17D	SER Table 3-2
Electromark Labels	~ 21	9.9D (1)	Testing

(1) ZOI is based on destruction testing data and observations. This testing is discussed in the response to NRC Information Item 3.b.3.
(2) ZOI is based on ALION Analysis.
(3) See discussion following Table 3b1-6 of Reference 1.

I&M Response to Information Item 3.b.3

The information previously provided in References 1 and 2 is supplemented by the following information.

As discussed in the response to Information Items 3.b.1 and 3.b.2, the previously credited Wyle jet impingement testing for specific CNP materials was determined to be non-conservative. The minimum choke point diameter was determined to be 1.6131 in. The choke point was located 12.365 in upstream of nozzle face. As a result, the originally determined ZOIs were not used for the Marinite and fire barrier tape. New debris generation quantities were determined for these materials using a ZOI of 17D. Refer to the discussion in the response to Information Items 3.b.1 and 3.b.2 for the Electromark labels and Armaflex insulation.

I&M Response to Information Item 3.b.4

The information previously provided in Reference 1 is supplemented by the following information.

Tables 3a3-3 through 3a3-46 provide the debris generation quantities for all break locations except the pressurizer enclosure. The quantity of debris generated by a break in the pressurizer enclosure is provided in Attachment 3 response to RAI 25.b).

As can be seen in Tables 3a3-3 through 3a3-46 in this attachment, the quantity of Cal-Sil debris generated is significantly lower than reported in the equivalent tables in Reference 1. There are two factors that contributed to this reduction. The first was that the original debris generation analysis did not completely account for the as-installed Cal-Sil insulation configuration that was documented during containment walkdowns performed in the 2005 to 2007 time frame. The second contributor was the methodology that was used for the most recent debris generation analysis to determine the quantity of Cal-Sil insulated lines affected by a pipe break. In the original debris generation analysis, an Excel pivot table was used to determine the piping that could be within a potential ZOI based on an Excel spreadsheet that identified the insulated piping systems. This methodology was such that the predicted debris quantity was based on the amount of insulation installed on the entire segment of piping even if only a portion of the segment fell within the ZOI. The current methodology uses the CAD model to determine the piping or portions thereof that are with the ZOI, and then calculate the debris quantity resulting from only the portion within the ZOI.

Since the majority of Cal-Sil insulation exists within the Loop 1 or Loop 4 regions in the loop compartment, the CAD model was used to determine the quantity of Cal-Sil debris generated within those break locations. The Excel pivot table method was used for breaks in the Loops 2 and 3 regions.

The limiting break location for the DEGB is Unit 1 Loop 4. The limiting break for the DGBS is Unit 2 Loop 4.

I&M Response to Information Item 3.b.5

The information provided in Table 3b5-1 of Reference 2 remains applicable with the exception of the small and large pieces of fire barrier tape, and submerged Electromark labels. Table 3b5-1 provides the updated information for these materials and supersedes Table 3b5-1 of Reference 2.

Table 3b5-1 Bounding Quantity of Debris Available to Transport That Can Reduce Effective Strainer Area

Debris Type	Upper Containment	Loop Compartment	Pipe Annulus	Ice Condenser
Submerged Electromark Labels below Elevation 614 ft, ft^2	-	4.58	15.24	-
Unqualified Labels, ft^2 (bounding value)	8.77	13.62	3.55	-
Fire Barrier Tape Small Pieces (< 4 in), ft^2	-	105.3	-	-
Fire Barrier Tape Large Pieces (≥ 4 in), ft^2	-	28.1	-	-
Flexible Conduit PVC Jacketing, ft^2	-	1.57	-	-
Ice Storage Bag Liner Shards, ft^2	-	-	-	0.87
Pieces of Work Platform Rubber, ft^2	-	-	-	0.22
Total, ft^2	**8.77**	**153.17**	**18.79**	**1.09**

NRC Information Item 3.c - Debris Characteristics

The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its contribution to head loss.

1. *Provide the assumed size distribution for each type of debris.*
2. *Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.*
3. *Provide assumed specific surface areas for fibrous and particulate debris.*
4. *Provide the technical basis for any debris characterization assumptions that deviate from NRC-approved guidance.*

I&M Response to NRC Information Item 3.c.

The information provided in the Reference 1 response to Information Item 3.c remains applicable with the exception of the assumed ZOI for Marinite as given in Table 3c1-2.

Table 3c1-2 Marinite Size Distribution

Size	17D ZOI
Fines (Particulate)	1.3%
Small Pieces (<1/2 in to <2 in)	0.5%
Large Pieces (2 in to >4 in)	2.7%
Remains on Target	95.5%

NRC Information Item 3.d - Latent Debris

The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris existing within the containment and its potential impact on sump screen head loss.

1. *Provide the methodology used to estimate quantity and composition of latent debris.*
2. *Provide the basis for assumptions used in the evaluation.*
3. *Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under c. above.*
4. *Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.*

I&M Response to Information Items 3.d.1, 3.d.2, and 3.d.3

The information provided in the Reference 1 response to Information Items 3.d.1, 3.d.2, and 3.d.3 remains applicable.

I&M Response to Information Item 3.d.4

The information provided for Information Item 3.d.4 in Reference 2 has been updated to reflect unit specific values for debris sources that could potentially be transported to and block the main and remote strainers. The concept of bounding debris quantities, as presented in Tables 3d4-1 and 3d4-2 of Reference 1 is no longer being used. Actual debris quantities, as presented in Tables 3d4-3 through 3d4-6, have been updated to reflect the additional fire barrier tape quantities based on the increased ZOI.

I&M has conservatively assigned 76 ft^2 of the available surface area of the main strainer (900 ft^2 total available) and 83 ft^2 of the available surface area of the remote strainer (1072 ft^2 total available) for miscellaneous latent debris in containment. These sacrificial strainer areas were based on the area that was assumed to be blocked for large scale strainer testing (50 ft^2 for the main, and 72 ft^2 for the remote) as described in the response to Information Item 3.f.4 in this attachment. Also contained in the response to Information Item 3.f.4 is the discussion of the additional sacrificial strainer area that was actually used during large scale testing due to the impracticality of testing with a portion of a pocket obstructed. This resulted in an additional sacrificial strainer area of 26 ft^2 for the main strainer and 11 ft^2 for the remote strainer. Refer to

Tables 3d4-3 through 3d4-6 below for unit specific debris quantities expected to arrive at the main and remote strainers for both the DEGB and the DGBS.

Tables 3d4-3 and 3d4-4 below provide the calculated quantities of debris for Unit 2 for the DEGB and the DGBS that were considered for strainer sacrificial area, before applying the provisions of Section 3.5.2.2.2 of the SER. With the debris transport fractions from Tables 3d4-3 and 3d4-4 applied to the Unit 2 calculated quantity of debris, a quantity of material equivalent to 29.12 ft^2 is available for potential blockage of the main strainer, and a quantity of material equivalent to 32.41 ft^2 is available for potential blockage of the remote strainer. Using the provisions of Section 3.5.2.2.2 of the SER, the assumed effective Unit 2 strainer area blocked is (0.75)(29.12 ft^2) = 21.84 ft^2 for the main strainer, and (0.75)(32.41 ft^2) = 24.31 ft^2 for the remote strainer. This provides a margin of 54.16 ft^2 for the main strainer and 58.69 ft^2 for the remote strainer.

Table 3d4-3 Unit 2 Debris at Main Strainer for Sacrificial Strainer Area Consideration for DEGB and DGBS

Debris Type	Debris Generated	Transport Fraction	Debris at Strainer
Electromark Labels (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Labels (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels (all of containment), ft^2	9.58	0.86	8.24
Fire Barrier Tape Small Pieces (< 4 in), ft^2	28.1	0.13	3.653
Fire Barrier Tape Large Pieces (≥ 4 in), ft^2	105.3	0.13	13.689
Flexible Conduit PVC Jacketing, ft^2	1.57	1	1.57
Ice Storage Bag Liner Shards, ft^2	0.87	0.63	0.548
Pieces of Work Platform Rubber, ft^2	0.22	0.63	0.139
Total, ft^2	**185.94**	-	**29.12**

Table 3d4-4 Unit 2 Debris at Remote Strainer for Sacrificial Strainer Area Consideration for DEGB and DGBS

Debris Type	Debris Generated	Transport Fraction	Debris at Strainer
Electromark Labels (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Labels (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels (all of containment), ft^2	9.58	0.4	3.83
Fire Barrier Tape Small Pieces (< 4 in), ft^2	28.1	0	0
Fire Barrier Tape Large Pieces (≥ 4 in), ft^2	105.3	0	0
Flexible Conduit PVC Jacketing, ft^2	1.57	0.3	0.471
Ice Storage Bag Liner Shards, ft^2	0.87	0.42	0.365
Pieces of Work Platform Rubber, ft^2	0.22	0.42	0.092
Total, ft^2	**185.94**	-	**32.41**

Tables 3d4-5 and 3d4-6 below provide the calculated quantities of debris for Unit 1 for the DEGB and DGBS that are considered for strainer sacrificial area, before applying the provisions of Section 3.5.2.2.2 of the SER. With the debris transport fractions from Tables 3d4-5 and 3d4-6 applied to the calculated Unit 1 debris quantity, 18.95 ft^2 of material is available for potential blockage of the main strainer, and 33.50 ft^2 of material is available for potential blockage of the remote strainer. Using the provisions of Section 3.5.2.2.2 of the SER, the assumed effective Unit 1 strainer area blocked is (0.75)(18.95 ft^2) = 14.21 ft^2 for the main strainer, and (0.75)(33.50 ft^2) = 25.13 ft^2 for the remote strainer. This provides a margin of 61.79 ft^2 for the main strainer and 57.87 ft^2 for the remote strainer.

Table 3d4-5 Unit 1 Debris at Main Strainer for Sacrificial Strainer Area Consideration for DEGB and DGBS

Debris Type	Debris Generated	Transport Fraction	Debris at Strainer
Electromark Labels (inside ZOI), ft^2	0.7	0.13	0.091
Electromark Labels (outside ZOI), ft^2	39.6	0.03	1.188
Unqualified Labels (all of containment), ft^2	12.31	0.86	10.59
Fire Barrier Tape Small Pieces (< 4 in), ft^2	7.8	0.13	1.014
Fire Barrier Tape Large Pieces (≥ 4 in), ft^2	29.3	0.13	3.809
Flexible Conduit PVC Jacketing, ft^2	1.57	1	1.57
Ice Storage Bag Liner Shards, ft^2	0.87	0.63	0.548
Pieces of Work Platform Rubber, ft^2	0.22	0.63	0.139
Total, ft^2	**92.37**	-	**18.95**

Table 3d4-6 Unit 1 Debris at Remote Strainer for Sacrificial Strainer Area Consideration for DEGB and DGBS

Debris Type	Debris Generated	Transport Fraction	Debris at Strainer
Electromark Labels (inside ZOI), ft^2	0.7	0.47	0.329
Electromark Labels (outside ZOI), ft^2	39.6	0.69	27.324
Unqualified Labels (all of containment), ft^2	12.31	0.4	4.92
Fire Barrier Tape Small Pieces (< 4 in), ft^2	7.8	0	0
Fire Barrier Tape Large Pieces (≥ 4 in), ft^2	29.3	0	0
Flexible Conduit PVC Jacketing, ft^2	1.57	0.3	0.471
Ice Storage Bag Liner Shards, ft^2	0.87	0.42	0.365
Pieces of Work Platform Rubber, ft^2	0.22	0.42	0.092
Total, ft^2	**92.37**	-	**33.50**

NRC Information Item 3.e – Debris Transport

The objective of the debris transport evaluation process is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

1. *Describe the methodology used to analyze debris transport during the blowdown, washdown, pool-fill-up, and recirculation phases of an accident.*
2. *Provide the technical basis for assumptions and methods used in the analysis that deviate from the approved guidance.*
3. *Identify any computational fluid dynamics codes used to compute debris transport fractions during recirculation and summarize the methodology, modeling assumptions, and results.*
4. *Provide a summary of, and supporting basis for, any credit taken for debris interceptors [DIs].*
5. *State whether fine debris was assumed to settle and provide basis for any settling credited.*
6. *Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the strainers.*

I&M Response to Information Item 3.e

The information provided in the Reference 1 response to Information Items 3.e.1 through 3.e.5 remains applicable.

The information provided in the Reference 1 response to Information Item 3.e.6 remains applicable with the exception of the total quantities of debris transported to the strainers as shown in Tables 3e6-5 through 3e6-10, which are provided below. For Tables 3e6-7 and 3e6-10, the right end column is the actual debris that would reach the remote strainer. This value represents a total available quantity of debris such that the total transport factor to all strainers does not exceed 100%.

Table 3e6-5 Debris Transported to Main Strainer During Pool Fill for Unit 1 Loop 4 DEGB

Debris Type	Debris Generated	Debris at Strainer
RMI Small Pieces, ft^2	70105	6309.45
RMI Large Pieces, ft^2	23368	1168.4
Cal-Sil Fines, lbs	40.7	13.024
Erosion of Cal-Sil Small Pieces to Fines, lbs	26.5	0
Cal-Sil Small Pieces, lbs	26.5	1.325
Marinite I Fines, lbs	0	0
Erosion of Marinite I Small Pieces to Fines, lbs	0	0
Marinite I Small Pieces, lbs	0	0
Erosion of Marinite I Large Pieces to Fines, lbs	0	0
Marinite I Large Pieces, lbs	0	0
Marinite 36 Fines, lbs	1.5	0.48
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.6	0
Marinite 36 Small Pieces, lbs	0.6	0.03
Erosion of Marinite 36 Large Pieces to Fines, lbs	3.1	0
Marinite 36 Large Pieces, lbs	3.1	0.124
Min-K, lbs	1.6	0.512
Epoxy Paint (inside ZOI), lbs	216	69.12
Alkyd Paint (inside ZOI), lbs	1.9	0.608
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0
Dirt and dust, lbs	170	40.8
Latent Fiber, ft^3	12.5	3.00
Fire Barrier Tape Fines, lbs	3.3	1.056
Fire Barrier Tape Small Pieces, ft^2	7.8	0.702
Fire Barrier Tape Large Pieces, ft^2	29.3	2.637
Ice Storage Bag Fibers, ft^3	0.026	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.063
Electromark Label (outside ZOI), ft^2	39.6	0
Unqualified Labels – Paper, ft^2	0.28	0
Unqualified Labels – Other, ft^2	25.66	0
Flex Conduit PVC Jacketing, ft^2	1.57	0

Table 3e6-6 Total Debris Transported to Main Strainer During Pool Fill & Recirculation for Unit 1 Loop 4 DEGB

Debris Type	Debris Generated	Debris at Strainer
RMI Small Pieces, ft^2	70105	9113.65
RMI Large Pieces, ft^2	23368	1869.44
Cal-Sil Fines, lbs	40.7	17.908
Erosion of Cal-Sil Small Pieces to Fines, lbs	26.5	2.65
Cal-Sil Small Pieces, lbs	26.5	2.65
Marinite I Fines, lbs	0	0
Erosion of Marinite I Small Pieces to Fines, lbs	0	0
Marinite I Small Pieces, lbs	0	0
Erosion of Marinite I Large Pieces to Fines, lbs	0	0
Marinite I Large Pieces, lbs	0	0
Marinite 36 Fines, lbs	1.5	0.66
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.6	0.06
Marinite 36 Small Pieces, lbs	0.6	0.06
Erosion of Marinite 36 Large Pieces to Fines, lbs	3.1	0.434
Marinite 36 Large Pieces, lbs	3.1	0.217
Min-K, lbs	1.6	0.704
Epoxy Paint (inside ZOI), lbs	216	95.04
Alkyd Paint (inside ZOI), lbs	1.9	0.836
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	361.5375
Dirt and dust, lbs	170	88.4
Latent Fiber, ft^3	12.5	6.5
Fire Barrier Tape Fines, lbs	3.3	1.452
Fire Barrier Tape Small Pieces, ft^2	7.8	1.014
Fire Barrier Tape Large Pieces, ft^2	29.3	3.809
Ice Storage Bag Fibers, ft^3	0.026	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.091
Electromark Label (outside ZOI), ft^2	39.6	1.188
Unqualified Labels – Paper, ft^2	0.28	0.2408
Unqualified Labels – Other, ft^2	25.66	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1.57

Table 3e6-7 Total Debris Transported to Remote Strainer for Unit 1 Loop 4 DEGB

Debris Type	Debris Generated	Amount Available to Transport	Predicted Debris at Strainer	Actual Debris at Strainer
RMI Small Pieces, ft^2	70105	60991.35	0	0
RMI Large Pieces, ft^2	23368	21498.56	0	0
Cal-Sil Fines, lbs	40.7	19.536[(1)]	21.164[(1)]	19.536
Erosion of Cal-Sil Small Pieces to Fines, lbs	26.5	23.85	2.12	2.12
Cal-Sil Small Pieces, lbs	26.5	23.85	0	0
Marinite I Fines, lbs	0	0	0	0
Erosion of Marinite I Small Pieces to Fines, lbs	0	0	0	0
Marinite I Small Pieces, lbs	0	0	0	0
Erosion of Marinite I Large Pieces to Fines, lbs	0	0	0	0
Marinite I Large Pieces, lbs	0	0	0	0
Marinite 36 Fines, lbs	1.5	0.84	0.78	0.78
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.6	0.54	0.048	0.048
Marinite 36 Small Pieces, lbs	0.6	0.54	0	0
Erosion of Marinite 36 Large Pieces to Fines, lbs	3.1	2.666	0.186	0.186
Marinite 36 Large Pieces, lbs	3.1	2.883	0	0
Min-K, lbs	1.6	0.896	0.832	0.832
Epoxy Paint (inside ZOI), lbs	216	120.96	112.32	112.32
Alkyd Paint (inside ZOI), lbs	1.9	1.064	0.988	0.988
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	10.14	12.168	10.14
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	63.984	66.96	63.984
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	14.88	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	1.428	2.006	1.428
Unqualified Cold Galvanizing Compound, lbs	388.75	27.2125	136.0625	27.2125
Dirt and dust, lbs	170	81.6	95.2	81.6
Latent Fiber, ft^3	12.5	6	7	6
Fire Barrier Tape Fines, ft^2	3.3	1.848	1.716	1.716
Fire Barrier Tape Small Pieces, ft^2	7.8	6.786	0	0
Fire Barrier Tape Large Pieces, ft^2	29.3	25.491	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.00962	0.01092	0.00962
Ice Storage Bag Liner Shards, ft^3	0.00022	0.0000814	0.0000924	0.0000814
Pieces of Work Platform Rubber, ft^3	0.002	0.00074	0.00084	0.00074
Electromark Label (inside ZOI), ft^2	0.7	0.609	0.329	0.329
Electromark Label (outside ZOI), ft^2	39.6	38.412	27.324	27.324
Unqualified Labels – Paper, ft^2	0.28	0.0392	0.112	0.0392
Unqualified Labels – Other, ft^2	25.66	3.5924	10.264	3.5924
Flex Conduit PVC Jacketing, ft^2	1.57	0	0.471	0

(1) 8% of Cal-Sil fines transport to the reactor cavity (inactive volume) and are subtracted from the debris generated value prior to determining the amount available to transport.

Table 3e6-8 Debris Transported to Main Strainer During Pool Fill for Unit 2 Loop 4 DGBS

Debris Type	Debris Generated	Debris at Strainer
RMI Small Pieces, ft^2	36510	3285.9
RMI Large Pieces, ft^2	12170	608.5
Cal-Sil Fines, lbs	14.2	4.544
Erosion of Cal-Sil Small Pieces to Fines, lbs	9.3	0
Cal-Sil Small Pieces, lbs	9.3	0.465
Marinite I Fines, lbs	0.9	0.288
Erosion of Marinite I Small Pieces to Fines, lbs	0.3	0
Marinite I Small Pieces, lbs	0.3	0.015
Erosion of Marinite I Large Pieces to Fines, lbs	1.8	0
Marinite I Large Pieces, lbs	1.8	0.072
Marinite 36 Fines, lbs	2	0.64
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.8	0
Marinite 36 Small Pieces, lbs	0.8	0.04
Erosion of Marinite 36 Large Pieces to Fines, lbs	4.2	0
Marinite 36 Large Pieces, lbs	4.2	0.168
Min-K, lbs	0	0
Epoxy Paint (inside ZOI), lbs	2.7	0.864
Alkyd Paint (inside ZOI), lbs	0.2	0.064
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	0
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	0
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	0
Unqualified Cold Galvanizing Compound, lbs	388.75	0
Dirt and dust, lbs	170	40.8
Latent Fiber, ft^3	12.5	3
Fire Barrier Tape Fines, lbs	10.4	3.328
Fire Barrier Tape Small Pieces, ft^2	24.4	2.196
Fire Barrier Tape Large Pieces, ft^2	91.5	8.235
Ice Storage Bag Fibers, ft^3	0.026	0.0117
Ice Storage Bag Liner Shards, ft^3	0.00022	0.000099
Pieces of Work Platform Rubber, ft^3	0.002	0.0009
Electromark Label (inside ZOI), ft^2	0.7	0.063
Electromark Label (outside ZOI), ft^2	39.6	0
Unqualified Labels – Paper, ft^2	0.28	0
Unqualified Labels – Other, ft^2	25.66	0
Flex Conduit PVC Jacketing, ft^2	1.57	0

Table 3e6-9 Total Debris Transported to Main Strainer During Pool Fill & Recirculation for Unit 2 Loop 4 DGBS

Debris Type	Debris Generated	Debris at Sump
RMI Small Pieces, ft^2	36510	4746.3
RMI Large Pieces, ft^2	12170	973.6
Cal-Sil Fines, lbs	14.2	6.248
Erosion of Cal-Sil Small Pieces to Fines, lbs	9.3	0.93
Cal-Sil Small Pieces, lbs	9.3	0.93
Marinite I Fines, lbs	0.9	0.396
Erosion of Marinite I Small Pieces to Fines, lbs	0.3	0.03
Marinite I Small Pieces, lbs	0.3	0.03
Erosion of Marinite I Large Pieces to Fines, lbs	1.8	0.252
Marinite I Large Pieces, lbs	1.8	0.126
Marinite 36 Fines, lbs	2	0.88
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.8	0.08
Marinite 36 Small Pieces, lbs	0.8	0.08
Erosion of Marinite 36 Large Pieces to Fines, lbs	4.2	0.588
Marinite 36 Large Pieces, lbs	4.2	0.294
Min-K, lbs	0	0
Epoxy Paint (inside ZOI), lbs	2.7	1.188
Alkyd Paint (inside ZOI), lbs	0.2	0.088
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	6.76
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	10.416
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	16.12
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	1.972
Unqualified Cold Galvanizing Compound, lbs	388.75	361.5375
Dirt and dust, lbs	170	88.4
Latent Fiber, ft^3	12.5	6.5
Fire Barrier Tape Fines, lbs	10.4	4.576
Fire Barrier Tape Small Pieces, ft^2	24.4	3.172
Fire Barrier Tape Large Pieces, ft^2	91.5	11.895
Ice Storage Bag Fibers, ft^3	0.026	0.01638
Ice Storage Bag Liner Shards, ft^3	0.00022	0.0001386
Pieces of Work Platform Rubber, ft^3	0.002	0.00126
Electromark Label (inside ZOI), ft^2	0.7	0.091
Electromark Label (outside ZOI), ft^2	39.6	1.188
Unqualified Labels – Paper, ft^2	0.28	0.2408
Unqualified Labels – Other, ft^2	25.66	22.0676
Flex Conduit PVC Jacketing, ft^2	1.57	1.57

Table 3e6-10 Total Debris Transported to Remote Strainer for Unit 2 Loop 4 DGBS

Debris Type	Debris Generated	Amount Available to Transport	Predicted Debris at Strainer	Actual Debris at Strainer
RMI Small Pieces, ft^2	59564	51820.68	0	0
RMI Large Pieces, ft^2	19855	18266.6	0	0
Cal-Sil Fines, lbs	14.2	6.816(1)	7.384(1)	6.816
Erosion of Cal-Sil Small Pieces to Fines, lbs	9.3	8.37	0.744	0.744
Cal-Sil Small Pieces, lbs	9.3	8.37	0	0
Marinite I Fines, lbs	0.9	0.504	0.468	0.468
Erosion of Marinite I Small Pieces to Fines, lbs	0.3	0.27	0.024	0.024
Marinite I Small Pieces, lbs	0.3	0.27	0	0
Erosion of Marinite I Large Pieces to Fines, lbs	1.8	1.548	0.108	0.108
Marinite I Large Pieces, lbs	1.8	1.674	0	0
Marinite 36 Fines, lbs	2	1.12	1.04	1.04
Erosion of Marinite 36 Small Pieces to Fines, lbs	0.8	0.72	0.064	0.064
Marinite 36 Small Pieces, lbs	0.8	0.72	0	0
Erosion of Marinite 36 Large Pieces to Fines, lbs	4.2	3.612	0.252	0.252
Marinite 36 Large Pieces, lbs	4.2	3.906	0	0
Min-K, lbs	0	0	0	0
Epoxy Paint (inside ZOI), lbs	2.7	1.512	1.404	1.404
Alkyd Paint (inside ZOI), lbs	0.2	0.112	0.104	0.104
Unqualified OEM Epoxy (outside ZOI), lbs	16.9	10.14	12.168	10.14
Unqualified OEM Alkyd (outside ZOI), lbs	74.4	63.984	66.96	63.984
Unqualified Non-OEM Epoxy (outside ZOI), lbs	31	14.88	0	0
Unqualified Non-OEM Alkyd (outside ZOI), lbs	3.4	1.428	2.006	1.428
Unqualified Cold Galvanizing Compound, lbs	388.75	27.2125	136.0625	27.2125
Dirt and dust, lbs	170	81.6	95.2	81.6
Latent Fiber, ft^3	12.5	6	7	6
Fire Barrier Tape Fines, lbs	10.4	5.824	5.408	5.408
Fire Barrier Tape Small Pieces, ft^2	24.4	21.228	0	0
Fire Barrier Tape Large Pieces, ft^2	91.5	79.605	0	0
Ice Storage Bag Fibers, ft^3	0.026	0.00962	0.01092	0.00962
Ice Storage Bag Liner Shards, ft^3	0.00022	0.0000814	0.0000924	0.0000814
Pieces of Work Platform Rubber, ft^3	0.002	0.00074	0.00084	0.00074
Electromark Label (inside ZOI), ft^2	0.7	0.609	0.329	0.329
Electromark Label (outside ZOI), ft^2	39.6	38.412	27.324	27.324
Unqualified Labels – Paper, ft^2	0.28	0.0392	0.112	0.0392
Unqualified Labels – Other, ft^2	25.66	3.5924	10.264	3.5924
Flex Conduit PVC Jacketing, ft^2	1.57	0	0.471	0

(1) 8% of Cal-Sil fines transport to the reactor cavity (inactive volume) and are subtracted from the debris generated value prior to determining the amount available to transport.

NRC Information Item 3.f – Head Loss and Vortexing

The objectives of the head loss and vortexing evaluations are to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

1. *Provide a schematic diagram of the emergency core cooling system (ECCS) and containment spray systems (CSS).*
2. *Provide the minimum submergence of the strainer under small-break loss-of-coolant accident (SBLOCA) and large-break loss-of-coolant accident (LBLOCA) conditions.*
3. *Provide a summary of the methodology, assumptions and results of the vortexing evaluation. Provide bases for key assumptions.*
4. *Provide a summary of the methodology, assumptions, and results of prototypical head loss testing for the strainer, including chemical effects. Provide bases for key assumptions.*
5. *Address the ability of the design to accommodate the maximum volume of debris that is predicted to arrive at the screen.*
6. *Address the ability of the screen to resist the formation of a "thin bed" or to accommodate partial thin bed formation.*
7. *Provide the basis for the strainer design maximum head loss.*
8. *Describe significant margins and conservatisms used in the head loss and vortexing calculations.*
9. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.*
10. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis.*
11. *State whether the sump is partially submerged or vented (i.e., lacks a complete water seal over its entire surface) for any accident scenarios and describe what failure criteria in addition to loss of net positive suction head (NPSH) margin were applied to address potential inability to pass the required flow through the strainer.*
12. *State whether near-field settling was credited for the head-loss testing and, if so, provide a description of the scaling analysis used to justify near-field credit.*
13. *State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.*
14. *State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.*

I&M Response to Information Items 3.f.1 through 3.f.3, 3.f.5 through 3.f.8, and 3.f.11 through 3.f.14

The information provided in the Reference 1 response to Information Item 3.f remains applicable for these information items.

I&M Response to Information Item 3.f.4

Revisions to the sections titled "Head Loss Testing" (starting on page 197 of Attachment 3 to Reference 1) and "Strainer head Loss Conclusion" (starting on page 206 of Attachment 3 to Reference 1) are provided below. All figures and tables referenced in the revised sections below that are not located within the revised sections are located in the Reference 1 Attachment 3 response to Information Item 3.f. The revised sections include the supplemental information provided by Reference 2.

Head Loss Testing

Debris-only strainer head loss testing was performed on the large scale test loop for both DEGB and DGBS scenarios. The tests that were performed were 1) the "standard" head loss test consisting of stepped flow rates and stepped homogeneous debris additions, 2) debris sequence tests, and 3) event sequence tests. The details associated with each test are provided below.

DEGB Head Loss Test

The DEGB head loss test steps, with the data recorded at the designated points are provided in Figure 3f4-21, below.

Figure 3f4-21 DEGB 100% Flow 100% Debris Extended Duration Head Loss Test with Flow Reduction and Flow Restart to 120% Flow 120% Debris

Test step #	Time [hh:mm]	Fluid temperature [°C]	Δp U-tube [cmH_2O]	Δp [mbar]	Flow rate [m^3/h]	Remarks
0	09:18	16.66	0.1	0.0615	48	60% flow rate
1	12:29	17.14	5.6	5.716	48	60% flow rate, 60% debris
2	14:15	17.44	14.3	14.33	64	80% flow rate, 80% debris
09/04/07						
3*	***16:37***	***21.96***	***23.6***	***22.98***	***80***	***100% flow rate, 100% debris***
4	18:19	21.94	14.6	14.44	61.1	76.4% flow rate, 100% debris
5	19:31	21.84	7.9	7.95	42.2	52.8% flow rate, 100% debris
6	20:01	21.78	2.2	2.11	21.1	26.4% flow rate, 100% debris
						Pump stop; restart
7	20:18	21.76	0.3	0.14	21.1	26.4% flow rate, 100% debris
8	21:05	21.66	0.6	0.60	40	50% flow rate, 100% debris
09/05/07						
9*	***00:09***	***22.08***	***13.5***	***13.494***	***80***	***100 % flow rate, 100% debris***
10	02:10	22.36	39.7	38.856	96	120% flow rate, 120% debris

The annotation of Test Steps 3 and 9 with an * indicates that flow propeller measurements were taken during these steps as indicated in Figure 3f4-22.

As discussed in the response to Information Item 3.f.1 in Reference 1, debris additions occurred to the respective side of the test strainer at the designated points in the test. The debris was added directly in front of the strainer pockets to minimize any settling of the debris. No credit was taken for any near-field settling of material in this or any of the tests performed. The data that was recorded at each of the test steps was obtained at the condition described in the "Remarks" column. The test steps are described below.

Test Step 0: Flow was established at 60%.

Test Step1: 60% of the debris was added to the main and remote strainer sides, then head loss was allowed to stabilize.

Test Step 2: 20% of the debris quantities were added to the respective side of the test strainer, i.e., the total debris was now 80%. Head loss was allowed to become reasonably stable. At that time, flow was increased to the 80% point. Head loss was monitored until it was again reasonably stable.

Test Step 3: Another 20% debris addition was made, and head loss was monitored until it became reasonably stable. Flow was then increased to 100%. The objective of this part of test, and the subsequent DGBS test, was to determine if head loss would continue to increase over an extended time. The tests were to maintain flow for a minimum of 24 hours following achieving a 100% flow, 100% debris condition. After the 24 hour time, head loss was checked to determine if it was stable, i.e., less than 1% increase in two consecutive 30 minute periods. Once stable head loss was achieved, flow propeller measurements were taken to provide an approximate flow distribution between the main and remote strainers. This information was used as one of the inputs to establish an overall system head loss since the waterway connecting the remote strainer to the recirculation sump could not be tested in the test loop. After the propeller measurements were obtained, the testing proceeded into a flow reduction sequence. Since I&M is utilizing the GR and SER Chapter 6 approach for the DEGB, test data to determine the CNP-specific debris mixture response to a flow reduction sequence was an important input to the effectiveness of reducing flow and its result on head loss across the strainer.

Test Step 4: The flow reduction sequence consisted of first reducing flow equivalent to removing one CTS pump from operation. Head loss was allowed to become reasonably stable between each of the flow reduction steps.

Test Step 5: The second flow reduction step was to reduce flow equivalent to removing another CTS pump.

Test Step 6: The third flow reduction step was to reduce flow equivalent to removing an RHR pump.

Test Step 7: The final flow reduction step was to reduce flow to zero (equivalent to stopping the last running pump), and then restarting flow equivalent to an RHR pump within about a minute to a minute and a half. The purpose of this step was to determine if a limited hydraulic backflush would occur. Note that I&M is not crediting stopping all pumps to mitigate a high head loss condition at the recirculation sump within design basis response to an event. This action would be solely a "beyond design basis" action.

Test Step 8: Once flow was re-established equivalent to restarting an RHR pump, it was incrementally increased equivalent to restarting a CTS pump.

Test Step 9: The flow was increased equivalent to starting a second RHR and CTS pumps at the same time. Head loss was allowed to become reasonably stable between the incremental changes in flow.

Test Step 10: After a stable head loss at 100% flow was achieved, the debris quantity was increased to 120% of the calculated debris quantity, followed by an increase in flow to the 120% value.

The step results of this sequence are provided in Figure 3f4-21 above for the DEGB. Based on the testing, it was determined that a flow reduction sequence would be effective in reducing the head loss across the recirculation sump strainers. Based on the reduction in head loss observed during the testing, it is not anticipated that removal of more than one pump would be required to return head loss to an acceptable value.

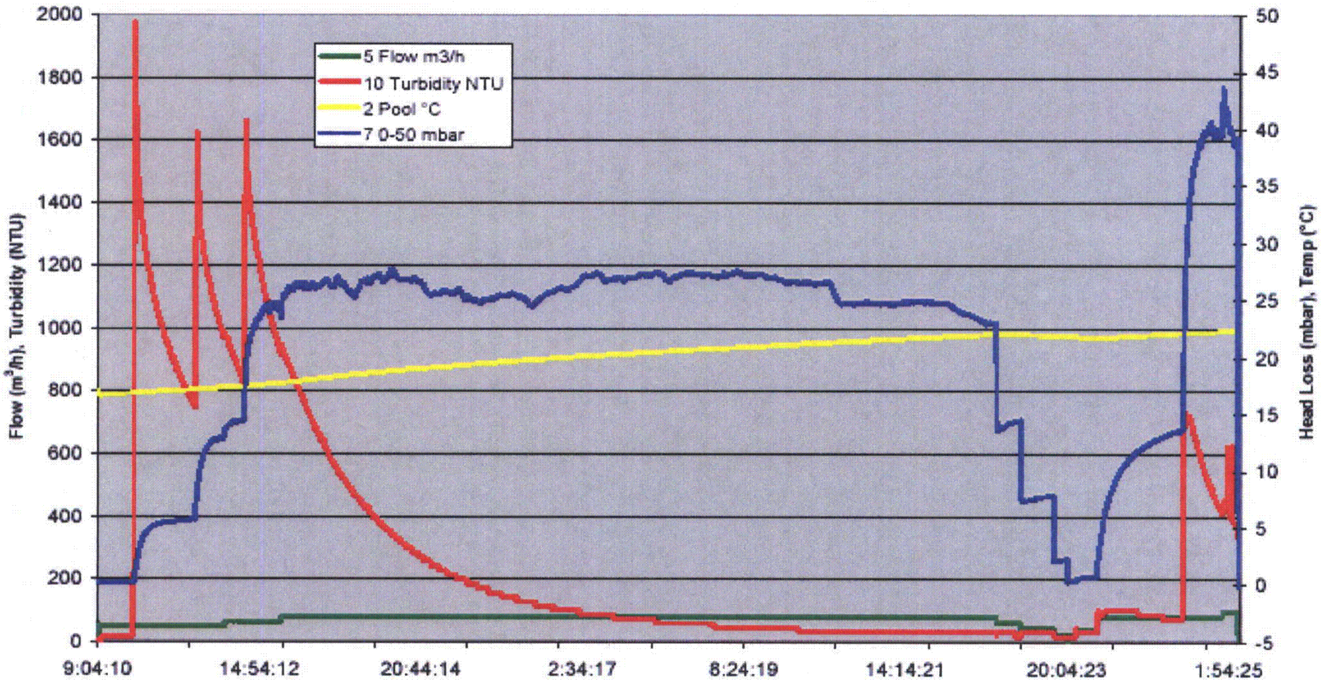
Figure 3f4-22, below, provides the flow propeller measurements taken at Test Steps 3 and 9. At each of the required test points, two data points were taken at each of the flow holes. Refer to Figure 3f4-2 for the location of the measuring points.

Figure 3f4-22 Flow Propeller Measurements for the DEGB Test

(*) Flow measurement	Window 1 [rpm]	Window 2 [rpm]	Window 3 [rpm]	Window 4 [rpm]	Window 5 [rpm]	Window 6 [rpm]
TS 3: 1	401	433	389	271	270	237
TS 3: 2	426	462	401	270	236	245
TS9: 1	605	539	585	120	47	52
TS9: 2	553	545	614	114	44	63

Figure 3f4-23, below, provides the graphical representation of the sequence described above for the DEGB scenario.

Figure 3f4-23 DEGB Test Plot



As can be seen from the test plot, the head loss during the extended time at 100% debris, 100% flow varied within about a 5 mbar range, but ultimately reached a very stable value. To provide for equivalent comparison of the head loss values obtained, the head loss values were normalized to 20°C. This temperature is below the temperature that would be expected in the containment recirculation sump pool, which provides conservative results. The highest head loss during that period was 11.106 in H_2O at approximately 16 hours after achieving the 100% debris, 100% flow condition. The head loss at the end of the 24-hour period was approximately 9.59 in H_2O and slowly decreasing.

DGBS Head Loss Test

The same test sequence was performed for the DGBS test as was described for the DEGB test. In the figures provided below, Figure 3f4-24 provides the DGBS test data points, Figure 3f4-25 provides the flow propeller measurement data, and Figure 3f4-26 provides the test plot.

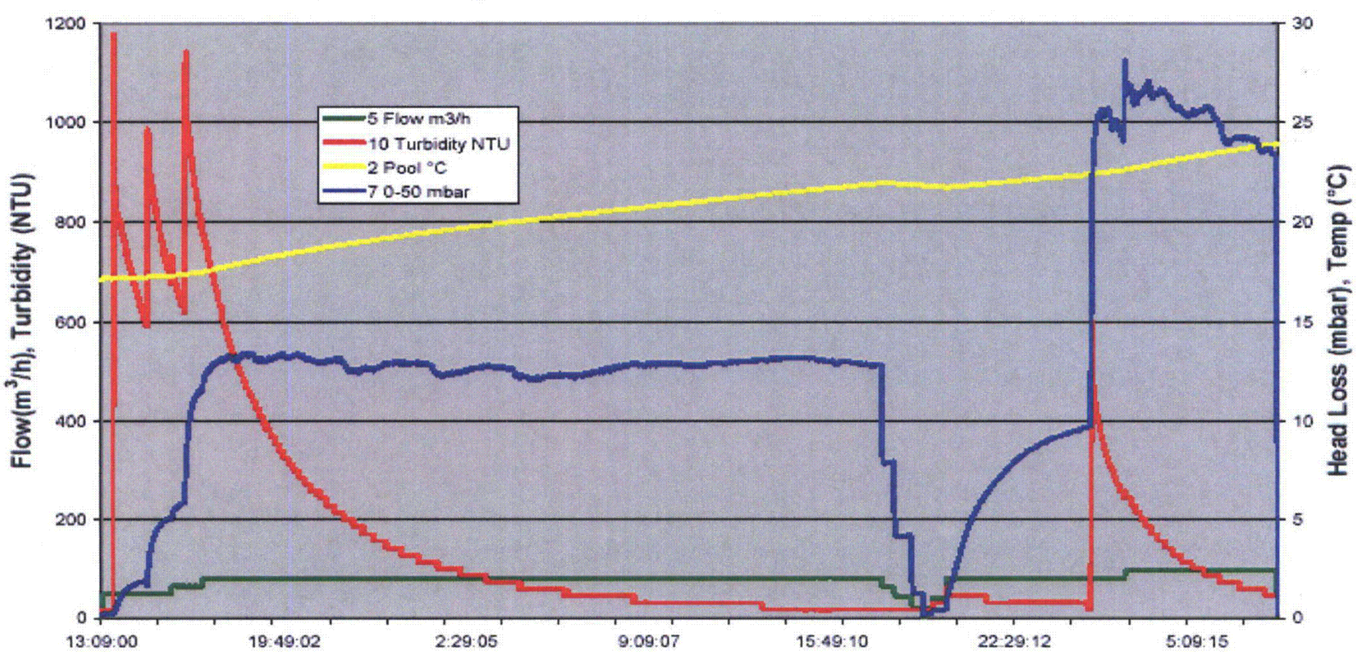
Figure 3f4-24 DGBS 100% Flow 100% Debris Extended Duration Head Loss Test with Flow Reduction and Flow Restart to 120% Flow 120% Debris

Test step #	Time [hh:mm]	Fluid temperature [°C]	Δp U-tube [cmH₂0]	Δp [mbar]	Flow rate [m³/h]	Remarks
1	14:44	17.18	1.7	1.764	48	60% flow rate, 60% debris
2	16:05	17.34	5.8	5.782	64	80% flow rate, 80% debris
3*	*17:26*	*21.86*	*13.0*	*12.825*	*80*	*100% flow rate, 100% debris*
08/28/07						
4	18:01	21.88	8.2	7.990	61.1	76.4% flow rate, 100% debris
5	18:38	21.84	4.3	4.164	42.2	52.8% flow rate, 100% debris
6	19:05	21.80	1.2	1.134	21.1	26.4% flow rate, 100% debris
						Pump stop; restart
7	19:25	21.74	0.2	0.12	21.1	26.4% flow rate, 100% debris
8	19:56	21.70	0.3	0.293	40	50% flow rate, 100% debris
08/29/07						
9*	*01:09*	*22.32*	*9.6*	*9.840*	*80*	*100 % flow rate, 100% debris*
10	08:02	23.86	24.5	23.450	96	120% flow rate, 120% debris

Figure 3f4-25 Flow Propeller Measurements for the DGBS Test

(*) Flow measurement	Window 1 [rpm]	Window 2 [rpm]	Window 3 [rpm]	Window 4 [rpm]	Window 5 [rpm]	Window 6 [rpm]
TS 3: 1	363	341	313	356	365	293
TS 3: 2	364	336	345	345	371	313
TS9: 1	410	414	379	268	275	235
TS9: 2	413	443	424	282	261	236

Figure 3f4-26 DGBS Test Plot



As can be seen from the test plot, the head loss during the extended time at 100% debris, 100% flow varied within an approximate 2 mbar range, and reached a stable value. The highest head loss during the 100% period was 5.35 in H_2O at approximately 23 hours after achieving the 100% debris, 100% flow condition. The head loss at the end of the 24 hour period was less than the maximum head loss and slowly decreasing. The head loss value provided is the 20°C normalized value.

DEGB Event Sequence Test

The steps of the test that were performed, with the data recorded from the test at the designated points are provided in Figure 3f4-27, below.

Figure 3f4-27 DEGB Event Sequence Test

Test step #	Time [hh:mm]	Fluid temperature [°C]	Δp U-tube [cmH₂0]	Δp [mbar]	Flow rate [m³/h]	Remarks
0	8:13	15.44	0.0	0.038	30.6	38.2% flow rate
1	8:51	15.46	0.2	0.213	30.6	38.2% flow rate, 30 min stabilization with pool fill debris to main strainer
2	9:11	15.50	0.4	0.567	39.4	49.3% flow rate, 15 min stabilization with "pool fill" debris to main strainer
3	9:23	15.54	3.0	3.081	40	50% flow rate, 5min stabilization removed blanking cover, 100% debris
	9:44					Adding of 3.84 kg Main and 1.52 kg Remote stone flour due to new "organic" Zinc density (250 lb/ft³)
4*	14:29	17.16	21.8	21.380	80	100% flow rate with 100% debris
5	16:08	17.54	26.2	25.581	80	100% flow rate, 100% debris + 25% increase of unqualified paint chips to main and remote strainer

The annotation of Test Step 4 with an * indicates that flow propeller measurements were taken during this step as indicated in Figure 3f4-28.

Test Step 0 An equivalent flow was established through the main strainer side of the test strainer (38.2%), with the remote strainer side blocked off, that was calculated in Reference 8 to exist during the pool fill period of an event.

Test Step 1 The quantities of debris that are assumed to be at the main strainer, as given in Table 3f4-4, were added to the main strainer side. This configuration was then maintained for 30 minutes to establish the debris bed.

Test Step 2: The flow rate was increased to 49.3% and allowed to stabilize approximately 15 minutes.

Test Step 3– After 30 minutes, the following steps were performed simultaneously.

- The flow rate was increased to 50% to represent the transfer of one RHR and one CTS pump to the recirculation alignment.

- The blanking cover was removed from the remote strainer side of the test strainer.
- Debris additions were made to both sides of the test strainer to bring the total debris quantity to 50%.

These conditions were maintained for approximately 5 minutes.

Test Step 4 Flow was increased to 100% and debris for both the main strainer and remote strainer sides were increased to 100% of the total recirculation flow quantities as given in Table 3f4-5. Head loss was then allowed to reach stable conditions of less than 1% increase in two consecutive 30 minute periods. After stable head loss conditions were reached, flow propeller measurements were obtained.

Test Step 5 An additional 25% of the total unqualified coatings, as chips, were added to the respective sides of the test strainer. The test was then allowed to run for approximately one and a half hours, at which time a reasonably stable head loss had been achieved.

The objective of this test, and the similar DGBS test, was to determine if the expected pre-loading of the main strainer during pool fill would result in head loss values significantly different than those determined during the stepped sequence debris and flow increases described previously in the response to this information item. The objective of adding the extra paint chips was to determine the impact on the strainer head loss of this magnitude increase in paint chips.

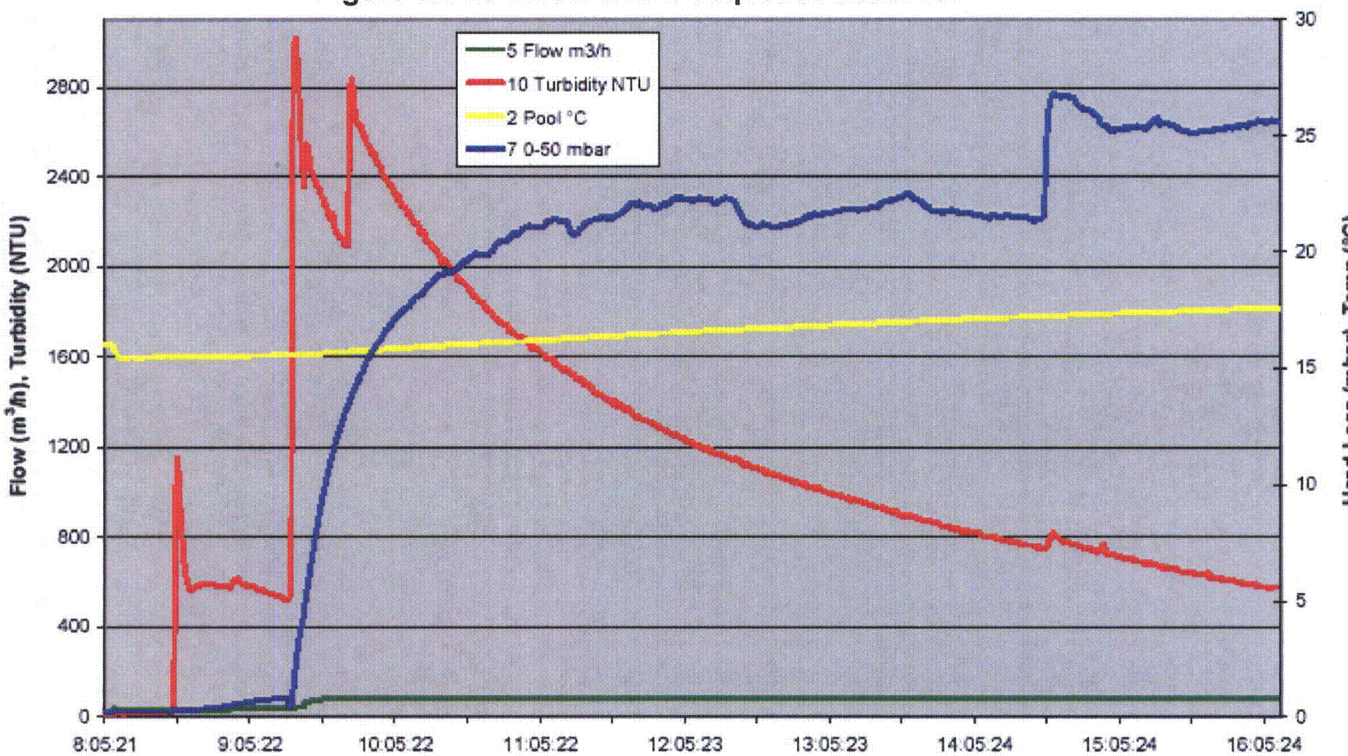
Figure 3f4-28, below, provides the flow propeller measurements taken at Test Step 4. Two data points were taken at each of the flow holes. Refer to Figure 3f4-2 for the location of the measuring points.

Figure 3f4-28 Flow Propeller Measurements for the DEGB Event Sequence Test

(*) Flow measurement	Window 1 [rpm]	Window 2 [rpm]	Window 3 [rpm]	Window 4 [rpm]	Window 5 [rpm]	Window 6 [rpm]
TS 4: 1	384	378	400	151	156	138
TS 4: 2	428	458	478	163	149	134

Figure 3f4-29, below, provides a graphical representation of the sequence described above for the DEGB event sequence scenario.

Figure 3f4-29 DEGB Event Sequence Test Plot



As can be seen from the test plot, the head loss slowly increased to a peak value over an approximate three hour period and then varied within an approximate 2 mbar range until head loss started to steadily decrease until the additional significant quantity of paint chips were added to the test loop. The highest head loss during the 100% period was 9.018 in H_2O at approximately four hours after initiation of the recirculation phase. The head loss at the end of the 100% test period was less than the maximum head loss and slowly decreasing. The head loss value provided is the 20°C normalized value.

DGBS Event Sequence Test

The same test sequence was performed for the DGBS event sequence test as was described for the DEGB test, except that the additional coatings chips were not added at the end of the test. Figure 3f4-30 below provides the DGBS event sequence test data points, Figure 3f4-31 provides the flow propeller measurement data, and Figure 3f4-32 provides the test plot.

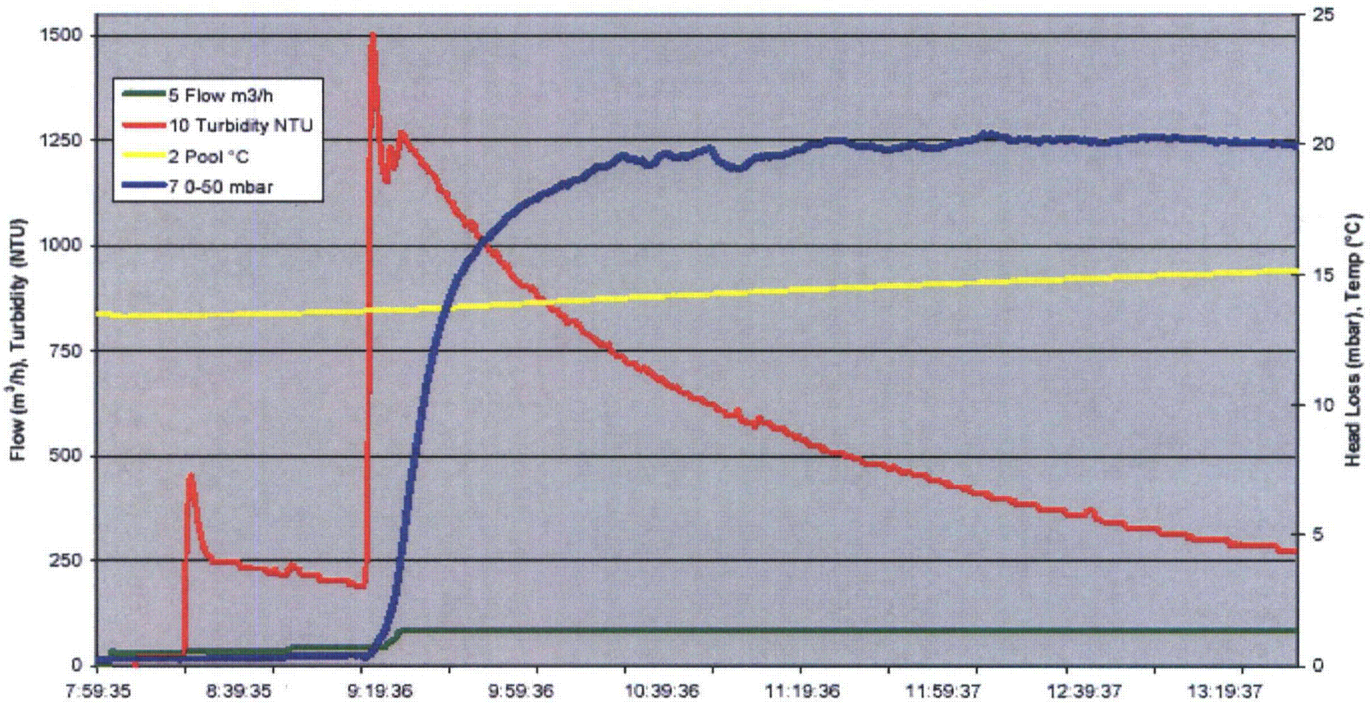
Figure 3f4-30 DGBS Event Sequence Test

Test step #	Time [hh:mm]	Fluid temperature [°C]	Δp U-tube [cmH_2O]	Δp [mbar]	Flow rate [m^3/h]	Remarks
0	8:08	13.36	0.10	0.042	30.6	38.2% flow rate
1	8:50	13.48	0.15	0.115	30.6	38.2% flow rate, 30 min stabilization with "pool fill" debris to main strainer
2	9:06	13.52	0.25	0.192	39.4	49.3% flow rate, 15 min stabilization with "pool fill" debris to main strainer
3	9:17	13.58	0.8	0.903	40	50% flow rate, 5min stabilization with 100% debris to Main and Remote strainer and removed blanking cover
4*	13:35	15.14	20.4	19.95	80	100% flow rate, 100% debris

Figure 3f4-31 Flow Propeller Measurements for the DGBS Event Sequence Test

(*) Flow measurement	Window 1 [rpm]	Window 2 [rpm]	Window 3 [rpm]	Window 4 [rpm]	Window 5 [rpm]	Window 6 [rpm]
TS 4: 1	572	566	559	148	156	118
TS 4: 2	566	529	563	144	156	109

Figure 3f4-32 DGBS Event Sequence Test Plot



As can be seen from the test plot, the head loss slowly increased to a peak value and then varied within an approximate 1 millibar range until head loss started to slowly decrease. The highest head loss achieved during this test was 8.197 in H_2O approximately 3 3/4 hours after reaching 100% flow. At the end of the test, the head loss was at approximately 7.999 in H_2O and decreasing slowly. The head loss values provided are the 20°C normalized values.

DEGB and DGBS Debris Sequence Tests

The test was initiated by establishing 100% flow in the test loop. Nukon fibers, prepared as described above in "Debris Preparation," were added in increments of 40%, 40%, and 20% of the total quantity determined, as given in Table 3f4-5, with five pool turnovers (15 minutes, 35 seconds) provided between each addition. The Cal-Sil and Marinite debris were then added in the same incremental steps with the same pool turnovers provided between each addition. The particulate debris was then added, again with the same incremental steps and time between steps. Finally, the RMI was added in increments of 50% per addition, with the same pool turnovers provided between additions.

The objective of this test, and the similar DGBS test was to determine if a debris addition sequence that pre-loads the test strainer with purely fibrous debris, then with debris that contains both fibers and particulate, in the quantities that have been calculated for CNP, would potentially form a thin bed that would result in higher head losses than a homogeneously mixed debris when the substantial quantities of particulate were added.

Strainer Head Loss Testing Conclusions

Based on the strainer testing performed, the addition of a homogenous debris mixture has been determined to be the most limiting for CNP. The response to Information Item 3.f.10 provides the most limiting strainer head loss values as a result of this testing, normalized to 20°C. This temperature was chosen solely as a convenient point to establish equivalent head loss values since, as could be seen from the test plots, temperature in the test loop tended to increase during the test sequences.

Note that, during testing, the strainers performed as a very effective filter for removing suspended particulate from the flow stream. For the long duration tests, the pool water clarity was very high. This is also evidenced by the significant reduction in measured turbidity in the test loop. Water samples were collected at selected points during the tests performed.

Debris concentration analysis of water samples that were collected during debris only head loss testing at CCI was performed by ALION (Reference 9). These samples were collected after a stable head loss was achieved at 100% flow and 100% debris conditions. The samples were taken from a sample connection downstream of the test strainers in the pump discharge piping. The estimated concentration in the test pool following completion of debris addition varied between about 4000 ppm for the DGBS tests and 6600 ppm for the DEGB tests. The results of this analysis are provided in Table 3f4-1, below. The analysis results demonstrate the filtering capability of the CNP strainer system which provides significant conservatism to the assumptions used for debris quantities that would be resident in the systems downstream of the strainers and the time period for which those quantities of debris are assumed to exist.

Table 3f4-1 Test Sample Debris Concentration

Sample Identification	Test Description	Time From Final Debris Addition hrs	Sample Concentration ppm
T-2121-2	Standard (Homogeneous) DGBS Head Loss Test	25	1.6
T-2121-3	Standard (Homogeneous) DEGB Head Loss Test	26	2.1
T-2121-4	DGBS Debris Sequence Head Loss Test	2.5	89.8
T-2121-5	DEGB Debris Sequence Head Loss Test	2.3	198.6
T-2121-6	DGBS Event Sequence Head Loss Test	5.5	37.0
T-2121-7	DEGB Event Sequence Head Loss Test	3.8	125.8

All information on chemical effects testing is provided in the response to Information Item 3.o.

I&M Response to Information Item 3.f.9

A revision to the response to Information Item 3.f.9 is provided below. This revised response supersedes that provided in Reference 1. All figures referenced in the revised response below are located in the Reference 1 Attachment 3 response to Information Item 3.f.9.

As described in the response to Information Item 3.f.4, the strainer installation at CNP consists of a main strainer at the recirculation sump in the loop compartment, and a remote strainer in the annulus with a connecting waterway to the recirculation sump. Since strainer head loss testing was performed with parallel path equivalent main and remote strainers, the contribution of the waterway to the overall system head loss was not tested. An analysis by ALION (Reference 10) was performed to determine the head loss for the installed configuration based on the strainer testing performed at CCI.

As shown in Figures 3f4-1 and 3f4-2, the configuration used during strainer testing resulted in different areas for each side of the strainer test assembly to represent the main and remote strainers. The flow to each pool area on each side of the strainer assembly was passed through equivalent sized flow holes to allow for comparative flow measurements to evaluate the flow split between the strainers. The results of these flow splits during clean strainer head loss testing were used as inputs to the clean strainer head loss determination.

For the clean strainer head loss determination, ALION used results obtained from Reference 8 and Reference 11 to determine the overall system head loss. With the information from the strainer testing and the CFD-based hydraulic analysis, the determination of applicable K-factors for the main and remote strainer were calculated. Once these K-factors were obtained, the head loss for the main strainer, remote strainer, and waterway were calculated. For the installed configuration, the head loss of the main strainer will be equal to the sum of the head loss of the remote strainer and the head loss of the remote waterway. The calculation determined the system clean strainer head loss to be 0.00539 ft H_2O. As determined by ALION's calculation, the clean strainer head losses for the CNP configuration are very low, providing an insignificant contribution to debris laden strainer head loss.

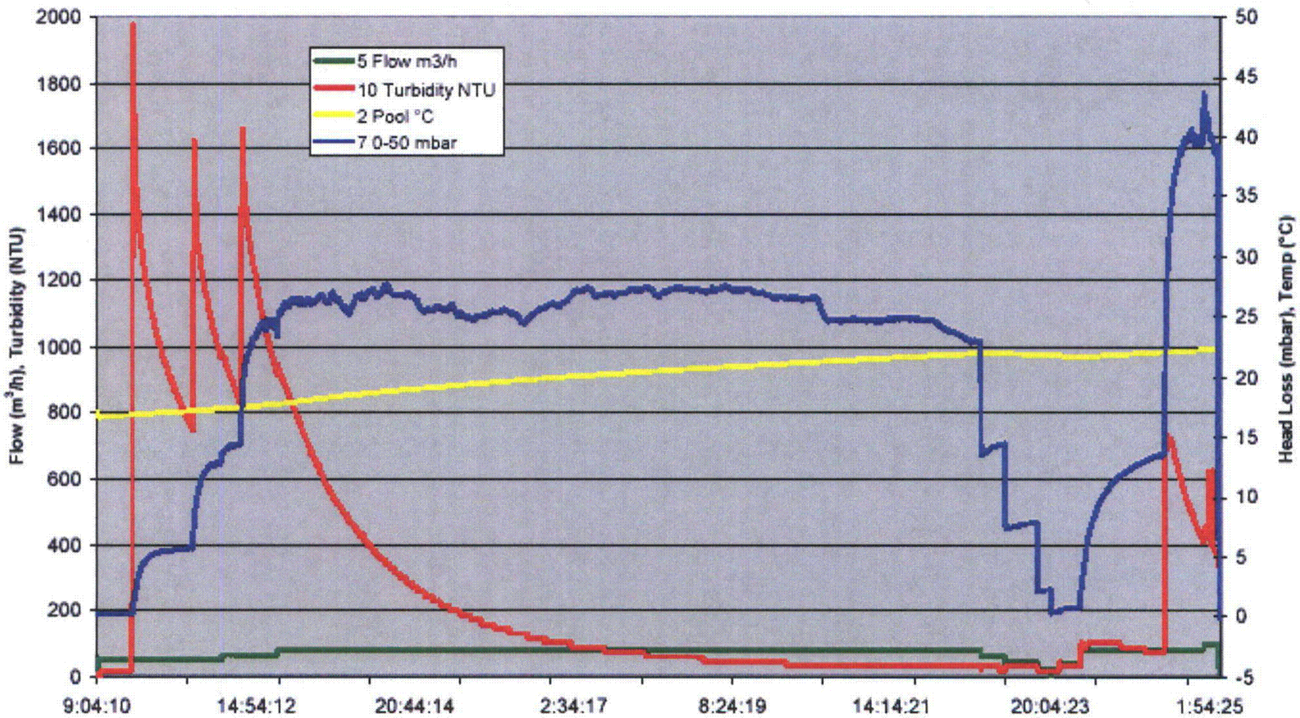
I&M Response to Information Item 3.f.10

A revision to the response to Information Item 3.f.10 is provided below. This revised response supersedes that provided in Reference 1.

As described in the response to Information Item 3.f.9, a similar methodology was used for determining the system head losses for debris laden strainers as it was for clean strainers.

The limiting debris head loss case for the DEGB was determined to be an all debris case, designated as Test Case T2121-3, that utilized homogeneous debris mixtures added to the test loop in increments of 60% for the first debris addition, and then 20% debris addition for the next two additions (100% total debris). For the test, the flow rate was established at 60% flow and then the 60% debris quantity was added. As described in the response to Information Item 3.f.4, the test pool was separated so that debris additions would be made to the main and remote strainer sides of the test configuration per the test specification directed quantities. These test specification quantities were provided to CCI by I&M for the testing. For subsequent increases in flow or debris quantities, the debris quantity was increased to the next increment, e.g., 60% to 80%, then the head loss was allowed to stabilize prior to increasing the flow rate to the next increment, e.g., 60% to 80%. Again, the head loss was allowed to reach a level of stability prior to increasing the debris quantity again. After achieving 100% debris and 100% flow, the test was allowed to run for 24 hours. The highest head loss achieved during the 24-hour run was 11.106 in H_2O at approximately 16 hours after 100% debris, 100% flow was achieved. The head loss at the end of 24 hours from the 100% debris, 100% flow point was approximately 9.59 in H_2O and slowly decreasing. The head loss values provided are the 20°C normalized values. Figure 3f10-1, below, provides the plot for this test.

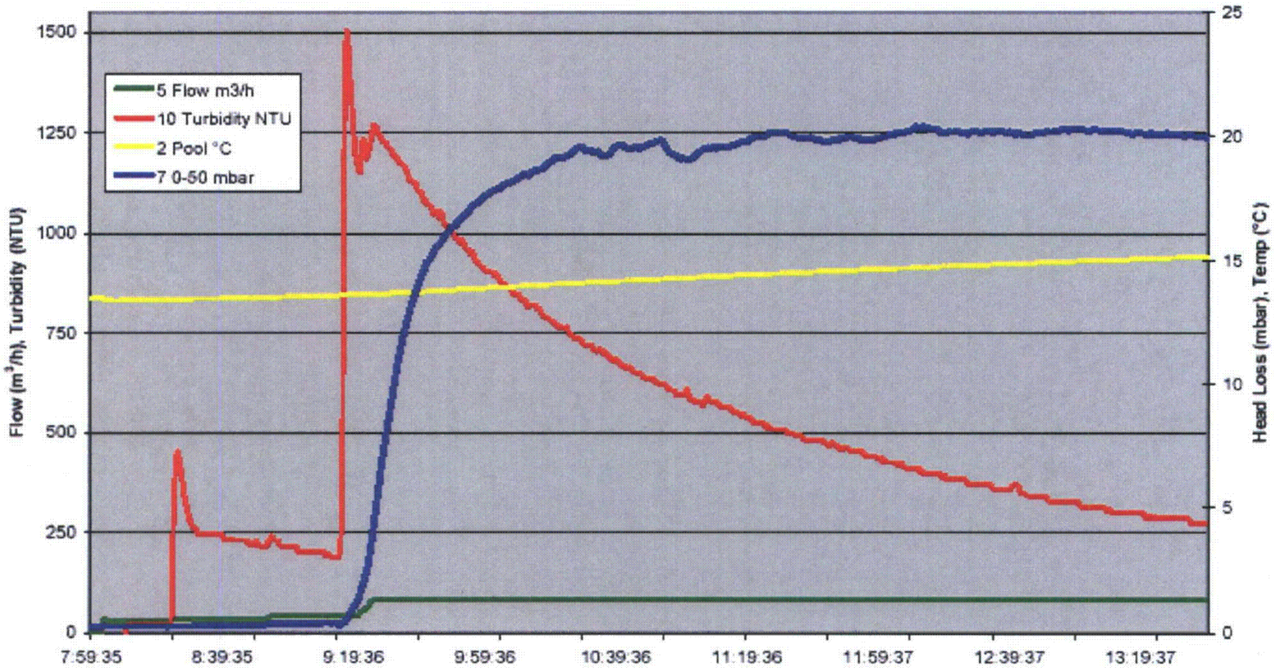
Figure 3f10-1 DEGB All Debris Head Loss Test Plot



The DEGB test also included a flow reduction sequence which represented removal of one pump from service at a time, followed by returning flow to the equivalent 100% value, then increasing debris to 120%, and then increasing flow to 120%.

The limiting debris head loss case for the DGBS was determined to be an event sequence test, designated as Test T2121-6, that used homogeneous debris mixtures. This test was intended to mimic the sequence of events that would occur in the plant following a LOCA. For this test, the remote strainer inlets were blocked off and flow was initiated through the remote strainer at approximately 75% of the flow rate that was calculated by the debris transport analysis (Reference 12) to occur through the main strainer during pool fill. With this flow rate established, the quantity of debris determined to be transported to the main strainer during pool fill was added to the main strainer side of the test strainer. After 30 minutes, the flow rate was increased to 100% of the calculated pool fill flow rate through the main strainer. This flow rate was maintained for 15 minutes. After this time period, the blanking plate was removed from the remote strainer side of the test strainer, and the 100% quantity of debris determined to be transported to remote strainer, and the difference in debris quantity between the pool fill value and the 100% value for the main strainer was added to the respective sides of the strainer. Also, the flow rate was increased to 50% of the total flow rate to represent the alignment of the first train of ECCS and CTS pumps to the recirculation sump. These last steps (removal of blanking plate, addition of debris, and increase of flow rate) were accomplished as simultaneously as possible. Approximately five minutes after these actions were completed, the flow rate was increased to 100% of the total flow rate to represent the final alignment in which both trains of ECCS and CTS take suction from the recirculation sump. The highest head loss achieved during this test was 8.19 in H_2O approximately 3 3/4 hours after reaching 100% flow. At the end of the test, the head loss was at approximately 7.992 in H_2O and decreasing slowly. The head loss values provided are the 20°C normalized values. Figure 3f10-2, below, provided the plot for this test.

Figure 3f10-2 DGBS Event Sequence Head Loss Test Plot



With the limiting debris only head loss cases established for the DEGB and DGBS, the determination of the overall system head loss is necessary. As discussed in the response to Information Item 3.f.9, ALION performed a calculation (Reference 10) to determine the overall system head loss. The first step was to perform a temperature normalization of the waterway (duct) K-factor. This effort resulted in a K-factor for the duct of 1.910 at 20°C. To provide an understanding of this method, the applicable text in Reference 10 has been excerpted and presented below for the bounding DGBS test case.

Calculation for Test Case 2121-6

Test Case 2121-6 measured and recorded the head loss for the strainer system test configuration for the DGBS Event Sequence. The DGBS Event Sequence is characterized in Reference 2.

Determine Test Case 2121-6 Open Strainer Areas and Head Losses for the Main and Remote Strainers

The head loss for the strainer system test configuration for Test Case 2121-6 is:

$h_{L.case6} = 8.190 in - H2O$ From Section 5.1.5.

$h_{L.case6} = 0.682 ft - H2O$

Test achieved 100% of the design flow $Q_d := 100\% \left(14400 \frac{gal}{min} \right)$, or $Q_d := 32.083 \frac{ft^3}{sec}$.

The test was scaled to a factor of 1:41 (from Section 3.15).

From the test report:

$Q_t = \frac{Q_d}{SF}$ From Sections 3.5.1 and 3.15.

Thus, the scaled test flow:

$$Q_t = 0.785 \frac{ft^3}{sec}$$

$RatioCase6_{AvgRS.AvgMS} = 4.037$ From Section 3.4.

From the definition of the $RatioCase\ 6_{AvgRS.AvgMS}$:

$$Q_{rs6} := RatioCase6_{AvgRS.AvgMS} \left(Q_{ms6} \right)$$

$$Q_t = Q_{ms6} + Q_{rs6}$$

$$Q_t := Q_{ms6} + RatioCase6_{AvgRS.AvgMS} \left(Q_{ms6} \right)$$

$Q_t := \frac{Q_d}{SF}$ Scaled test flow.

$Q_t = 0.785 \frac{ft^3}{sec}$

$Q_{ms6} = 0.156 \frac{ft^3}{sec}$ Case 6 main strainer flow

$Q_{rs6} := Q_t - Q_{ms6}$

$Q_{rs6} = 0.629 \frac{ft^3}{sec}$ Case 6 remote strainer flow

K-factors for the main and remote strainers were calculated for the test configuration in Section 6.1.

$K_{ms} = 1218$

$K_{rs} = 1022$

These inputs are then used to determine the equivalent clean strainer area of the debris laden test strainers, as well as the head loss for strainer test configuration.

Solution Matrix Input:

Unknowns	Equations	
A_{ms6}	$h_{Lms6} = \frac{K_{ms}\left(\frac{Q_{ms6}}{A_{ms6}}\right)^2}{2g}$	Equation 0-1

[redacted]

A_{rs6}

$$h_{Lrs6} = \frac{K_{rs}\left(\frac{Q_{rs6}}{A_{rs6}}\right)^2}{2g}$$ Equation 0-2

[redacted]

h_{Lms6}

$$h_{Lms6} = h_{L.case6}$$ Equation 0-3

[redacted]

h_{Lrs6}

$$h_{Lrs6} = h_{L.case6}$$ Equation 0-4

Find the solution:

$$h_{Lms6} = h_{L.case6}$$ Equation 0-3

[redacted]

$h_{Lms6} = 0.682 ft - H2O$ Answer: $h_{Lms6} = 0.682 ft - H2O$

[redacted]

$$h_{Lrs6} = h_{L.case6}$$ Equation 0-4

[redacted]

$h_{Lrs6} = 0.682 ft - H2O$ Answer: $h_{Lrs6} = 0.682 ft - H2O$

[redacted]

$$h_{Lms6} = \frac{K_{ms}\left(\frac{Q_{ms6}}{A_{ms6}}\right)^2}{2g}$$ Equation 0-1

[redacted]

$$A_{ms6} = \sqrt{\frac{Q_{ms6}^{\ 2}(K_{ms})}{h_{Lms6}(2g)}}$$

[redacted]

$$A_{ms6} = \sqrt{\frac{\left(0.156\frac{ft^3}{\sec}\right)^2(1218)}{0.682ft(2)\left(32.174\frac{ft}{\sec^2}\right)}} = 0.822ft^2$$ Answer: $A_{ms6} = 0.822ft^2$

$$h_{Lrs6} = \frac{K_{rs}\left(\frac{Q_{rs6}}{A_{rs6}}\right)^2}{2g}$$ Equation 0-2

$$A_{rs6} = \sqrt{\frac{Q_{rs6}{}^2(K_{rs})}{h_{Lrs6}(2g)}}$$

$$A_{rs6} = \sqrt{\frac{\left(0.629\frac{ft^3}{\sec}\right)^2(1022)}{0.682ft(2)\left(32.174\frac{ft}{\sec^2}\right)}} = 3.035ft^2$$ Answer: $A_{rs6} = 3.035ft^2$

Solution Matrix Output:

$h_{Lms6} = 0.682ft - H2O$ $h_{Lms6} = 8.190in - H2O$

$h_{Lrs6} = 0.682ft - H2O$ $h_{Lrs6} = 8.190in - H2O$

$A_{ms6} = 0.822ft^2$

$A_{rs6} = 3.035ft^2$

Determining the Strainer System Head Loss Based on Case 2121-6 for the Actual Configuration

Using the main and remote strainer K-factors calculated in Section 0 the head loss for the actual configuration of the strainer system is calculated.

Known values:

$$Q_d = 14400 \frac{gal}{\min}$$

$$Q_t = \frac{Q_d}{SF}$$

$$A_{duct} := 5.727 ft^2$$

$K_{duct} := 1.910$ From Section 5.2

K-factors for the main and remote strainers were calculated for the test configuration in Section 6.1.

$$K_{ms} = 1218$$

$$K_{rs} = 1022$$

Area of the strainers was determined by strainer area that remained open from Test Case 2121-6 data reduction in Section 0.

$$A_{ms6} = 0.822 ft^2$$

$$A_{rs6} = 3.035 ft^2$$

The flow through the main and remote strainers is then determined, considering the additional head loss due to the duct being in series with the remote strainer. Flow represents three of the unknowns (i.e., Q_{ms6}, Q_{rs6}, and Q_{duct6}). The unknown flows also result in unknown head losses for the main and remote strainers, and the duct (h_{Lms6}, h_{Lrs6}, h_{Lduct6}). The last unknown is the overall strainer system head loss for the actual configuration (i.e., h_{Lsys6}).

Solution Matrix Input:

Unknowns	Equations	
h_{Lsys6}	$h_{Lduct6} = \dfrac{K_{duct}\left(\dfrac{41Q_{duct6}}{A_{duct}}\right)^2}{2g}$	Equation 0-1
h_{Lduct6}	$h_{Lms6} = \dfrac{K_{ms}\left(\dfrac{Q_{ms6}}{A_{ms6}}\right)^2}{2g}$	Equation 0-2
h_{Lms6}	$h_{Lrs6} = \dfrac{K_{rs}\left(\dfrac{Q_{rs6}}{A_{rs6}}\right)^2}{2g}$	Equation 0-3
h_{Lrs6}	$h_{Lms6} = h_{Lsys6}$	Equation 0-4
Q_{duct6}	$h_{Lrs6} + h_{Lduct6} = h_{Lsys6}$	Equation 0-5
Q_{ms6}	$Q_t = Q_{ms6} + Q_{rs6}$	Equation 0-6
Q_{rs6}	$Q_{rs6} = Q_{duct6}$	Equation 0-7

Find the solution:

$h_{Lms6} = \dfrac{K_{ms}\left(\dfrac{Q_{ms6}}{A_{ms6}}\right)^2}{2g}$	Equation 0-2
$\eta_{ms6} = \dfrac{K_{ms}}{2g\left(A_{ms6}{}^2\right)}$	Define η_{ms6} as an aggregate term equivalent to all the known terms in the h_{Lms6} equation.
$h_{Lms6} = \eta_{ms6}\left(Q_{ms6}{}^2\right)$	Defined as Equation 0-8
$h_{Lrs6} = \dfrac{K_{rs}\left(\dfrac{Q_{rs6}}{A_{rs6}}\right)^2}{2g}$	Equation 0-3
$\eta_{rs6} = \dfrac{K_{rs}}{2g\left(A_{rs6}{}^2\right)}$	Define η_{rs6} as an aggregate term equivalent to all the known terms in the h_{Lrs6} equation.
$h_{Lrs6} = \eta_{rs6}\left(Q_{rs6}{}^2\right)$	Defined as Equation 0-9
$h_{Lduct6} = \dfrac{K_{duct}\left(\dfrac{41Q_{duct6}}{A_{duct}}\right)^2}{2g}$	Equation 0-1

$$\eta_{duct} = \frac{K_{duct}(41)^2}{2g\left(A_{duct}^{\ 2}\right)}$$

Define η_{duct} as an aggregate term equivalent to all the known terms in the h_{Lduct6} equation.

$$h_{Lduct6} = \eta_{duct}\left(Q_{duct6}^{\ 2}\right)$$

Defined as Equation 0-10

$$h_{Lrs6} + h_{Lduct6} = h_{Lsys6}$$

Equation 0-5

$$h_{Lms6} = h_{Lsys6}$$

Equation 0-4

$$h_{Lrs6} + h_{Lduct6} = h_{Lms6}$$

$$\eta_{rs6}\left(Q_{rs6}^{\ 2}\right) + \eta_{duct}\left(Q_{duct6}^{\ 2}\right) = h_{Lms6}$$

Using Equation 0-9 and Equation 0-10

$$Q_{rs6} = Q_{duct6}$$

Equation 0-7

$$Q_{rs6}^{\ 2}\left(\eta_{rs6} + \eta_{duct}\right) = h_{Lms6}$$

$$Q_{rs6}^{\ 2}\left(\eta_{rs6} + \eta_{duct}\right) = \eta_{ms6}\left(Q_{ms6}^{\ 2}\right)$$

Using Equation 0-8

$$Q_{rs6}^{\ 2} = \frac{\eta_{ms6}}{\left(\eta_{rs6} + \eta_{duct}\right)}\left(Q_{ms6}^{\ 2}\right)$$

$$Q_{rs6} = \sqrt{\frac{\eta_{ms6}}{\left(\eta_{rs6} + \eta_{duct}\right)}\left(Q_{ms6}\right)}$$

Defined as Equation 0-11

$$Q_t = Q_{ms6} + Q_{rs6}$$ Equation 0-6

$$Q_t = Q_{ms6} + \sqrt{\frac{\eta_{ms6}}{(\eta_{rs6} + \eta_{duct})}}(Q_{ms6})$$ Using Equation 0-11

$$Q_{ms6} = \frac{Q_t}{1 + \sqrt{\frac{\eta_{ms6}}{(\eta_{rs6} + \eta_{duct})}}}$$

$$Q_{ms6} = \frac{Q_t}{1 + \sqrt{\frac{\frac{K_{ms}}{2g(A_{ms6}{}^2)}}{\left(\frac{K_{rs}}{2g(A_{rs6}{}^2)} + \frac{K_{duct}(41)^2}{2g(A_{duct}{}^2)}\right)}}}$$ Using the Definitions of η_{ms6}, η_{rs6}, and η_{duct}

$$Q_{ms6} = \frac{Q_t}{1 + \sqrt{\frac{\frac{K_{ms}}{(A_{ms6}{}^2)}}{\left(\frac{K_{rs}}{(A_{rs6}{}^2)} + \frac{K_{duct}(41)^2}{(A_{duct}{}^2)}\right)}}}$$

$$Q_{ms6} = \frac{0.785\frac{ft^3}{\sec}}{1 + \sqrt{\frac{\frac{1218}{(0.822^2)(ft^2)}}{\left(\frac{1022}{(3.035^2)(ft^2)} + \frac{1.910(41)^2}{(5.727^2)(ft^2)}\right)}}} = 0.199\frac{ft^3}{\sec}$$ Answer: $Q_{ms6} = 0.199\frac{ft^3}{\sec}$

$$Q_t = Q_{ms6} + Q_{rs6}$$ Equation 0-6

[redacted]

$$Q_{rs6} = Q_t - Q_{ms6}$$

[redacted]

$$Q_{rs6} = 0.785\frac{ft^3}{\sec} - 0.199\frac{ft^3}{\sec} = 0.586\frac{ft^3}{\sec}$$

Answer: $Q_{rs6} = 0.586\frac{ft^3}{\sec}$

[redacted]

$$Q_{rs6} = Q_{duct6}$$

Equation 0-7

[redacted]

$$Q_{duct6} = 0.586\frac{ft^3}{\sec}$$

Answer: $Q_{duct6} = 0.586\frac{ft^3}{\sec}$

[redacted]

$$h_{Lduct6} = \frac{K_{duct}\left(\frac{41Q_{duct6}}{A_{duct}}\right)^2}{2g}$$

Equation 0-1

[redacted]

$$h_{Lduct6} = \frac{1.910\left(\frac{41(0.586)\frac{ft^3}{\sec}}{5.727\,ft^2}\right)^2}{2(32.174)\frac{ft}{\sec^2}} = 0.522\,ft - H2O$$

Answer: $h_{Lduct6} = 0.522\,ft - H2O$

[redacted]

$$h_{Lms6} = \frac{K_{ms}\left(\frac{Q_{ms6}}{A_{ms6}}\right)^2}{2g}$$

Equation 0-2

[redacted]

$$h_{Lms6} = \frac{1218\left(\dfrac{0.199\dfrac{ft^3}{\sec}}{0.822\,ft^2}\right)^2}{2(32.174)\dfrac{ft}{\sec^2}} = 1.109\,ft - H2O$$

Answer: $h_{Lms6} = 1.109\,ft - H2O$

$$h_{Lrs6} = \frac{K_{rs}\left(\dfrac{Q_{rs6}}{A_{rs6}}\right)^2}{2g}$$

Equation 0-3

$$h_{Lrs6} = \frac{1022\left(\dfrac{0.586}{3.035}\right)^2}{2(32.174)\dfrac{ft}{\sec^2}} = 0.592\,ft - H2O$$

Answer: $h_{Lrs6} = 0.592\,ft - H2O$

$$h_{Lms6} = h_{Lsys6}$$

Equation 0-4

$$h_{Lsys6} = 1.109\,ft - H2O$$

Answer: $h_{Lsys6} = 1.109\,ft - H2O$

$$h_{Lrs6} + h_{Lduct6} = h_{Lsys6}$$

Equation 0-5

$$h_{Lsys6} = 0.592 + 0.522 = 1.114\,ft - H2O$$

Answer: $h_{Lsys6} = 1.114\,ft - H2O$

$$1.109\,ft - H2O \approx 1.114\,ft - H2O$$

There is a slight discrepancy between Equation 0-4 and Equation 0-5 due to rounding error, so the larger is chosen for conservatism.

Solution Matrix Output:

$h_{Lduct6} = 0.522 ft - H2O$ $\qquad$ $h_{Lduct6} := 6.264 in - H2O$

$h_{Lms6} = 1.109 ft - H2O$ $\qquad$ $h_{Lms6} := 13.308 in - H2O$

$h_{Lrs6} = 0.592 ft - H2O$ $\qquad$ $h_{Lrs6} := 7.104 in - H2O$

$h_{Lsys6} = 1.114 ft - H2O$ $\qquad$ $h_{Lsys6} := 13.368 in - H2O$

$$Q_{duct6} = 0.586 \frac{ft^3}{sec}$$

$$Q_{ms6} = 0.199 \frac{ft^3}{sec}$$

$$Q_{rs6} = 0.586 \frac{ft^3}{sec}$$

As shown above, the applied methodology conservatively determined the overall system head loss, normalized to 20°C. For the DEGB case, the maximum debris only system head loss is 1.129 ft H_2O. For the DGBS case (presented above), the maximum debris only system head loss 1.114 ft H_2O. For both the DGBS and DEGB cases, the system head loss values include the clean strainer head loss. To address uncertainties associated with the complex strainer configuration and potential differences in flow and debris splits between the main and remote strainers, the system head loss, including chemical effects, will be increased to establish the design basis strainer system head loss. This increase is discussed in the response to Information Item 3.o.15.a.

The response to this information item has focused on the test results that provided the maximum debris-only head loss. Refer to the response to Information Item 3.f.4 for the discussion of other tests that were performed and their results.

NRC Information Item 3g - Net Positive Suction Head (NPSH)

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a loss-of-coolant accident (LOCA) considering a spectrum of break sizes.

1. *Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level.*
2. *Describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.*
3. *Provide the basis for the required NPSH values, e.g., three percent head drop or other criterion.*
4. *Describe how friction and other flow losses are accounted for.*
5. *Describe the system response scenarios for LBLOCA and SBLOCAs.*
6. *Describe the operational status for each ECCS and CSS pump before and after the initiation of recirculation.*
7. *Describe the single failure assumptions relevant to pump operation and sump performance.*
8. *Describe how the containment sump water level is determined.*
9. *Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.*
10. *Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.*
11. *Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.*
12. *Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.*
13. *If credit is taken for containment accident pressure in determining available NPSH, provide description of the calculation of containment accident pressure used in determining the available NPSH.*
14. *Provide assumptions made which minimize the containment accident pressure and maximize the sump water temperature.*
15. *Specify whether the containment accident pressure is set at the vapor pressure corresponding to the sump liquid temperature.*
16. *Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.*

I&M Response to NRC Information Items 3.g.1 through 3.g.16

The information provided in the Reference 1 and Reference 2 response to Information Items 3.g.1 through 3.g.16 remains applicable.

NRC Information Item 3.h – Coatings Evaluation

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

1. *Provide a summary of type(s) of coating systems used in containment, e.g., Carboline CZ 11 Inorganic Zinc primer, Ameron 90 epoxy finish coat.*
2. *Describe and provide bases for assumptions made in post-LOCA paint debris transport analysis.*
3. *Discuss suction strainer head loss testing performed as it relates to both qualified and unqualified coatings and what surrogate material was used to simulate coatings debris.*
4. *Provide bases for the choice of surrogates.*
5. *Describe and provide bases for coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on ZOI size for qualified and unqualified coatings.*
6. *Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.*
7. *Describe any ongoing containment coating condition assessment program.*

I&M Response to Information Item 3.h.1 through 3.h.4, and 3.h.7

The information provided in the Reference 2 response to Information Item 3.h.1 through 3.h.4, and 3.h.7 remains applicable.

I&M Response to Information Item 3.h.5 and 3.h.6

Revisions to Table 3h5-2 and Table 3h5-4 are provided below. These revised tables supersede those provided in Reference 2.

Table 3h5-2 is revised to reflect the limiting break location, Unit 2 Loop 4 for the DGBS. For the DGBS, the previous methodology used a 10% increase in debris quantity associated with the DEGB unqualified coating debris generation within the ZOI. Table 3h5-2 now reflects a more realistic, yet conservative quantity of unqualified coatings debris generated for the DGBS within the ZOI.

Table 3h5-2 DGBS Coating Debris Generated Within ZOI

Coating Type	Area, ft^2	Thickness, mils	Analysis Size, microns	Volume, ft^3	Density, lbs/ft^3	Weight, lbs
Qualified Coatings – Concrete Surfaces (ZOI – 5D)	0	12	10	0.0	111.6	0.0
Qualified Coatings – Steel Surfaces (ZOI – 5D)	20	12	10	0.02	111.6	2.2
Total Qualified (ZOI – 5D)	**20**	**-**	**-**	**0.02**	**-**	**2.2**
Unqualified Alkyd Coatings (ZOI – 10D)	7.7	4	10	0.0025	98	0.2
Unqualified Epoxy Coatings (ZOI – 10D)	14.9	4	10	0.0049	94	0.5
Total Unqualified (ZOI – 10D)	**22.6**	-	-	**0.0074**	-	**0.7**

Table 3h5-4 has been revised to reflect an assumed 50% failure of the cold galvanizing compound. This is conservative with respect to the less than 5% failure that was observed during DBA testing of this material, as reported in the Reference 2 response to Information Item 3.b.3.

Table 3h5-4 Unqualified Coatings Debris Generated Outside ZOI

Coating Type	Area, ft^2	Thickness, mils	Analysis Size, microns	Volume, ft^3	Density, lbs/ft^3	Weight, lbs
Unqualified OEM Alkyd Handwheels and Limitorque Coatings outside 10D ZOI	1,429.5	4	83	0.48	98	47.0
Remaining Unqualified OEM Alkyd Coatings outside 10D ZOI	841.7	4	83	0.28	98	27.4
Remaining Unqualified OEM Epoxy Coatings outside 10D ZOI	538.0	4	83	0.18	94	16.9
Unqualified non-OEM Alkyd Coatings outside 10D ZOI	105.8	4	10% (250–500) 80% (500–1000) 10% (1000–4000)	0.035	98	3.4
Unqualified non-OEM Epoxy Coatings outside 10D ZOI	991.2	4	10% (250–500) 80% (500–1000) 10% (1000–4000)	0.33	94	31.0
Cold Galvanizing Compound	4662.5	4	10	1.56	250	388.75
Total Unqualified	**8568.7**	-	-	**2.86**	-	**514.45**

NRC Information Item 3.i – Debris Source Term

The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

Provide the information requested in GL 04-02 Requested Information Item 2.(f) regarding programmatic controls taken to limit debris sources in containment.

GL 2004-02 Requested Information Item 2(f)
A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) will be assessed for potential adverse effects on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating

Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.

In responding to GL 2004 Requested Information Item 2(f), provide the following:

1. *A summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. Specifically for RMI/low-fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.*
2. *A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.*
3. *A description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.*
4. *A description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.*

If any of the following suggested design and operational refinements given in the guidance report (guidance report, Section 5) and SE (SE, Section 5.1) were used, summarize the application of the refinements.

5. *Recent or planned insulation change-outs in the containment which will reduce the debris burden at the sump strainers*
6. *Any actions taken to modify existing insulation (e.g., jacketing or banding) to reduce the debris burden at the sump strainers*
7. *Modifications to equipment or systems conducted to reduce the debris burden at the sump strainers*
8. *Actions taken to modify or improve the containment coatings program*

<u>I&M Response to Information Items 3.i</u>

The information provided in the Reference 1 and Reference 2 response to Information Item 3.i remains applicable.

<u>NRC Information Item 3.j – Screen Modification Package</u>

The objective of the screen modification package section is to provide a basic description of the sump screen modification.

1. *Provide a description of the major features of the sump screen design modification.*
2. *Provide a list of any modifications, such as reroute of piping and other components, relocation of supports, addition of whip restraints and missile shields, etc., necessitated by the sump strainer modifications.*

<u>I&M Response to Information Item 3.j</u>

The information provided in the Reference 1 and Reference 2 response to Information Item 3.j remains applicable.

<u>NRC Information Item 3.k - Sump Structural Analysis</u>

The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer including seismic loads and loads due to differential pressure, missiles, and jet forces.

Provide the information requested in GL 2004-02 <u>Requested Information</u> Item 2(d)(vii).

> *<u>GL 2004-02 Requested Information Item 2(d)(vii)</u>*
> *Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under flow conditions.*

1. *Summarize the design inputs, design codes, loads, and load combinations utilized for the sump strainer structural analysis.*
2. *Summarize the structural qualification results and design margins for the various components of the sump strainer structural assembly.*
3. *Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable).*
4. *If a backflushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.*

<u>I&M Response to Information Item 3.k</u>

The information provided in the Reference 1 and Reference 2 response to Information Item 3.k remains applicable.

<u>NRC Information Item 3.l – Upstream Effects</u>

The objective of the upstream effects assessment is to evaluate the flowpaths upstream of the containment sump for holdup of inventory which could reduce flow to and possibly starve the sump.

Provide a summary of the upstream effects evaluation including the information requested in GL 2004-02 <u>Requested Information</u> Item 2(d)(iv).

<u>*GL 2004-02 Requested Information Item 2(d)(iv)*</u>
The basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flowpaths.

1. *Summarize the evaluation of the flow paths from the postulated break locations and containment spray washdown to identify potential choke points in the flow field upstream of the sump.*
2. *Summarize measures taken to mitigate potential choke points.*
3. *Summarize the evaluation of water holdup at installed curbs and/or debris interceptors.*
4. *Describe how potential blockage of reactor cavity and refueling cavity drains has been evaluated, including likelihood of blockage and amount of expected holdup.*

<u>I&M Response to Information Item 3.l</u>

The information provided in the Reference 1 response to Information Item 3.l remains applicable.

<u>NRC Information Item 3.m - Downstream Effects - Components and Systems</u>

The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams.

Provide the information requested in GL 04-02 <u>Requested Information</u> Item 2(d)(v) and 2(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in the ECCS and CSS downstream of the sump.

<u>*GL 2004-02 Requested Information Item 2(d)(v)*</u>
The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.

<u>*GL 2004-02 Requested Information Item 2(d)(vi)*</u>
Verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

1. *If NRC-approved methods were used (e.g., WCAP-16406-P with accompanying NRC SE), briefly summarize the application of the methods. Indicate where the approved methods were not used or exceptions were taken, and summarize the evaluation of those areas.*
2. *Provide a summary and conclusions of downstream evaluations.*

3. *Provide a summary of design or operational changes made as a result of downstream evaluations.*

I&M Response to Information Item 3.m

The information provided in the Reference 1 and Reference 2 response to Information Item 3.m remains applicable.

NRC Information Item 3.n Downstream Effects - Fuel and Vessel

The objective of the downstream effects, fuel and vessel section is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on core cooling.

1. *Show that the in-vessel effects evaluation is consistent with, or bounded by, the industry generic guidance (WCAP-16793), as modified by NRC staff comments on that document. Briefly summarize the application of the methods. Indicate where the WCAP methods were not used or exceptions were taken, and summarize the evaluation of those areas.*

I&M Response to Information Item 3.n.1

The information presented below supplements that contained in the Reference 2 response to this information item.

As previously described in the response to Information Item 3.n.1 in Reference 2, the LOCADM evaluation was performed in accordance with the guidance contained within WCAP-16793.

I&M plans to evaluate the potential for in-vessel effects in accordance with WCAP-16793, which is currently under NRC review. I&M will report the results of this evaluation following NRC approval of the WCAP. I&M considers that, due to the very low fiber concentration in the CNP containments and the use of Westinghouse fuel, the potential for concerns regarding in-vessel blockage is extremely small.

To support the statement that the potential for in-vessel blockage is extremely small, Tables 3n-1 and 3n-2 provide the calculated quantity of fiber per fuel assembly for each Unit using the as-tested strainer bypass quantity, a conservatively assumed 5% bypass fraction, the calculated quantity of fiber in each unit's containments, and a conservatively assumed bounding latent debris quantity of 30 lbs of fibrous debris. Since CNP does not have any fibrous debris source other than latent debris and a minimally assumed quantity in the ice condenser, the potential quantities are limited by the bounding latent debris. Both Unit 1 and Unit 2 have 193 fuel assemblies, supplied by Westinghouse.

Table 3n-1 Unit 1 Fibrous Debris In-Vessel

Fiber Bypass (%)	Quantity Of Fiber (lbs)	Fiber per Fuel Assembly (g/FA)
1.2	24.33	0.687
	30	0.847
5	24.33	2.862
	30	3.528

Table 3n-2 Unit 2 Fibrous Debris In-Vessel

Fiber Bypass (%)	Quantity Of Fiber (lbs)	Fiber per Fuel Assembly (g/FA)
1.2	17.66	0.499
	30	0.847
5	17.66	2.077
	30	3.528

As can be seen from the tables, the quantity of fiber per fuel assembly is significantly below the reported limit for Westinghouse fuel.

NRC Information Item 3.o Chemical Effects

I&M has restructured this section to include those items from the content guide (Reference 3) and the review guidance (Reference 13) to provide consecutively numbered sections and sub-sections.

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

1. *Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.*

2. *Sufficient Clean Strainer Area*

   a) *Those licensees performing a simplified chemical effects analysis should justify the use of this simplified approach by providing the amount of debris determined to reach the strainer, the amount of bare strainer area and how it was determined, and any additional information that is needed to show why a more detailed chemical effects analysis is not needed.*

3. *Debris Bed Formation*

   a) *Licensees should discuss why the debris from the break location selected for plant-specific head loss testing with chemical precipitate yields the maximum head loss. For example, plant X has break location 1 that would produce maximum head loss without consideration of chemical effects. However, break location 2, with chemical effects considered, produces greater head loss than break location 1. Therefore, the debris for head loss testing with chemical effects was based on break location 2.*

4. *Plant Specific Materials and Buffers*

   a) *Licensees should provide their assumptions (and basis for the assumptions) used to determine chemical effects loading: pH range, temperature profile, duration of containment spray, and materials expected to contribute to chemical effects.*

5. *Approach to Determine Chemical Source Term*

   a) *Licensees should identify the vendor who performed plant-specific chemical effects testing.*

6. *WCAP Base Model*

   a) *For licensees proceeding from block 7 to diamond 10 in the Figure 1 flow chart, justify any deviations from the WCAP base model spreadsheet (i.e., any plant specific refinements) and describe how any exceptions to the base model spreadsheet affected the amount of chemical precipitate predicted.*

   b) *List the type (e.g., AlOOH) and amount of predicted plant-specific precipitates.*

7. *Solubility of Phosphates, Silicates and Al Alloys*

   a) *Licensees should clearly identify any refinements (plant-specific inputs) to the base WCAP-16530 model and justify why the plant-specific refinement is valid.*
   b) *For crediting inhibition of aluminum that is not submerged, licensees should provide the substantiation for the following: (1) the threshold concentration of silica or phosphate needed to passivate aluminum, (2) the time needed to reach a phosphate or silicate level in the pool that would result in aluminum passivation, and (3) the amount of containment spray time (following the achieved threshold of chemicals) before aluminum that is sprayed is assumed to be passivated.*
   c) *For any attempts to credit solubility (including performing integrated testing), licensees should provide the technical basis that supports extrapolating solubility test data to plant-specific conditions. In addition, licensees should indicate why the overall chemical effects evaluation remains conservative when crediting solubility given that small amount of chemical precipitate can produce significant increases in head loss.*
   d) *Licensees should list the type (e.g., AlOOH) and amount of predicted plant specific precipitates.*

8. *Chemical Injection into the Loop*

   a) *Licensees should provide the one-hour settled volume (e.g., 80 ml of 100 ml solution remained cloudy) for precipitate prepared with the same sequence as with the plant-specific, in-situ chemical injection.*
   b) *For plant-specific testing, the licensee should provide the amount of injected chemicals (e.g., aluminum), the percentage that precipitates, and the percentage that remains dissolved during testing.*
   c) *Licensees should indicate the amount of precipitate that was added to the test for the head loss of record (i.e., 100 percent 140 percent).*

9. *Pre-mix in Tank*

   a) *Licensees should discuss any exceptions taken to the procedure recommended for surrogate precipitate formation in WCAP-16530.*

10. *Integrated Head Loss Test With Near- Field Settlement Credit*

   a) *Licensees should provide the one-hour or two-hour precipitate settlement values measured within 24 hours of head loss testing.*
   b) *Licensees should provide a best estimate of the amount of surrogate chemical debris that settles away from the strainer during the test.*

11. *Head Loss Testing Without Near Field Settlement*

   a) *Licensees should provide an estimate of the amount of debris and precipitate that remains on the tank/flume floor at the conclusion of the test and justify why the settlement is acceptable.*
   b) *Licensees should provide the one-hour or two-hour precipitate settlement values measured and the timing of the measurement relative to the start of head loss testing (e.g., within 24 hours).*

12. *Test Termination Criteria*

   a) *Provide the test termination criteria.*

13. *Data Analysis*

   a) *Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.*
   b) *Licensees should explain any extrapolation methods used for data analysis.*

14. *30-day Integrated Head Loss Test*

   a) *Licensees should provide the plant-specific test conditions and the basis for why these test conditions and test results provide for a conservative chemical effects evaluation.*

b) *Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.*

15. <u>Data Analysis Bump Up Factor</u>

a) *Licensees should provide the details and the technical basis that show why the bump-up factor from the particular debris bed in the test is appropriate for application to other debris beds.*

<u>I&M Response to Information Item 3.o.1 through 3.o.13</u>

The information provided in the Reference 1 response to Information Item 3.o.1 through 3.o.13 remains applicable for these information items.

<u>I&M Response to Information Item 3.o.14</u>

I&M is not crediting any portion of the ALION Vuez 30-Day Integrated Test that was provided in the Reference 2 response.

<u>I&M Response to Information Item 3.o.15.a</u>

I&M intends to use a chemical effects bump-up factor of 1.7 times the maximum determined head loss obtained from the large scale testing for both the DEGB and DGBS cases. The maximum head loss observed from the large scale tests was reported in the response to Information Item 3.f.4 and 3.f.10. The response to Information Item 3.f.10 also provided information describing that I&M will increase the strainer system head loss values by a sufficient factor to account for testing uncertainties and to provide additional margin.

As a result of the chemical additions to the fully developed, debris-only bed in the strainer, head loss increased by a factor of 1.43 for the DEGB test, and 1.53 for the DGBS test. This was based on the recorded data from the test which occurred at different test loop temperatures. To provide consistency in establishing the true head loss increase, the head loss values were temperature normalized to 20°C. The results of these temperature-normalized head loss values are provided in Table 3o15a-1, below.

Table 3o15a-1 MFTL Chemical Effects Head Loss Test Results Normalized to 20°C

Test	20°C Adjusted Head Loss Values		Ratio
	Debris-only	Debris with Chemical Effects	
DEGB	2.67 ft H_2O	3.83 ft H_2O	1.43
DGBS	4.43 ft H_2O	6.80 ft H_2O	1.53

As a result of this normalization, a chemical effects bump-up factor will be used to establish the overall system head loss for CNP. The bump-up factor that will be applied is 1.7 for chemical effects. For the DEGB, the strainer system head loss value, considering the 1.7 factored increase, is 1.92 ft H_2O. For the DGBS, the strainer system head loss value, considering the 1.7 factored increase, is 1.89 ft H_2O. To address uncertainties and provide additional margin, for the DEGB, the system head loss for the recirculation sump strainers will be established at 2.78 ft H_2O. For the DGBS, the head loss for the recirculation sump strainers will be established at 2.63 ft H_2O. These values represent a factored increase in strainer system head loss of 1.45 for the DEGB and 1.39 for the DGBS. For the SBLOCA, the head loss will be established at 2.38 ft H_2O, a factored increase of 1.26. For the SBLOCA, the test results from the DGBS are used to establish a significantly conservative system head loss given the reduced demand on the strainer system and the reduced quantity of debris that could be generated.

The basis for the acceptability of the chemical effects bump-up factor is provided below.

As stated previously in the response to Information Item 3.o.1, the chemical effects testing was performed with an equivalent to only the main strainer. The main strainer would be the most heavily loaded of the two strainers following an event, as predicted by the debris generation (Reference 14) and debris transport analyses (Reference 12). The 20°C normalized debris-only head loss for the DEGB chemical effects test was 2.67 ft H_2O. For the DGBS chemical effects test, this head loss was 4.43 ft H_2O. As determined in the response to Information Item 3.f.4, the 20°C normalized maximum overall system head loss for the DEGB case was 1.129 ft H_2O, and was 1.114 ft H_2O for the DGBS case.

Both the large scale test and MFTL test were performed with the same debris materials. As a result, the chemical effects precipitate would be expected to behave similarly if they could have been used in the large scale test loop.

The remote strainer will be loaded with significantly less debris, including latent fiber, as established in the debris generation (Reference 14) and debris transport analyses (Reference 12). The remote strainer also has a larger effective surface area (1000 ft^2 vs. 850 ft^2 for the main strainer).

Based on the information provided above, I&M considers the application of a conservative bump-up factor of 1.7, determined as a result of the MFTL chemical effects testing, to be applicable to the debris-only head loss values obtained in the large scale tests.

NRC Information Item 3.p – Licensing Basis

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications.

Provide the information requested in GL 04-02 Requested Information Item 2(e) regarding changes to the plant licensing basis. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

GL 2004-02 Requested Information Item 2(e)
A general description of and planned schedule for any changes to the plant licensing bases resulting from any analysis or plant modifications made to ensure compliance with

the regulatory requirements listed in the Applicable Regulatory Requirements section of this GL. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included.

I&M Response to Information Item 3.p

The following information is in addition to that provided in the Reference 1 and Reference 2 response to Information Item 3.p.

Licensing Basis Changes Associated with Mechanistic Evaluation

As described in the Reference 2 response to this information item, the UFSAR was updated to reflect the results of the mechanistic evaluation performed prior to submittal of Reference 2. The NRC issued a final RAI to I&M on June 18, 2009, (Reference 15) regarding Reference 1 and Reference 2. Several changes have been made to the mechanistic evaluation results including development of specific margins between the as-tested quantity of debris and the actual available quantity of debris in the CNP Unit 1 and Unit 2 containments.

In discussions with the NRC staff, it was determined that a portion of these margins would remain under regulatory control to prevent erosion of the basis for acceptability. Tables 3p-1 and 3p-2 below provide the information that supports protection of the regulatory margin.

Table 3p-1 Unit 1 FSAR Margins Table

Debris Type	DEGB Test Quantity	Actual Quantity Available at Both Strainers	Allowable Design Limit	Allowable Design Margin	Regulatory Controlled Margin	DGBS Test Quantity	Actual Quantity Available at Both Strainers	Allowable Design Limit	Allowable Design Margin	Regulatory Controlled Margin
Problematic Debris (lbs)	310.9	45.92	125.41	79.49	185.49	78.36	15.23	34.17	18.94	44.19
Particulates (lbs)	1488.65	849.38	1041.16	191.78	447.49	1288.87	651.14	842.46	191.32	446.41
Fibers (ft^3)	13.15	10.14	10.74	0.60	2.41	13.15	10.14	10.74	0.60	2.41

Table 3p-2 Unit 2 FSAR Margins Table

Debris Type	DEGB Test Quantity	Actual Quantity Available at Both Strainers	Allowable Design Limit	Allowable Design Margin	Regulatory Controlled Margin	DGBS Test Quantity	Actual Quantity Available at Both Strainers	Allowable Design Limit	Allowable Design Margin	Regulatory Controlled Margin
Problematic Debris (lbs)	310.9	40.95	121.94	80.99	188.96	78.36	18.92	36.75	17.83	41.61
Particulates (lbs)	1488.65	819.85	1020.49	200.64	468.16	1288.87	612.01	815.07	203.06	473.80
Fibers (ft^3)	13.15	7.36	8.52	1.16	4.63	13.15	7.36	8.52	1.16	4.63

The primary basis for providing design margin in Tables 3p-1 and 3p-2 is to provide for temporary conditions that would necessitate changes in materials inside containment to support continued plant operation. For example, if a piece of RMI insulation was damaged such that it could no longer perform its function, I&M could temporarily install other insulation materials until such time a new piece of RMI could be obtained and installed. This would typically take one operating cycle (approximately 18 months).

I&M plans to update the UFSAR with this newly developed information and with other specific data that has changed since the May 31, 2008 update. I&M will complete this update by December 31, 2010, following completion of the in-vessel effects analysis. It should be noted that the current licensing basis (UFSAR) does not provide more than a minimal margin for debris sources thus preventing inadvertent increases in debris source terms inside containment prior to the planned UFSAR update.

NRC Information Item 3 – Conclusions

The Conclusions sections in Attachment 3 to Reference 1 and Attachment 3 to Reference 2 provided information regarding the alternate evaluation methodology, conservatisms and margins, and downstream effects. These topics are addressed elsewhere in Reference 1, Reference 2, and this letter. Therefore, the conclusions sections in Reference 1 and Reference 2 are considered superseded.

ATTACHMENT 5 TO AEP-NRC-2010-39

REGULATORY COMMITMENTS

The following table identifies those actions committed to by I&M in this letter. Any other actions discussed in this submittal represent intended or planned actions by I&M. They are described to the NRC for the NRC's information and are not regulatory commitments.

Commitment	**Date**
I&M will evaluate the potential for in-vessel effects in accordance with WCAP-16793, which is currently under NRC review. I&M will report the results of this evaluation.	Following NRC approval of WCAP-16793.
An update to the CNP licensing basis will be completed following receipt of the NRC letter documenting closure of GL 2004-02 for CNP, which is expected following completion of the in-vessel blockage analysis.	December 31, 2010