Entergy

Entergy Operations, Inc.
1448 S.R. 333
Russellville, AR 72802
Tel 479-858-4619

Dale E. James
Manager, Licensing
Nuclear Safety Assurance
Arkansas Nuclear One

0CAN020803

February 28, 2008

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

Subject: GL 2004-02 Preliminary Supplemental Response
Arkansas Nuclear One – Units 1 and 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6

Dear Sir or Madam:

By letters dated August 31, 2005 (0CAN080501), December 15, 2005 (0CAN120504), and October 18, 2006 (0CAN100602), Entergy provided a response to Generic Letter (GL) 2004-02, *Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors (PWRs),*" dated September 13, 2004 (0CNA090401), for Arkansas Nuclear One (ANO). By letter dated March 26, 2006 (0CNA030608), the NRC allowed licensees to provide a supplemental response to GL 2004-02 by December 31, 2007, in lieu of responding to requests for additional information dated February 9, 2006 (1CNA020601 and 2CNA020602 for ANO-1 and ANO-2, respectively).

By letter dated November 21, 2007, from the NRC to the Nuclear Energy Institute (NEI), the NRC provided a revised content guide for the GL 2004-02 supplemental responses. The content guide recommends that if a licensee cannot provide complete information by December 31, 2007 (e.g., the licensee has received an extension), that the licensee should provide all relevant information by that date. Remaining information would be provided within 90 days of completion of all actions needed to address GL 2004-02. By letter dated November 30, 2007, from the NRC to NEI, the NRC authorized licensees up to two months beyond December 31, 2007 (i.e., February 29, 2008), to provide the supplemental responses.

By letter dated November 7, 2007, (0CAN110701), Entergy requested extension of the completion dates for the ANO units which were approved by the NRC in correspondence dated December 21, 2007 (0CNA120703). The approved completion dates are by the end of April 2008 for ANO-1 and prior to the restart from the upcoming spring 2008 refueling outage (2R19) for ANO-2 with licensing basis updates within 60 days of completion dates. In accordance with the NRC's Content Guide, Entergy will submit a final supplemental response within 90 days of completion of all actions.

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Due to the complexity of the resolution of the issues associated with GL 2004-02, Entergy is still in the process of testing and analysis. This response reflects the information that is available to date recognizing that it is preliminary and subject to change. Therefore, this submittal is being provided for information only, and the final supplemental response will be provided as requested in the content guide within 90 days of completion of GL 2004-02 actions. Attachments 1 and 2 provide a preliminary supplemental response to GL 2004-02 for ANO-1 and ANO-2, respectively.

New commitments contained in this submittal are summarized in Attachment 3. If you have any questions or require additional information, please contact Natalie Mosher at 479-858-4635.

Sincerely,

DEJ/nbm

Attachments
1. ANO-1 Preliminary Supplemental Response
2. ANO-2 Preliminary Supplemental Response
3. List of Regulatory Commitments

cc: Mr. Elmo E. Collins
Regional Administrator
U. S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 400
Arlington, TX 76011-8064

NRC Senior Resident Inspector
Arkansas Nuclear One
P.O. Box 310
London, AR 72847

U. S. Nuclear Regulatory Commission
Attn: Mr. Alan B. Wang
Mail Stop O-7D1
Washington, DC 20555-0001

Attachment 1

0CAN020803

ANO-1 Preliminary Supplemental Response

ANO-1 Preliminary Supplemental Response

1. Overall Compliance

Provide information requested in Generic Letter GL 2004-02, "Requested Information," Item 2(a) regarding compliance with regulations. That is, provide confirmation that the emergency core cooling system (ECCS) and containment spray system (CSS) 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 the licensing basis has been updated to reflect the results of the analysis.

By letter dated December 21, 2007 (0CNA120703), the NRC approved a request for an extension of the completion date to the end of April 2008 with a licensing basis update by the end of June 2008. This was requested in Entergy correspondence dated November 7, 2007, (0CAN110701). In accordance with the NRC's Content Guide, Entergy will submit a final response within 90 days of completion of all actions. For ANO-1 this will be by July 30, 2008. Entergy is currently in the process of resolving remaining testing/analyses in order to achieve compliance with GL 2004-02; therefore, confirmation will be provided in the final submittal.

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). That is, provide a general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this GL.

During the spring 2007 refueling outage (1R20), the original sump screen (approximately 200 ft^2) was replaced with a new engineered strainer. The replacement strainer is a modular design and has a surface area of 2715 ft^2. A significant amount of insulation was changed with the replacement of the steam generators (SGs) during 1R19. Also, additional insulation replacements were made in 1R20.

In December 2007 a design modification was implemented to reduce the concentration of the sodium hydroxide chemical buffer. The concentration was reduced to a value within the current technical specification (TS) allowable range to support the updated chemical effects analysis and is being administratively controlled until a formal license amendment request is processed and approved by the NRC.

3. Specific Information Regarding Methodology for Demonstrating Compliance

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.**

3.a.1 Baseline Break Selection
The ANO-1 nuclear steam supply system (NSSS) is a Babcock and Wilcox two-loop pressurized water reactor (PWR). The system consists of one reactor vessel, two SGs, four reactor coolant pumps (RCPs), one pressurizer, and the reactor coolant system (RCS) piping. The NSSS system is located inside a bioshield (D-ring) consisting of two SG cavities and one reactor cavity. Each SG cavity houses one SG and two RCPs. Additionally, the north SG cavity houses the pressurizer. The outer walls of the D-ring extend from the reactor building base elevation (El.) 336'-6" to El. 424'-6". The ANO-1 sump is located on the north side of the reactor building on the 336'-6" elevation partially inside the D-ring.

The piping runs considered for breaks were the RCS hot legs, the RCS cross-over legs (piping between the RCP and SG), the RCS cold legs, and RCS attached energized piping. Breaks in these lines could decrease RCS inventory and result in the emergency core cooling system (ECCS) and/or reactor building spray (RBS) system operating in recirculation mode.

The postulated break locations are summarized as follows

- S1 SG-A hot leg in north D-ring at El. 377 ft., 36" inside diameter (ID)
- S2 Pressurizer surge line in the north D-ring at El. 364.5 ft., 8.75" ID
- S3 SG-A cross-over leg to RCP P32C at El. 371 ft., 28" ID
- S4 SG-A hot leg piping in north D-ring at El. 409.7 ft., 36" ID
- S5 SG-A cross-over leg to RCP P32C at El. 344.1 ft., 28" ID
- S6 Hot leg break in north SG cavity, 11.188" ID

Break locations comparable to these have also been modeled in the south SG cavity, with the exception of break S2 since it is located at the pressurizer and there is no similar component in the south cavity.

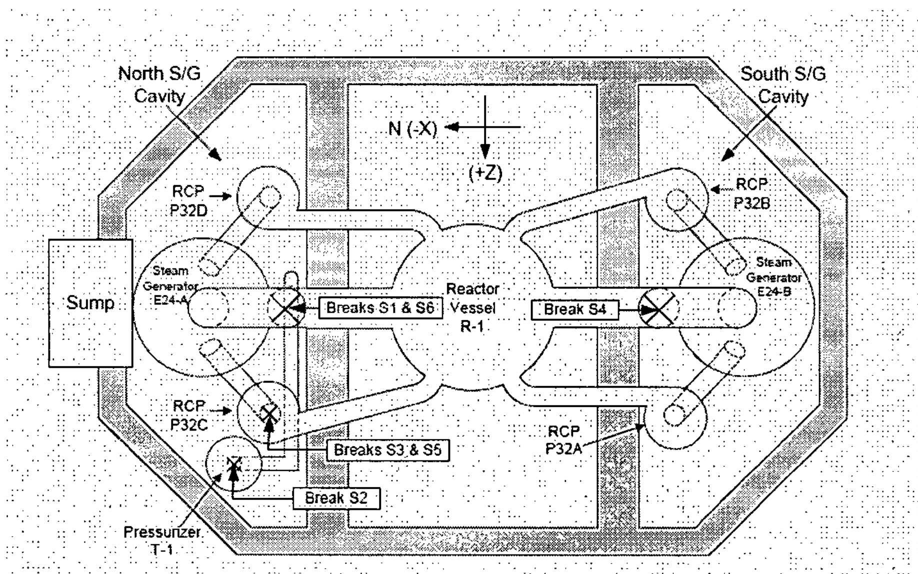


Figure 3.a.1-1 ANO-1 Break Locations

3.a.2 Secondary Line Breaks
Recirculation is not required for feedwater line breaks and main steam line breaks; therefore, breaks in the main steam and feedwater lines are not analyzed.

3.a.3 Size and Location Conclusion

The break locations have been selected to ensure that the maximum fiber debris generated with a single break and the maximum particulate debris is generated with a single break. This ensures that the analysis was bounding and presents the greatest challenge to post-accident sump performance.

The hot leg is the largest line (36-inch ID) within the SG cavity and produces the largest zone-of-influence (ZOI). Initially higher insulation debris totals existed in the north SG cavity, which includes the pressurizer. Subsequent outage modification work to reduce fiber and calcium-silicate insulation resulted in the south SG cavity having the largest insulation debris totals for both fiber and calcium-silicate insulation materials. The hot leg breaks, S1 and S4, modeled in the south SG cavity produced the greatest amount of fiber and calcium-silicate insulation debris. The upper hot leg break (S4) produced the largest release of calcium-silicate insulation; however, break S4 produced 1/3 less fiber insulation than the limiting fiber break S1. Break S1 had 15% less calcium-silicate than break S4. Since the materials did not vary greatly, the largest calcium-silicate and largest fiber combination between these two breaks was conservatively combined for qualification testing.

Also a break postulated in the cold leg suction SG E-24B to RCP P32A was taken at El. 344.5" to capture the coating on the D-ring floor. The other postulated break locations were too high to impact the reactor building floor, therefore, this break was modeled to evaluate if it produces the most particulate debris. Since the cold leg breaks did not produce the greatest amount of fiber or calcium-silicate insulation debris, to avoid running an extensive array of tests the maximum coating debris from any break was bounded in the qualification tests combined with the largest calcium-silicate and fiber amounts.

3.b Debris Generation/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/safety evaluation (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.**

3.b.1 <u>ZOI Methodology</u>
With the exception of the following inputs, the ZOI radii for insulation materials are in accordance with NEI 04-07 and its associated SE:

- Since there is no guidance regarding the ZOI for Thermal-Wrap fiber and high density fiberglass (HDFG) insulation, it was assumed that the ZOI for these materials is equal to that of unjacketed Nukon (17D). This is reasonable since the insulation is fibrous material and the ZOI for Nukon is in the upper range of tested insulation materials.

- Since there is no guidance regarding the ZOI for calcium-silicate insulation with screwed rather than banded lagging, a ZOI of 25D was utilized. This ZOI includes most of the insulation of this type in the respective SG cavity for the associated hot or cold leg breaks.

- The original Transco RMI insulation includes a few small sections with Temp-Mat insulation instead of the reflective metal foil due to reduction in available insulation thickness caused by interferences. Where this material is covered with standard Transco jacketing and fasteners similar to the surrounding RMI, then a ZOI of 2.0 is applied to this material.

- Thermal wrap insulation on pipe that has been covered with stainless steel lagging and includes banding is assumed to have a ZOI of 5.45D. This is conservatively taken from the ZOI in the SE for banded calcium-silicate insulation based on testing conducted by the Ontario Power Group (OPG). Application of this ZOI is considered conservative since stainless steel lagging is used versus aluminum lagging in the OPG tests, with the aluminum lagging having been the source of failure, as well as the thermal wrap blanket providing an additional barrier against release of the internal fiberglass batting. Exposure of the thermal wrap fabric or dislodgement of the fabric section containing the insulation would not result in release of the internal insulation unless the fabric was also breached and the internal material ejected.

3.b.2 <u>Destruction ZOI and Basis</u>
See Table 3.b.2-1.

Table 3.b.2-1 Destruction ZOIs and Basis

Debris Sources	ZOI	Basis
Transco Reflective Metal Insulation (RMI)	2.0	NEI 04-07
Thermal-Wrap Fiber	17.0	Note 1
Thermal-Wrap Fiber (SS cladding, SS banding)	5.45D	Note 1
High Density Fiberglass (HDFG)	17.0	Note 1
Calcium-silicate (SS cladding, SS bands)	5.45	NEI 04-07
Calcium-silicate (screwed lagging)	25D	Note 1

Note 1: See section 3.b.1.

3.b.3 <u>Destruction Testing</u>
The 25D ZOI for calcium-silicate insulation with sheet metal screws instead of banding is a conservative input since this distance includes most of this insulation type in the affected SG cavity, thus testing is not considered necessary to support this input.

3.b.4 Debris Type Quantity
See Table 3.b.4-1 for the four most limiting breaks.

Table 3.b.4-1 - Summary of Loss-of-Coolant Accident (LOCA)-Generated Debris

Debris Type	Units	South Break S1	South Break S4	South Break S5	North Break S1
Transco RMI Foil	ft^2	11019	4959	1032	11263
Transco Temp Mat	ft^3	2.4	0.32	0	2
Calcium-Silicate	ft^3	9.5	11.2	1.2	7.7
High Density Fiberglass Insulation (HDFG)	ft^3	12.4	12.4	12.4	4.3
Thermal-Wrap Insulation	ft^3	3.1	0	8.9	0
Penetration Fiber (Note 1)	lb	2	2	2	1.5

Note 1: Fabric blankets are installed over the RCS cold leg pipe penetrations into the SG cavities with 10% of the blanket weight assumed as fiber fines.

3.b.5 Miscellaneous Materials
The total surface area of signs, placards, tags, tape and similar foreign materials in the reactor building following efforts to remove these potential debris sources is approximately 31.8 ft^2, which is well below the 200 ft^2 allowed for foreign material blockage in the strainer qualification tests.

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.**

3.c.1 Size Distribution
Entergy utilized debris characteristics consistent with the guidance provided in NEI 04-07 for the material present in the plant. The debris types applicable to ANO-1 are provided in Table 3.b.4-1.

3.c.2 Bulk Densities
The bulk densities of materials and debris are consistent with those reported in NEI 04-07.

3.c.3 Surface Areas
Entergy did not use the NUREG/CR-6224 correlation to determine the debris bed head loss, and therefore, the specific surface area is not applicable.

3.c.4 Debris Characterization Deviations
The debris characteristics assumptions utilized do not deviate from the NRC-approved guidance.

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.**
4. **Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.**

3.d.1 Quantity Estimate
Walkdowns were performed at ANO-1 to collect samples throughout the reactor building on a wide variety of surfaces and various elevations to document potential debris in accordance with NEI 02-01. Latent debris surveys have been performed in two consecutive outages on ANO-1 with consistent results.

3.d.2 Basis for Assumptions
Per NEI 04-07, 15% of the latent debris is comprised of fiber and the remaining 85% is comprised of particulate. It was assumed that the debris is normally distributed for a given sample type. This assumption is supported by plant walkdown observations that debris distribution appeared to be uniform for a given surface type. Walkdown data was not available for grating areas. Hence conservatively, the floor attributes were applied to the grating area.

3.d.3 Evaluation Results
Based on data collected in the walkdowns, the amount of latent debris is estimated to be 122.4 lb_m. Strainer qualification testing used a latent debris loading of approximately 150 lb_m to provide margin on measured values. In addition, strainer qualification tests have included margin for both fiber and particulate material that could be allocated to address even larger latent debris totals in the future, if necessary.

3.d.4 Sacrificial Strainer Surface Area
Strainer qualification testing has assumed 200 ft^2 of surface area is blocked by miscellaneous latent debris.

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, wash down, 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 (CFD) 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.**
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.**

3.e.1 Debris Transport Methodology

The ANO-1 sump strainer qualification has been performed with a bounding case that conservatively assumes 100% transport of all debris types potentially generated following a LOCA. Additional testing may be performed that considers reduction in debris transport for increased margin purposes, and will be discussed in the final submittal as applicable.

3.e.2 Deviations

No deviations were taken from the approved guidance.

3.e.3 CFD Codes

No CFD codes were used.

3.e.4 Debris Interceptors

No credit was taken in the transport analysis for debris interceptors.

3.e.5 Settling

The debris transport fraction for fine debris was assumed to be 100%. No credit was taken for settling of fine debris.

3.e.6 Debris Transport Fractions

100% of all generated debris is considered transported to the sump following a LOCA. For debris quantities refer to Table 3.b.4-1 as well as sections 3.b.5 and 3.d.3.

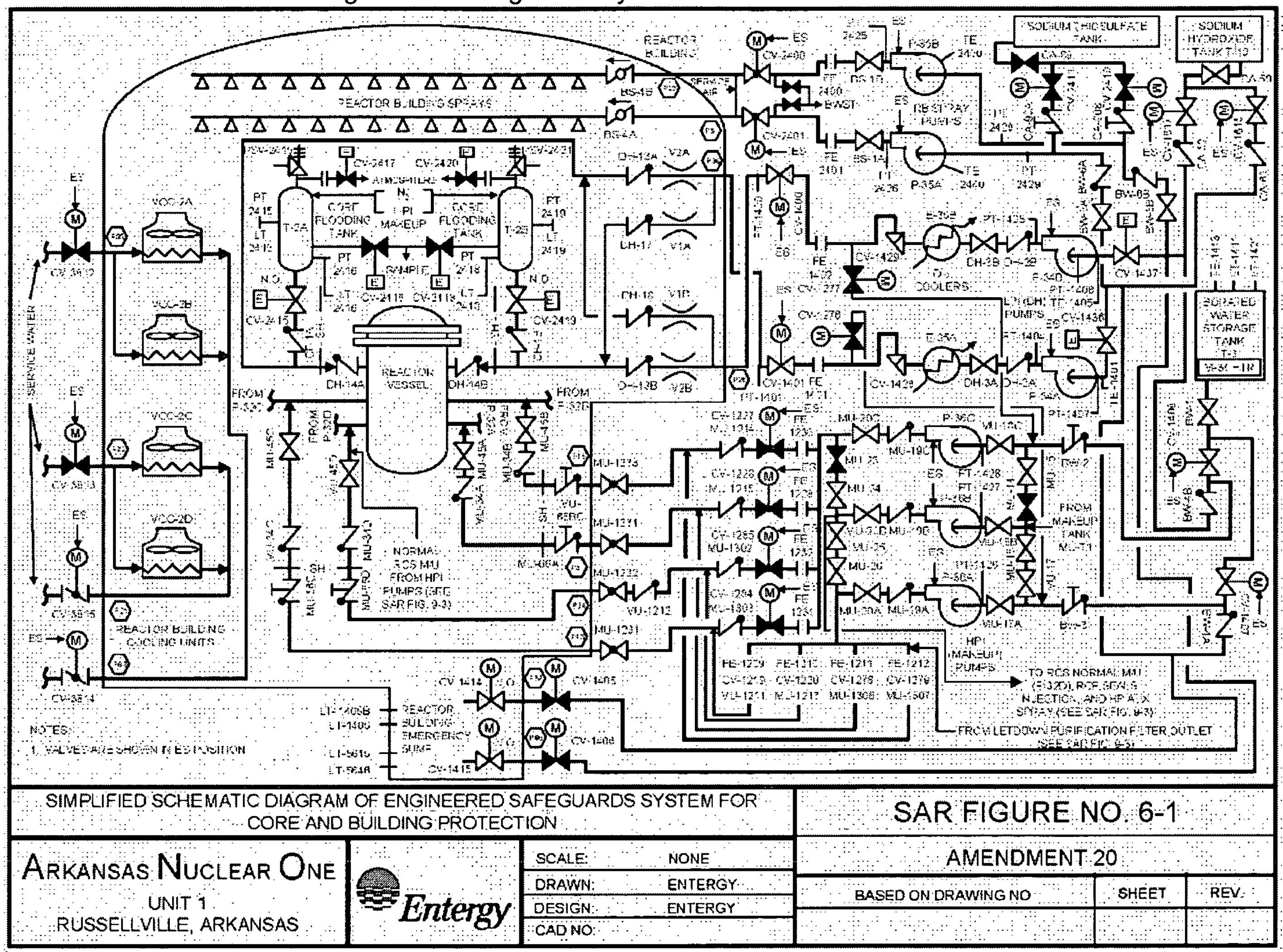
3.f Head Loss and Vortexing

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 ECCS and CSS.**
2. **Provide the minimum submergence of the strainer under small-break LOCA (SBLOCA) and large-break LOCA (LBLOCA) condition.**
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.**

3.f.1 Schematic Diagrams

Figure 3f.1-1 ANO-1 Schematic of the Engineered Safeguards System



3.f.2 Minimum Submergence
The minimum reactor building flood level (El. 341.45') determines the submergence of the strainer for both SBLOCAs and LBLOCAs. The strainer's maximum height is at El. 340.83'. Thus the minimum submergence is (341.45' – 340.83') = 0.62 feet or 7.44 inches.

3.f.3 Vortexing Evaluation
The vortexing evaluation was accomplished by comparing analytically the design parameters for the ANO-1 sump strainer design against the parameters of a proven design. The proven design relied on test data to show that vortices were not present.

In addition, the required water coverage to preclude air vortexing based on a ratio of Froude numbers was calculated for the ANO-1 strainer design and the actual performed test design. The result of the calculation shows a water level much lower than the minimum reactor building water level is necessary for vortices or air ingestion to occur.

A key assumption that was made in the vortexing evaluation is that based on previously performed tests with perforated cover plates, where the water coverage limit between the regimes of vortex/no vortex is roughly proportional to the Froude number. The Froude number is a basic physical parameter being used for the underlying physical phenomena. The actual parameter values are different for different geometries. However, the tendencies of vortex phenomena (linearity) are similar, independent of geometry. Therefore, it is concluded that the data with the relevant regimes for perforated plates can be used.

3.f.4 Head Loss Testing
Strainer qualification testing was performed at a test flume facility constructed by Fauske and Associates using strainer cartridges fabricated by CCI. The test facility consisted of two strainer cartridges installed in a tank with a recirculation pump and instrumentation for measurement of flow and head loss. The installed strainer cartridges are identical to those installed in ANO-1, with a total surface area of 54 ft^2 compared to an installed screen surface area of 2715 ft^2. An allowance of 200 ft^2 was deducted from the installed screen for foreign material debris blockage, for a net available surface area of 2515 ft^2. The surface area ratio between the test facility strainer cartridges and those installed in the plant was used to ratio the flows in the test facility and the debris quantities to be tested.

Debris materials consisted of RMI foils, calcium-silicate insulation consistent with newer calcium-silicate installed in the plant (original calcium-silicate contained asbestos fibers), high density fiberglass, thermal wrap fiberglass, zinc powder from Carboline (used for the inorganic zinc primer) and silicon carbide as a surrogate for epoxy paints and latent debris. Paint chips of Carboline were also used and were sieved to obtain a size small enough to maximize transportability but large enough to potentially block the 1/16" strainer openings. Debris preparation included pulverizing the calcium-silicate into fines, shredding the fiberglass insulation into fines and very small pieces, and shredding/crumpling the RMI foils. The fiber fines were soaked in water to have them in suspension prior to addition to the flume in order to avoid having material floating on the surface of the flume. The zinc powder was of similar size as the particles used for zinc primer and the silicon carbide was ordered as 600 mesh (9 micron average), therefore did not require processing.

Debris addition was performed in sequences with the fiber material added first and stirred as needed until essentially all material was transported into the strainer. The calcium-silicate insulation was added in discrete weight increments. The silicon carbide, zinc powder and paint chip materials were added separately from the calcium-silicate and fiber. The debris materials were stirred to achieve as close to complete transport into the strainer cartridges as possible (i.e., only trace particles or isolated paint chips visible in flume and continued stirring was not causing a head loss increase), thereby avoiding near-field settling. After head loss stability was achieved, additional calcium-silicate and/or particulate material was added to the flume in some tests to measure more than one debris load condition.

Testing was not conducted for 30 days; however, head loss was monitored to ensure maximum head loss values had been reached. The debris beds for ANO-1 include thin fiber beds of approximately 1/8" thickness if evenly distributed. Based on debris preparation that involved shredding the fibers into fines and small pieces combined with pouring this material (in a water solution) into a flowing flume, formation of a thin-bed was expected. Filtering clean-up of the test flume water provided confirmation of thin-bed type filtration combined with the elevated head loss measurements. Head loss typically remained at near zero values after the fiber was added and during initial calcium-silicate addition until a threshold was reached creating a deflection point or "knee" in the head loss curve, after which rapid increases in head loss followed small increases in debris loading. After the head-loss "knee" was exceeded, the head loss characteristics of the debris beds produced an initial peak in head loss once essentially all debris was transported into the strainer, but the head loss subsequently decreased over time to a relatively stable value.

Since the head loss characteristics of the debris bed did not show an increasing trend over time, and the early peak value was used for qualification, there was no need to run extended duration tests. The fiber bed with 100% debris loading remains relatively thin (approximately 1/8") and therefore does not support compaction due to settling or potential breakdown of fibers. The initial settling of the particulate and fiber bed resulted in a reduction in the peak head loss with a stable value typically reached within the first few hours of operation. Earlier sensitivity tests run for a few days did not provide indication that the head loss response characteristic changed with increased time, therefore qualification tests were shortened to approximately 24 hours.

3.f.5 Debris Loading

The strainer cartridges can hold the entire debris load predicted by the debris generation calculation with the exception of RMI foils. The dominant insulation type is RMI with essentially all of the RCS, SG, and pressurizer insulation being RMI. The RMI foil volume would not fit into the strainers and was found to have either non-conservative or negligible effect on strainer head loss. The material does not readily lay flat against the strainer perforated plate. It forms a three dimensional layer or pile that can act as a pre-filter that catches fibers and other debris types, keeping them off of the strainer surface. The foil can also bury insulation that is on the floor of the test facility. If the non-RMI debris is added first and time is allowed for it to enter the strainer (which is non-prototypic) then the problem of burying other insulation types under RMI can be avoided, but even in this configuration the RMI fragments would be expected to puncture and disturb the established fiber and particulate debris bed and cause a reduction rather than an increase in head loss. Final qualification tests were conducted without RMI foils.

3.f.6 Thin-Bed Effect
As noted in section 3.f.4, testing has shown that "thin-bed" formation may occur. However, the testing also shows that the effects of thin-bed formation are acceptable. The debris bed exhibited a "knee" response in the head loss with particulate loading up to a certain threshold being very non-linear (near zero) and then rapidly increasing with additional loading, particularly of calcium-silicate insulation. The test water filtered to an essentially clear condition after sustained operation, with visual observation and stirring of the test flume floor confirming that the particulate had not simply settled out.

3.f.7 Maximum Head Loss
The strainer design maximum head loss is controlled by two principal parameters; NPSH margin and structural qualification. NPSH margin appears to be the limiting parameter, particularly early in the accident response time period. The draft results from the strainer qualification tests show that the strainer head loss would remain below the available NPSH margin. Structural qualification of the strainers is discussed in section 3.k. The structural maximum differential pressure or head loss across the strainers is 10.8'.

3.f.8 Margins
Some of the more significant margins and conservatisms used in the strainer head loss calculations and strainer testing are as follows:

- Strainer tests were able to achieve much greater uniformity of debris loading than would be expected in the plant. Debris was added at the top of the test flume with flow present and stirring was used to maintain debris suspended throughout the flow path. This allowed a much greater degree of uniform debris distribution than would be expected with strainer assemblies that are over 4' in height, mounted several inches off of the floor, and oriented in four different directions. Given the relatively low available fiber and particulate loads, a non-uniform distribution of the debris would be expected to result in open screen or screen surface with such low debris content that it does not cause a pressure drop. The majority of the debris would not be expected to remain in suspension during the approximate half-hour period when the basement is filling with water. Debris traveling on the floor would have limited ability to lift multiple feet to cover the upper strainer cartridges. Qualification testing intentionally tried to achieve the worst case or most conservative results by maximizing the potential for uniform debris distribution. This controlled processing and application of the debris in the test facility is considered to be a very conservative and non-prototypic bias applied to the qualification tests.

- 100% of fiber released debris is assumed to be reduced to fines or small pieces as well as 100% transport. A significant portion of the fiber debris (other than latent) would likely be released as large pieces (40% is conservatively noted in NEI 04-07 for several types of fiber). Industry testing conducted on several fiber types have shown that erosion fractions for these large pieces are much lower than the 90% value assumed in the guidance document. A portion of the fiber debris could reasonably be expected to be trapped in grating in the SG cavity, dislodged RMI foils, or other debris in the basement region below the break. No credit for these realistic reductions in fiber loading on the strainers was applied. This conservatism is significant for ANO-1 based on the relatively low available fiber, since a fiber layer of only approximately 1/8" is present with 100% transport to the screens as small pieces and fines. Therefore, reductions in fiber loading would result in greater potential for open screen, or even if perfectly distributed, would result in a weaker debris bed that might result in lower head loss values.

- Calcium-silicate debris generation uses a 25D ZOI for unbanded material. This results in all unbanded calcium-silicate insulation in the SG cavity to be considered debris for a hot or cold leg break.

- Banded calcium-silicate assumes a 5.45D ZOI based on OPG testing performed with weaker aluminum jacketing, which was the source of failure. ANO banded calcium-silicate uses stainless steel lagging which includes banding and sheet metal screws.

- Calcium-silicate insulation was assumed to erode 100% into fines with 100% transport to the screens. Testing conducted for ANO has indicated that a significant portion of the large calcium-silicate pieces would not erode into fines. In addition, tests indicated that calcium-silicate fines would not be expected to achieve 100% transport either. No credit was taken for these reductions in calcium-silicate volume, which is a significant conservatism given the very limited amount of available calcium-silicate and its significant affect on strainer head loss. Small reductions associated with lower erosion and/or transport values or reductions due to other causes such as material trapped under RMI or in swept into inactive flow regions, if credited, could result in significant reductions in the strainer head loss based on the knee response to debris loading.

- RMI was excluded from the flume testing which is considered a non-prototypic conservatism since the large volume of potentially released RMI would be expected to bury, trap, or filter some of the other debris types and limit the material reaching the strainers.

- No hold-up of debris in inactive flow areas or capture of debris on gratings or similar areas was credited.

- Debris head loss peaks are used for analysis versus lower stable readings, even though these peaks occur soon after the relatively short, non-prototypic debris addition time period compared to the more gradual debris build-up expected post-LOCA. Thus, the resultant stable head loss readings are expected to be representative of the actual head loss that would result from gradual buildup of an equal amount of debris.

- Shadowing of debris sources is not credited in the current results. Shadowing effects from the SGs would result in a notable reduction in debris loading due to the small number of remaining lines still having either calcium-silicate or fiber insulation. Due to the low totals for each of these debris types and the observed knee response in the head loss response curve, these potential reductions represent significant potential margin. Credit for shadowing from the SGs remains under consideration and may be included in the final submittal to provide margin between tested and actual insulation volumes and/or to justify lower test results.

- Viscosity effects are under consideration. No corrections are applied to the measured head loss numbers, which provide substantial conservatism for elevated temperature head loss comparisons. This correction is being reviewed against the test results to determine if full, partial or no viscosity correction will be used in the final submittal.

The vortex analysis used test data to demonstrate that a minimum submergence of 0.035 m (1.38 inches) was sufficient in preventing vortices. This is compared to the minimum submergence of 7.44 inches. It is also noted that the conditions the test strainer was exposed to were much more severe than those credited for the ANO-1 design. This is compared numerically using the Froude number, a ratio calculated to predict the likelihood of vortices. The Froude number for the test case was 86.9 compared to the Froude number for the ANO-1 design of 2.3. The Froude numbers can be used to calculate a scaled minimum submergence of 0.0009 m (0.04 inches).

3.f.9 Clean Strainer Head Loss
The clean head loss of the strainer cartridges themselves is negligible, because the velocities in the screen holes and the cartridge channels are comparatively very low. This is confirmed via clean head loss readings taken with the strainer cartridges used in the test facility.

Once inside the strainer, the flow path is relatively unrestricted with the principal loss term associated with the exit loss assumed into the sump pit. The clean head loss without debris is less than 0.2 ft at maximum flow based on current draft calculation analysis.

3.f.10 Debris Head Loss
See section 3.f.4. Results of the strainer debris head loss testing indicate a maximum head loss of 11".

3.f.11 Submergence/Venting
The sump has a complete water seal over its entire surface and is not vented above the water level for all events requiring recirculation. Water cover over the entire surface of the sump is equal to 0.62 feet or 7.44 inches. No additional failure criteria were applied.

3.f.12 Near-Field Settling
The debris addition process during strainer qualification testing did not credit near-field settling.

3.f.13 Scaling
Scaling of viscosity to correct for temperature differences between test and accident conditions was not applied to the strainer head loss results for debris-only conditions, but is under review for application to chemical effects head loss testing. Some of the strainer tests with larger head loss exhibited blow-holes or jetting streams of water through the strainer, which tended to affect the head loss response to velocity changes. Velocity changes were made in various tests to evaluate the responsiveness of the debris bed to head loss. If poor head loss responsiveness to velocity change exists, then it is believed that a similar lack of responsiveness to reduced viscosity would also exist and therefore the test results for that condition would not be suitable for viscosity correction. The jetting effect was particularly evident with higher head loss conditions (two plus feet) combined with very thin fiber beds, which is believed to be due to the debris bed reaching a structural limitation at a given head loss with an equilibrium being reached by breaches or perforations in the bed developing. Most of the lower head loss tests did not exhibit this perforated debris bed jetting and their head loss was responsive to flow changes. These test results are considered acceptable for application of viscosity corrections based on both visual observation during the test (via lack of blow through conditions) and the responsiveness of the debris bed head loss to flow changes.

3.f.14 Accident Pressure Credit

Reactor building accident pressure was credited to show flashing does not occur within the sump strainer. Reactor building pressure was determined using the existing ANO-1 reactor building sump pressure-temperature time response curve following a LOCA. The analysis compared the absolute pressure within the strainer to the vapor pressure of the sump water at the corresponding temperature. Since the post-accident analysis of containment conditions determines sump temperatures would exceed 212°F, the water would be assumed to be at saturated conditions (i.e., at the boiling temperature) if credit is not taken for overpressure. If saturated water temperatures are assumed, then the only protection against flashing across the screens due to debris pressure drop would be that provided by submergence depth of the strainer. The temperature profile analysis shows that the sump remains sub-cooled relative to reactor building pressure and temperature throughout the event response, which provides the basis for crediting overpressure with regards to flashing.

3.g Net Positive Suction Head

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a 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.**

3.g.1 Flow Rates, Temperature, and Water Level
See Tables 3.g.1-1 and 3.g.1-2.

Table 3.g.1-1 Pump Flow and Total Recirculation Sump Flow Rates

Low-Pressure Injection (LPI) pump maximum flow* (per pump)	3547 gpm
RBS pump maximum flow (per pump)	1320 gpm
Maximum sump flow rate (two-train operation)	9734 gpm
Minimum reactor building water level (El. 341.45 ft.)	4.95 ft.

*Listed flow rate does not include 100 gpm pump protection recirculation flow.

Table 3.g.1-2 Sump Temperature vs. Time

Time (sec)	Temperature (°F)
4000	259.0
5000	252.9
6000	252.6
7000	252.7
8000	252.6
9000	252.5
10,000	252.4
20,000	245.1
30,000	237.0
40,000	230.4
50,000	223.9
60,000	219.0
70,000	213.9
80,000	208.4
90,000	202.0
100,000	197.0
200,000	175.0
300,000	162.0
400000	157.0
500000	153.0
600,000	150.0
700,000	146.5
800,000	143.0
900,000	140.0
1,000,000	136.0
2,000,000	127.5
2,500,000	123.9

3.g.2 Assumptions
The following assumptions were applied to the parameters in section 3.g.1 at the maximum time-dependent sump temperature.

- Pump flow rates represent maximum design flow rate.
- For strainer qualification testing, the scaled flows were based on a total sump flow of 10,280 gpm to ensure margin existed above the maximum analyzed values.

See section 3.g.9 for additional minimum water level assumptions.

3.g.3 NPSHr Basis
Required NPSH for the LPI and spray pumps is from the certified pump curves in the technical manuals. The specific basis for the NPSHr term provided by the pump vendor was not specified in the vendor technical documents.

3.g.4 Friction and Other Flow Losses
The sump temperature and corresponding fluid density are used to calculate the Reynolds number which subsequently is used to calculate frictional losses in suction piping for both the LPI and RBS pumps. Frictional losses through the suction piping are calculated by taking pipe dimensions and resistance factors to determine losses through the piping system. Since sump temperature varies with time, frictional loss versus time is calculated and used in the analysis.

3.g.5 System Response
System response is determined by break size and resulting RCS and reactor building pressure characteristics. The high-pressure injection (HPI) pumps and LPI pumps are actuated when RCS pressure decreases to 1585 psig and/or the reactor building pressure reaches 18.7 psia. If the reactor building pressure reaches 44.7 psia the spray system is automatically actuated.

3.g.6 Pump Status
The initial injection of water by the LPI, HPI, and RBS systems involves pumping water from the borated water storage tank (BWST) into the reactor vessel and reactor building. When the BWST reaches an indicated level of 6 feet, the operator opens the suction valves from the reactor building sump permitting recirculation of the spilled reactor coolant and injection water and closes the BWST outlet valves. HPI pumps are secured prior to transfer of pump suction to the sump for LBLOCA conditions. Therefore, the more limiting NPSH condition occurs with only LPI and RBS pumps aligned to the sump.

3.g.7 Single Failure Assumptions
The principal design criterion for the LPI and RBS systems includes separate and independent flow paths as well as redundancy in active components, to ensure that the required functions are performed if a single failure occurs. The worst-case single failure for the LBLOCA analysis is the loss of an ECCS train. For LBLOCA analyses, HPI flow is not credited due to the copious amount of cooling volume available from the core flood tanks (CFTs) and the LPI system.

The systems are designed to perform their required function assuming a single failure. For conservatism, systems that draw suctions from the reactor building sump are assumed to be operational during recirculation for purposes of evaluating sump performance and NPSH adequacy.

3.g.8 Sump Water Level
The minimum reactor building sump water level is determined by calculating three parameters:

- Gross available volume in the lower elevations of the reactor building
- Volume of structures, systems, or components (SSCs) which offset the available volume
- Volume of water which comprises the sump water inventory

Using MathCAD computing software, the three parameters are determined as a function of water level within the reactor building. In determining the volume offset by SSCs, credit was taken for volumes occupied by various tanks, supports, concrete walls, piping, miscellaneous steel, concrete, pipes, pumps, elevator etc. To determine the conservative minimum amount of sump inventory, borated water injection was equal to the design minimum, water vapor was maximized, and surfaces assumed to be wetted.

3.g.9 Conservative Assumptions

- Conservative low CFT volume is used.
- Makeup and storage tank volume is assumed to be zero.
- BWST/NaOH discharge into the RBS system is determined at the lowest operation mode volume.
- 20% tube plugging of SGs is assumed resulting in a lower sump inventory.
- Holdup in the refueling canal is taken into consideration, resulting in lower RCS inventory.
- Water trapped as steam is subtracted from RCS inventory.
- Wetted surface is maximized.
- Volume of water in air is maximized.

3.g.10 Volumes

Spray piping is assumed empty downstream of the pump discharge motor-operated valve. The minimum water level calculation accounted for water droplets using an average droplet size of 451.7 microns for RBS design flow rate during recirculation. Drag forces were calculated to determine the terminal velocity of the water droplets. An average fall height was determined based on the reactor building dome elevation rise and the spray header locations. Condensation and holdup on horizontal and vertical surfaces are accounted for by water trapped on wetted surfaces and holdup in refueling canal. Total surface area is approximately 333,000 ft^2 and assumed water thickness on wetted surface is 1/8 inch.

3.g.11 Water Displacement

The following equipment is credited with displacing pool volume:

- Two SG supports
- Reactor cavity and instrument tunnel
- Cold legs
- Columns
- Elevator shaft and walls
- Secondary shield walls
- Block walls
- Quench tank
- Letdown coolers
- Three sets of stairs

3.g.12 Water Sources

The minimum water level is determined by first calculating the water available and then subtracting the trapped water that does not reach the reactor building floor. See Tables 3.g.12-1 and 3.g.12-2.

Table 3.g.12-1 Available Water Sources for Minimum Reactor Building Water Level

Source	ft^3	gal.
CFTs	1,660	12,418
Makeup and Storage Tank	0	0
BWST	42,256	316,096
Sodium Hydroxide Tank	535	4,000
SGs	3,460	25,883
Pressurizer (Liquid)	820	6,134
Pressurizer (Vapor)	700	5,236
Reactor Inlet Piping and RCP	1,477	11,049
Reactor Outlet Piping	979	7,323
Reactor Vessel	4,058	30,356

Table 3.g.12-2 Trapped Water used in Minimum Reactor Building Water Level

Source	ft^3	gal.
Refueling Canal	1,470	10996
RCS	11,394	85233
RBS Header	374	2798

Supporting assumptions are discussed in section 3.g.9.

3.g.13 Reactor Building Accident Pressure
No credit is taken for the reactor building accident pressure in the NPSH analysis.

3.g.14 Reactor Building Accident Pressure Assumptions
This is not applicable since the reactor building accident pressure is not credited.

3.g.15 Vapor Pressure
The minimum post-accident containment pressure was set equal to the minimum pressure allowed by TS (13.7 psia). The saturation temperature corresponding to this minimum containment pressure (208.4°F) was then established as the limiting sump pool temperature for purposes of determining NPSH available. For sump pool temperatures above the limiting temperature, containment pressure is set equal to the saturation pressure (i.e., vapor pressure) corresponding to the sump pool temperature. For sump pool temperatures at or below the limiting temperature, containment pressure is set equal to the minimum post-accident reactor building pressure (13.7 psia).

3.g.16 NPSH Margin Results
The NPSH margins for the LPI and RBS pumps are listed in Table 3.g.16-1. These numbers have been calculated using zero debris/strainer head loss.

Table 3.g.16-1 NPSH Margin

	NPSH Margin (feet)
A Train LPI Pump	5.25
B Train LPI Pump	4.92
A Train RBS Pump	5.68
B Train RBS Pump	3.78

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.**

3.h.1 Coating Systems in the Reactor Building

Tables 3.h.1-1, 3.h.1-2, and 3.h.1-3 list the various qualified coatings that may exist within the reactor building.

Table 3.h.1-1 Qualified Liner Steel Coatings

COATING DESCRIPTION	COATING TYPE
Primer Coat	Ameron Dimecote 6 Carboline CZ-11
Intermediate Coat	Ameron Amercoat 90 Carboline 890 Carboline 954
Final Coat	Ameron Amercoat 90 Ameron No. 1741 Carboline Phenoline 305 Carboline No. 3912

Table 3.h.1-2 Qualified Equipment/Support and Piping Steel Coating

COATING DESCRIPTION	COATING TYPE
Primer Coat	Ameron Amercoat 90 Ameron Dimecote 6 Carboline CZ-11 Carboline 890 Carboline 954
Intermediate Coat	Ameron Amercoat 90 Carboline 890 Carboline 954
Final Coat	Ameron Amercoat 90 Ameron No. 1741 Carboline No. 3912

Table 3.h.1-3 Qualified Concrete Floor Coating

COATING DESCRIPTION	COATING TYPE
Primer Coat	Carboline Starglaze 2011S Ameron NU-KLAD 105
Intermediate Coat	Carboline Starglaze 2011S Carboline Carbocrete D1340HS Carboline 890 Carboline 954
Final Coat	Carboline 890 Carboline 948 Carboline 954 Ameron NU-KLAD 110 AA

Unqualified coatings exist on a variety of components inside the reactor building such as valves, valve actuators, instrumentation, etc. The potential volume of this material has been calculated and included in the debris total for coatings debris generation. All of the unqualified coatings are assumed to fail. No credit is taken for the Electric Power Research Institute (EPRI) original equipment manufacturer (OEM) coatings testing program.

3.h.2 <u>Assumptions in Post-LOCA Paint Debris Transport</u>
ANO testing assumed 100% transport of all coating debris materials to the sump screen.

3.h.3 <u>Suction Strainer Head Loss Testing</u>
Strainer head loss testing is further discussed in section 3.f. Coatings materials were represented by either zinc filler material or 600 mesh black silicon carbide grit for suction strainer head loss testing. The zinc filler material was provided by Carboline and is the actual zinc constituent material used in the inorganic zinc primer and thus is not considered a surrogate, but a direct representation of the potential primer coating material.

The particulate size is in the 10 micron range within the quality control limits established by Carboline for this material. Unqualified coatings and qualified coatings (epoxy top coat) were modeled with 600 mesh silicon carbide, which is approximately a 9 micron size particle and is generally consistent with the 10 micron characteristic particle size recommend to represent the coatings particles.

The measured material density for the silicon carbide was 167 lb/ft^3 or a specific gravity of approximately 2.7, which is higher than the coating material density of 94-98 lb/ft^3 noted in Table 3-3 of NEI 04-07 for epoxy and alkyd coatings. The coating densities are applicable to the cured or finished product; however, the particulate pigment densities that formulate the coatings are somewhat higher. The cured coating density includes the effect of the lighter resin binder material. For coatings that are destroyed or disintegrated into fines (i.e., 10 micron particles) the lighter binding agent is lost leaving the pigments as debris, which has a higher particle density than the cured paint.

Entergy selected the silicon carbide material as a surrogate material based on its availability in the small particle product size and density that is near that of paint pigments, and it not being chemically reactive with other debris sources in the test facility (which included consideration of chemical precipitates at the time of selection).

The selection of particulate debris to create greatest head loss impact is based on the formation of thin-bed filtration conditions during the testing. Tests for the ANO-1 strainer qualification were consistently able to establish particulate filtering thin-beds, thus, the use of particulates was considered conservative. An additional portion of paint chips (approximately equivalent to one cubic foot of paint chips in the reactor building, scaled to the flume test size) beyond the amount predicted by the debris generation calculation was also added to the test facility. It is not considered credible that all coating debris would be generated as particulate, particularly degraded qualified coatings outside the ZOI, which are assumed to fail. While the transport of paint chips is significantly less likely than the small particulate material, the addition of some portion of paint chips was done as an additional conservative measure or margin that may be credited if needed to address future coating degradation or other sources.

Strainer head loss testing was not performed exclusively for coatings materials. It was performed with all debris materials included in the test facility; therefore, strainer qualification testing and head loss results are discussed in section 3.f.4.

3.h.4 Surrogates
See section 3.h.3 for bases for choice of surrogates.

3.h.5 Coatings Debris Generation Assumptions
Entergy has utilized WCAP 16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified Coatings" for determining qualified coatings ZOI values. From this report Entergy has applied a ZOI of 4D for qualified epoxy coatings and a ZOI of 5D for qualified inorganic zinc coatings. The associated break models have assumed that qualified coatings within the 4D ZOI region have both primer (inorganic zinc) and top coat (epoxy) coatings to maximize the coating debris quantity within this region. Since only zinc primer coatings are affected in the region between 4D and 5D from the break, qualified coating steel surfaces are assumed to have only primer in this region. For areas where the actual coating thickness was not available, the coating thickness was conservatively taken as the maximum of the possible coating thickness values specified by the ANO coating specification.

For floor coating, the 4D ZOI radius was truncated in accordance with NEI 04-07 and its associated SE. The area projected on the floor and the total volume of qualified coating debris generated by each break was calculated. The reactor building wall inside the D-rings is not coated.

The quantity of steel coating debris generated by break S1 was assumed to bound the coating debris generated by breaks S2, S3, and S5 since break S1 is a break on the largest pipe (36" inside diameter (ID) hot leg) and it is centrally located within the north SG cavity, which includes the pressurizer. Thus, this volume of generated steel coating debris was conservatively applied to all breaks.

3.h.6 Debris Characteristic Assumptions
See section 3.h.3 for bases for debris characteristic assumptions.

3.h.7 Coating Condition Assessment Programs
The majority of the coatings inside of the reactor building were procured and applied as qualified coatings. Qualified coatings are controlled under site procedures. In addition, the debris generation calculation includes margin for potential detachment or failure of limited quantities of qualified coatings. Entergy repairs or assesses damaged qualified coatings to ensure that the quantities of failed coatings in the debris generation calculation are not exceeded.

Unqualified coatings have been identified by location, surface area, and thickness. The majority of unqualified coatings inside of the reactor building are component OEM coatings. New or replacement equipment is evaluated for the potential of unqualified coatings. Entergy ensures that unqualified coatings introduced to the reactor building are identified. Entergy has administrative controls in place to track the unqualified coatings to ensure that the quantity of unqualified coatings in the debris generation calculation is not exceeded.

3.i <u>Debris Source Term</u>

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 2004-02 Requested Information Item 2(f) regarding programmatic controls taken to limit debris sources in containment. That is, provide 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. Specifically, 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 10CFR50.46 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, 10CFR50.65.**

If any of the following suggested design and operational refinements given in the guidance report (section 5) and 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**

3.i.1 <u>Reactor Building Debris Generation Assumptions</u>

As part of the reactor building walkdowns used to identify potential debris sources, measurements were taken to conservatively determine the amount of latent dirt and dust inside of the reactor building. These measurements were taken at a point during the respective refueling outage where the level of dirt and dust was much higher than during normal power operation. Subsequent to the measurements being taken but prior to unit startup, extensive cleaning was performed. These cleaning activities are consistent with normal housekeeping practices and associated administrative requirements. Entergy also has a very robust reactor building cleanliness procedure.

3.i.2 Foreign Material Exclusion (FME) Programmatic Controls
Maintenance housekeeping procedures are in place to control how and what kind of materials are used within the reactor building. These procedures act to minimize the creation of foreign materials. Following refueling outages, a reactor building closeout procedure is in place to inspect the reactor building to ensure that foreign materials are not present (including the sump). Entergy also has a very robust foreign material exclusion procedure.

3.i.3 Permanent Plant Changes Inside the Reactor Building
The Entergy procedure for control of design modifications includes a list of design input considerations. This list includes specific items which address insulation and coatings in the reactor building and any modification which may affect sump performance to ensure the plant continues to meet 10CFR50.46.

3.i.4 Maintenance Rule
Maintenance activities are planned, scheduled, and implemented within the bounds of 10CFR50.65. Maintenance involving the insulation or coating is performed in accordance with engineering approved specifications. Temporary modifications are controlled using the same design input considerations a permanent modification uses.

3.i.5 Reactor Building Insulation Change-Outs
During refueling outage 1R19 (fall 2005), actions were taken to reduce potentially detrimental insulation types in the SG cavities during the SG replacement project. Fiber and calcium-silicate insulation were removed from the RCS, feedwater, and main steam piping in the SG cavities and replaced with RMI. This effort removed the vast majority of the detrimental debris materials from the SG cavities. Additional actions were taken in the 1R20 refueling outage (spring 2007) by replacing additional sections of thermal wrap fiber insulation with RMI and removing fiber insulation from piping not requiring insulation.

3.i.6 Existing Insulation Modification
Modification of existing insulation was performed during refueling outage 1R20 (spring 2007). This consisted of the addition of banding to calcium-silicate insulation lagging (original lagging fastened with sheet metal screws) to reduce the ZOI to the 5.45D noted in the guidance document.

3.i.7 Equipment/System Modification
See section 3.i.6.

3.i.8 Reactor Building Coatings Program Modification
A site procedure controls ANO commitments related to its safety-related coatings program. This procedure provides the minimum requirements at ANO to ensure that coatings are properly selected, applied, and maintained so the coatings can perform their intended function without negatively impacting the safety functions of other SSCs. This procedure addresses the activities related to service-level I coatings inside the reactor building where the coating failure could adversely affect the operation of the post-accident fluid systems and thereby impair safe shutdown.

3.j Screen Modification Package

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.**

3.j.1 Sump Screen Design Modification

The sump screen design modification removed the original sump screen, vortex eliminator, carbon steel divider plate, and concrete curb with scuppers. The original screen was replaced with a new CCI strainer assembly. The new strainer assembly consists of modular screen cartridges with perforated 1/16 inch holes. The screen fits over the sump and has a footprint which is slightly larger than the nominal dimensions of sump. The new replacement strainer has a surface area of approximately 2715 ft^2compared to the original screen area of approximately 200 ft^2.

The stainless steel materials for the new components are more resistant to corrosion than the original carbon steel and provide improved performance with lower maintenance. The bottom of the strainer floor plate is approximately 1" higher than the reactor building floor. A stainless steel divider plate similar to the original divider plate was installed inside the strainer. The divider plate has a stainless steel screened mesh opening between the two sump halves consisting of 0.132 inch (nominal) square openings.

The new sump strainer assembly and divider plate (including the integral screen) was fabricated from stainless steel to preclude corrosion and eliminate the need for protective coatings. The original vortex eliminator was removed and not replaced.

3.j.2 Related Modifications

In order to lower the profile of the strainer so that it remains well below the water level, the original concrete curb surrounding the sump was removed. This curb contained scuppers so that water around the edges of the sump flow into the sump. When the curb was removed to keep the new strainer as low as possible, the scuppers were removed with it. To prevent ponding due to the new strainer edge thickness (less than 2"), new drains with integral filters were bored to allow water around the edge of the sump to flow into the sump.

3.k Sump Structural Analysis

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 Requested Information Item 2(d)(vii). GL 2004-02 Requested Information Item 2(d)(vii) 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 back-flushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.**

3.k.1 Design Inputs, Design Codes, Loads, and Load Combinations
See Tables 3.k.1-1, 3.k.1-2, and 3.k.1-3 parameters.

Table 3.k.1-1 Structural Qualification Source Documents

Input Document	**Description of Input**
ANO-1 Specification APL-C-501, Revision 2, Earthquake Resistant Design of Structures and/or Components Located in the Unit 1 Reactor Building	Seismic response spectra for the sump strainer structure
AISC, "Manual of Steel Construction, Allowable Stress Design," 9th Edition	Provided allowable stresses for normal and upset conditions. Faulted stresses were limited to the following: $0.90 \cdot F_y$ for tension and bending $0.50 \cdot F_y$ for shear (F_y = specified minimum yield strength) $0.50 \cdot P_{cr}$ for compression where P_{cr} = critical load (elastic or inelastic)
2004 ASME Boiler & Pressure Vessel Code, Section II; Part D – Properties	Provided yield and ultimate stresses for materials used based on design temperature for each load case.
ANO Design Guide, SES-18, Revision 2, "Concrete Anchor Bolt Design Criteria"	Provided allowable anchor bolt loads.

Table 3.k.1-2 Structural Load Combinations

Load Case	**Temperature (°F)**	**Load Combination**	**Load Category**	**Stress Limit Factor**
1	284	DL	NORMAL	1
2	120	DL+ E	UPSET	1
3	284	DL+ E'	FAULTED	1.5
4	255	DL+ E' + SLOSH	FAULTED	1.5
5	60-255	DL+ DL_D + E' + Δp + SLOSH	FAULTED	1.5
6	80-87	DL + SHLD	NORMAL	1

Table 3.k.1-3 Nomenclature

DL = Dead Load	Δp = Pressure differential across the screen
E = Operating Basis Earthquake (OBE)	DL_D = Debris Load
E' = Design Basis Earthquake (DBE)	SHLD = Temporary shielding (outages)
SLOSH = Water sloshing due to E'	

OBE and DBE loads were determined using site response spectra for the appropriate elevation. Design temperatures for the ANO-1 sump structure can be summarized:

- Minimum sump water temperature during recirculation = 60°F
- Maximum sump water temperature during recirculation = 255°F
- Maximum reactor building air temperature, normal = 120°F
- Maximum reactor building air temperature, accident = 285°F

In addition to these load cases, the effects of temperature, differential seismic movement, hydrodynamic water masses, and buoyancy were addressed in the calculation.

3.k.2 Structural Qualification Results
During the installation of the new ANO-1 sump strainer, columns were added to stiffen the main framing members. The analysis determined the maximum differential pressure that the screens and screen structure could sustain and remain code qualified is 10.8 feet of water (4.70 psi). This is considerably greater than the maximum head differential margin for NPSH.

3.k.3 Dynamic Effects
Also see section 3.k.1. There are no credible jet impact hazards to the reactor building sump strainer. There are no credible pipe whip effects to the sump. Walkdowns concluded that there are no credible missiles.

3.k.4 Back-Flushing
A back-flushing strategy was not credited for ANO-1.

3.l Upstream Effects

The objective of the upstream effects assessment is to evaluate the flow paths upstream of the containment sump for holdup of inventory, which could reduce flow to and possibly starve the sump. Therefore, provide a summary of the upstream effects evaluation including the information requested in GL 2004-02, "Requested Information," Item 2(d)(iv) including 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 flow paths.

1. **Summarize the evaluation of the flow paths from the postulated break locations and containment spray wash-down 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 was evaluated, including likelihood of blockage and amount of expected holdup.**

3.l.1 Choke Points
The sump pit is located below the north SG cavity at an opening on the north side of the D-ring wall. The flow path from a postulated break in the north cavity remains inside that cavity. The flow path from a south cavity break is from that cavity into the basement region between the two SG cavities and then flowing into the sump strainer both through the north SG cavity and around the outside wall to the opening where the sump is located. RBS wash-down would fall through gratings to the basement from the areas inside and outside the SG compartments. Spray flow falling into the refueling canal region drains through an open 6" pipe connection into the reactor cavity and incore tunnel and out through a locked open hatch into the basement. The refueling canal reactor cavity drainage paths have been evaluated to show that no potential debris blockage exists. Additionally, no credit is taken for flow through normal floor drains; therefore, no measures are necessary to mitigate potential choke points because none exist.

3.l.2 Choke Point Mitigation
No curbs and/or debris interceptors are present and no flow choke points exist.

3.l.3 Water Holdup
There are no curbs or debris interceptors installed. Therefore, no water holdup analysis for these structures is necessary.

3.l.4 Reactor/Refueling Cavity Drain Blockage
The refueling canal drainage path has been evaluated for potential debris blockage. No additional water hold-up beyond that currently assumed in the reactor building minimum level analysis was found to be necessary. No hold-up occurs in the reactor cavity as it is drained through a large open man-way.

The characteristics of the post-LOCA debris generated and deposited into the refueling canal do not obstruct drainage of RBS water inventory from the refueling canal to the reactor building sump. A maximum of approximately 11,000 gallons of RBS water is conservatively assumed to be retained in the refueling canal during post-LOCA conditions, based on spray flow that may fall into the refueling canal and the calculated head to support this flow rate out of the 6" drain line in the wall of the deep end. The refueling canal drain is configured to draw water from above the refueling deep end floor. RBS drainage flow in the refueling canal does not transport large and small debris. Large and small debris would rest on the refueling canal floor with the expected drain flow rate. Fines and floating debris would be carried in the drain stream without obstructing or plugging the 6" drain path. Complete blockage of the refueling canal deep end drain by post-LOCA generated debris is not credible based on the drain size, location, and geometry. Although large debris may migrate to the incore instrumentation tunnel access hatch opening during initial basement fill, it is not credible for large debris to be lifted up and block the open hatch.

3.m Downstream Effects - Components and Systems
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 2004-02, "Requested Information," 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 by explaining 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 flow paths 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. Also, provide 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, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191", with accompanying NRC SE) briefly summarize the application of the methods.**
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.**

3.m.1 NRC-Approved Methods
The approved methodology as documented in WCAP-16406-P and the accompanying SE is being utilized for the downstream effects analysis which is still in progress. Adverse blockage of downstream components has been evaluated by considering opening or gap sizes for components compared to the extremely fine (1/16") screen mesh size used in the sump strainer.

Blockage and wear concerns are being evaluated, and preliminary results indicate no problems requiring additional modification to the plant.

3.m.2 Downstream Evaluations
Analysis to evaluate downstream effects is currently in progress. However, preliminary results show no unacceptable conclusions for evaluated components.

3.m.3 Design/Operational Changes
Although analysis of downstream effects is in progress there are neither designs nor operational changes anticipated. This conclusion is based upon analysis per WCAP-16406-P prior to the NRC's SE of that document and draft results from the ongoing revision to that analysis.

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 comments on that document. Provide a basis for any exceptions.**

3.n.1 In-vessel Effects
The effects analysis for fuel and reactor vessel flow paths is in progress at this time.

3.o Chemical Effects
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. **Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425).**
   - **2.1 Sufficient 'Clean' Strainer Area**
     - **i. 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.**
   - **2.2 Debris Bed Formation**
     - **i. 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.**

2.3 Plant Specific Materials and Buffers

i. **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.**

2.4 Approach to Determine Chemical Source Term (Decision Point)

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

2.5 Separate Effects Decision (Decision Point)

i. **State which method of addressing plant-specific chemical effects is used.**

2.6 AECL Model

2.7 WCAP Base Model

i. **For licensees proceeding from block 7 to diamond 10 in the Figure 1 flow chart [in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425)], 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.**

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

2.8 WCAP Refinements: State whether refinements to WCAP-16530-NP were utilized in the chemical effects analysis.

2.9 Solubility of Phosphates, Silicates and Aluminum Alloys

i. **Licensees should clearly identify any refinements (plant-specific inputs) to the base WCAP-16530 model and justify why the plant-specific refinement is valid.**

ii. **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.**

iii. **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.**

iv. **Licensees should list the type (e.g., AlOOH) and amount of predicted plant specific precipitates.**

2.10 Precipitate Generation (Decision Point)

i. **State whether precipitates are formed by chemical injection into a flowing test loop or whether the precipitates are formed in a separate mixing tank.**

2.11 Chemical Injection into the Loop

i. **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.**

- ii. 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.
- iii. 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).

2.12 Pre-Mix in Tank

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

2.13 Technical Approach to Debris Transport (Decision Point)

- i. State whether near-field settlement is credited or not.

2.14 Integrated Head Loss Test with Near-Field Settlement Credit

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

2.15 Head Loss Testing Without Near-Field Settlement Credit

- i. 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.
- ii. 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).

2.16 Test Termination Criteria

- i. Provide the test termination criteria.

2.17 Data Analysis:

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

2.18 Integral Generation (Alion)

2.19 Tank Scaling/Bed Formation

- i. Explain how scaling factors for the test facilities are representative or conservative relative to plant-specific values.
- ii. Explain how bed formation is representative of that expected for the size of materials and debris that is formed in the plant specific evaluation.

2.20 Tank Transport

- i. Explain how the transport of chemicals and debris in the testing facility is representative or conservative with regard to the expected flow and transport in the plant-specific conditions.

2.21 30-Day Integrated Head Loss Test

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

2.22 Data Analysis Bump-Up Factor

- i. 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.

3.o.1 Evaluation Results
The ANO-1 approach to chemical precipitate analysis is two-fold. Testing has been conducted with the strainer test flume by Fauske and Associates to determine the combined effects of chemical precipitates and insulation debris; however, the analysis is not complete at this time. Testing has also been conducted by Westinghouse in an autoclave device to characterize the expected time periods that potential chemical precipitates may develop given a plant-specific debris mix.

The results of the combined debris and chemical precipitate tests indicate that for two-train full flow unacceptably high head loss may develop if all of the chemical loading is assumed to be present in the early accident response period when sump temperatures are elevated. Application of viscosity correction to the test data may show acceptable results for this condition, however it is not considered credible that a substantial portion of the predicted chemical precipitates would be present in the early accident response time period. The autoclave tests conducted by Westinghouse show both smaller amounts of chemical precipitants and a delay in the appearance of these materials.

The occurrence of chemical precipitates after the sump temperatures are lowered is significant since considerable NPSH margin would be present with lower sump temperatures due to the vapor pressure difference between the sub-cooled water temperature and reactor building pressure. Since credit is not taken for increased building pressure following a LOCA when determining available NPSH, the vapor pressure margin is assumed to be zero when sump temperatures are at or above 208.4°F (the saturation temperature at the minimum TS-allowed reactor building pressure of 13.7 psia). Below this temperature the difference in vapor pressure begins to add substantial NPSH margin such that the principal head loss limitations for conditions are related to the structural stress limits for the strainer, which are 10.8 ft. of differential pressure.

Combination of the two test results show that the additional head loss associated with chemical precipitates are acceptable based on most of this detrimental effect occurring at low temperatures when structural limitations on head loss are the limiting term. The chemical effects tests show acceptable results with full debris loading relative to the structural head loss limit of 10.8 ft.

3.o.2.1.i Sufficient 'Clean' Strainer Area
A simplified chemical effects analysis was not performed; therefore, this section is not applicable.

3.o.2.2.i Debris Bed Formation
The break selected for chemical effects testing was a conservative composite of the maximum fiber, calcium-silicate, and paint debris loading from three different breaks to achieve the maximum fiber and particulate loading for testing. Due to the limited amounts of non-RMI insulation debris types the fiber bed is of the thin-bed type even with the maximum fiber load. Use of maximum debris loading produces the largest initial head loss, prior to the addition of chemical precipitates, and produces the most structurally robust debris layer on which to capture the chemical precipitates. Test experience with thin-bed debris layers indicates that head loss would become limited due to perforations in the debris that relieve pressure. Since ANO-1 only produces thin-bed debris conditions, the use of maximum debris loading is considered conservative for achieving maximum possible head loss.

3.o.2.3.i Plant Specific Materials and Buffers
ANO-1 uses NaOH as the buffer. The only chemical precipitates predicted by the WCAP-16530 models are associated with aluminum compounds; therefore, the potential formation of aluminum precipitates is being addressed.

The pH evaluated for ANO-1 chemical effects is from a maximum of 9.0 to a minimum of 7.0. These limits are supported by analysis as limitations for the post-LOCA environment. Published data, as well as results of autoclave testing, show that aluminum corrosion has a significant dependency on pH, with corrosion rates increasing as pH increases. On the other hand, aluminum solubility decreases significantly as pH is lowered. Temperatures produce similar impacts on aluminum corrosion (higher at high temperatures) and solubility (lower at low temperatures). Since the WCAP-16530 model does not assume any solubility of aluminum it was conservatively modeled with maximum pH and the maximum equipment qualification (EQ) temperature profile, since those inputs produce the largest amount of predicted aluminum corrosion and therefore the greatest amount of precipitates.

The integrated tests run in the autoclave required more complex inputs due to the conflict created by trying to conservatively maximize both aluminum corrosion, which requires high pH and temperatures, and maximize precipitation (or minimize solubility), which requires minimum pH and temperatures. The allowed pressure drop across the sump strainer is limited by NPSH margin condition at elevated temperatures and by strainer structural limitations as temperatures decrease. Regardless of the time frame of the temperature decrease, the head loss margin profile (that is available to address screen head loss) is not changed. The autoclave tests were therefore structured with the maximum EQ temperature profile to maximize aluminum corrosion, other than near the end of the test when the ending temperature was reduced to near ambient conditions (approximately 80°F) to lower solubility.

While the sump pH can range between 7.0 and 9.0, this variation is almost entirely based on starting condition assumptions that affect the initial sump pH, with only a very small (<0.25) reduction from the starting pH over the course of the mission time due to acids generated post-LOCA. If the starting pH was near the upper limit of 9.0 at the beginning of the event, it would not decrease to 7.0 over the 30-day window, but only to about 8.8. Similar reductions would exist for other starting pH values. To evaluate the potential range of conditions two autoclaves were tested, one with a pH of 9.0 and the other with a pH of 8.0. The samples from each autoclave were tested at the test pH, as well as at two step reductions of 0.5 and 1.0 lower pH. This allowed comparison of the effects of different maximum starting pH values and the impact of pH reduction on both the amount of aluminum generated (i.e., corroded) and the resultant amount of precipitate formed.

Samples were drawn for chemical analysis and filtration effects testing to determine if chemical precipitates existed at time periods of one day, two days, three days, five days, and seven days. Earlier autoclave tests run for 30 days indicated that the aluminum corrosion was occurring during the elevated temperature conditions. Changes that occurred in the lower temperature region were not associated with continued release of materials but from precipitation associated with the temperature reduction. The temperatures at the end of seven days are already substantially reduced (i.e., approximately 150°F based on single train response), therefore the autoclave temperature profile was adjusted to ramp temperatures down to approximately 80°F over the last two days to provide a somewhat gradual temperature reduction, but significantly accelerated compared to the three-plus weeks associated with the 30-day mission time profile.

Containment spray is conservatively assumed to remain in operation for the full 30-day mission time. EOP guidance is provided for securing spray pending meeting specified conditions. While these conditions are highly likely to be met well before the end of the 30-day period, no credit is taken for securing spray or even reducing to single train operation for sump analysis. Materials evaluated for chemical response were based on the inputs to the WCAP-16530 model.

3.o.2.4.i Chemical Source Term
Plant-specific chemical testing was performed by Fauske and Associates for field testing of strainer head loss with chemical precipitates and debris. Plant-specific chemical testing was conducted by Westinghouse for autoclave analysis of potential chemical precipitates.

3.o.2.5.i Separate Effects Decision
The method of testing is described in section 3.o.1.

3.o.2.6 AECL Model
Entergy used CCI as the strainer vendor.

3.o.2.7.i WCAP Base Model Deviation
The base model of WCAP-16530 was used to predict the amount of chemical precipitate produced. However, as noted in section 3.o.1, the results of autoclave testing were also used to determine chemical precipitate loading. While strainer testing was conducted with the full WCAP-16530 predicted chemical precipitate loading, the autoclave test results establish that the full chemical loading does not occur early in the accident response period when pump NPSH margin is the limiting factor for strainer head loss, but after sump temperatures have been sub-cooled. Therefore, the strainer head loss associated with the WCAP-16530 chemicals is compared against the strainer structural margin (10.8 ft), which is the limiting factor for strainer head loss after sump temperatures are reduced. Due to difficulty meeting the settling criteria for aluminum oxyhydroxide material, the flume testing was conducted with only sodium aluminum silicate materials. Based on test results and bench-top comparison tests of the two precipitates, this change is not believed to affect the final results.

3.o.2.7.ii WCAP Base Model Precipitates
Predicted plant precipitates using the WCAP-16530 base model are approximately:

- Sodium Aluminum Silicate ($NaAlSi_3O_8$): 100 kg
- Aluminum Oxyhydroxide (AlOOH): 82 kg

3.o.2.8.i WCAP Refinements
The refinements provided in the WCAP were not utilized.

3.o.2.9.i Solubility Refinements
Refinements to the overall approach from a simple direct application of WCAP-16530 predicted chemical precipitates have been applied. The basis for the refinements is the extreme conservatism of the WCAP-16530 model with regard to the timing of precipitate formation, largely due to ignoring solubility affects. As an example, the WCAP-16530 model predicts that over half of the chemical precipitates would have been formed in the first nine hours of the start of an accident. While it is true the aluminum release rate would be high due to conditions promoting rapid corrosion during the elevated temperatures and assumed maximum pH condition, these same two factors that support high aluminum corrosion rates would also support high aluminum solubility, relative to the concentrations that could exist.

The timing of the chemical precipitate formation is the principal refinement that is being applied based on testing conducted for ANO site-specific conditions. The formation of precipitates after the sump temperature has decreased is a more realistic condition, which is supported by integrated test results. This shift in precipitate formation timing is significant due to the additional NPSH margin that exists from a sub-cooled sump.

3.o.2.9.ii Crediting Aluminum Inhibition
Credit is not taken for aluminum inhibition. The calcium-silicate insulation volumes potentially impacted by a LBLOCA combined with other potential silica sources are insufficient to reach the concentrations needed to support aluminum passivation.

3.o.2.9.iii Solubility Credit
Solubility credit is being taken for the primary purpose of the timing of chemical precipitate formation. The series of autoclave tests conducted by Westinghouse establishes that almost all of the chemical precipitate formation is occurring after the sump temperatures have decreased significantly. The tests used upper bounding values to conservatively maximize aluminum corrosion and also simulated conservative reductions in those conditions to maximize precipitate formation. The testing included simulation of pH buffering at various temperatures throughout the test period to ensure that the impact of potential pH reduction occurring at any time during the post-accident mission time are addressed. Since it is not possible to have both the maximum and minimum conditions of temperature and pH occurring simultaneously, it is appropriate to consider the impact of variation of these variables on chemical effects formation.

The overall chemical effects evaluation remains significantly conservative and the composite head loss analysis considering debris and chemical effects is even more conservative. The overall analysis includes a large number of stacked conservative inputs, which are assumed concurrently. For a plant such as ANO-1 with relatively small potential sources of fiber and particulate debris loading, several of the conservative inputs could by themselves reduce head loss to clean screen values. Sources of conservatism relative to the debris generation and head loss testing have been noted previously in section 3.f.8. In addition to those conservative approaches, the composite evaluation of margin with chemical effects contains additional conservatisms, including the following:

- Most aluminum corrosion occurs at elevated temperatures. Autoclave and WCAP-16530 model inputs for post-accident temperature profiles are based upon an assumed single failure of a train of equipment in order to achieve the most conservative (i.e., highest) temperature profile. Strainer testing is based upon assumptions of two trains of equipment in service at maximum flow. Reduced time at elevated temperatures would result from modeling two-train accident response, or if single train flow through the sump were assumed, the head loss would be significantly reduced by the lower flow rate.

- Sump flows assumed for chemical effects impact on screen head loss are not reduced from initial peak values, even though the chemical effects are shown to occur at lower temperatures. Securing of one or both spray pumps as well as one train of LPI is a reasonably expected operator response prior to reaching near ambient temperature conditions, but is not credited. Therefore maximum flows continue to be evaluated.

- Chemical surrogates were added in the test flume directly in front of the strainer cartridges and stirring of the water in the test flume was performed after addition to maintain the precipitates in solution to maximize transport into the strainer. The assumed full transport of the chemical precipitate material as well as mixing to minimize near-field settling type behavior is believed to be a conservative treatment of the material.

- Pump flows for both NPSH considerations and sump flow head losses are taken at conservative maximum bounding values including potential instrument errors associated with spray pump throttling performed prior to sump recirculation.

3.o.2.9.iv Predicted Plant-Specific Precipitates
Testing was performed with the precipitate quantity associated with the WCAP-16530 base model as noted in section 2.o.2.7.ii. Additional detail regarding the amount of precipitate predicted by the autoclave testing will be included in the final submittal.

3.o.2.10.i Precipitate Generation
Precipitates for strainer head loss testing were formed outside the test facility loop in accordance with guidance of the WCAP documents and adjusted settling criteria defined by the SE.

3.o.2.11.i Chemical Injection Precipitate Volume
The one hour settled volumes for sodium aluminum silicate precipitates were 8.5 to 9 ml for a 10 ml sample which remained cloudy. Preparation was in accordance with WCAP-16530.

3.o.2.11.ii Injected Chemicals
Plant specific chemical injection tests were not conducted versus preparation per WCAP-16530 guidance.

3.o.2.11.iii Added Precipitate
Testing included addition of approximately 112% of the aluminum precipitate, however, due to difficulty meeting the settling criteria for aluminum oxyhydroxide material, the flume testing was conducted with only sodium aluminum silicate materials. Based on test results and bench-top comparison tests of the two precipitates, this change is not believed to affect the final results.

3.o.2.12.i Pre-Mix in Tank
No exceptions were taken to the procedure recommended for surrogate precipitate formation in WCAP-16530.

3.o.2.13.i Near-Field Settlement
Near-field settling in the test flume was not credited. Stirring of the test flume water was performed as-needed to achieve transport of the added debris into the strainer cartridges. Acceptance was based on visual observation through the clear panels of the flume to confirm that only trace amounts of particulates or isolated paint chips remained outside the strainer. Stirring was also used with the chemical precipitates. However, a settled layer of chemical precipitate material would reform in the flume after stirring. Based on the head loss not changing in response to multiple stirring periods when a large portion of the chemical precipitates were in the flume, the affect of this settling of chemical precipitates was determined to not adversely impact the maximum head loss indicated. Chemical precipitates were also observed on horizontal surface downstream of the strainer, indicating that at least a portion of the material was passing through the strainer.

3.o.2.14.i Near-Field Settlement Values
This is not applicable since near-field settling was not credited.

3.o.2.14.ii Surrogate Chemical Debris Settlement
See section 3.o.2.13.i.

3.o.2.15.i Debris/Precipitate Without Near-Field Settlement Credit
See section 3.o.2.13.i.

3.o.2.15.ii Precipitate Values Without Near-Field Settlement Credit
The one-hour settled volumes for sodium aluminum silicate precipitates were 8.5 to 9 ml for a 10 ml sample which remained cloudy. Testing was performed within 24 hours of precipitate mixing with preparation in accordance with WCAP-16530.

3.o.2.16.i Test Termination Criteria
The strainer head loss had ceased showing an upward trend. Additional chemical precipitate addition ceased increasing the head loss after an earlier plateau value had been reached. Acceptance would be established based on the maximum plateau head loss, with subsequent values trending downward.

3.o.2.17.i Pressure Drop Curve as a Function of Time
Pressure drop curves will be provided in the final submittal.

3.o.2.17.ii Extrapolation Methods
Due to limitations of the test facility for elevated head loss measurement, the testing could not all be conducted at maximum flow conditions. The test facility is configured with a set of CCI strainer cartridges attached to a vertical divider plate in a test tank. The head loss across the strainer results in a physical elevation difference across the divider plate. The head loss is limited by the recirculation pump suction pipe elevation needing to remain covered. To maintain the head loss within the limits of the test facility, flow was lowered when level behind the strainer began to approach the suction pipe. Chemical precipitate continued to be added in 5% to 10% increments until full chemical loading was complete. Head loss response to flow changes was checked at two subsequent times after the flow reduction, once with 25% of chemicals added and after 100% of the chemicals were added. The measured head loss continued to respond to flow changes. Flow was maintained at approximately 50% of maximum values (equivalent to one train in service) for the later debris additions and the largest measured head loss under these conditions was approximately 1.36 psid or 3.14 ft. The response to flow increase at 25% chemical load was approximately directly proportional with a doubling of flow doubling the head loss. At 100% chemical loading the head loss response was slightly greater than a 1:1 proportion, although a more limited range of flow increase was compared due to reaching the test facility measurement limits after in increase of about 30%. While it is likely that the debris bed would have reached a maximum head loss limit caused by perforations (i.e., blow holes or jetting conditions) before this trend could be extrapolated up to doubling the flow, it is conservative to assume the rate of increase would be sustained. Thus, the peak head loss is extrapolated to be approximately 7.6 ft. at two-train full flow conditions with full chemical loading. Since the peak chemical loading is expected to occur when temperatures are lowered to near ambient, no viscosity corrections are applicable.

3.o.2.18.i Integral Generation
Entergy did not utilize Alion methodology.

3.o.2.19.i Scaling Factors
The test facility scaling factors were determined from the ratio of surface area of strainer in the test facility to surface area of strainer installed in the plant (minus area allowance for foreign material debris blockage of 200 ft^2). The tested strainer cartridges are identical to those installed at ANO-1, therefore the only scaling of the strainer was associated with the area of the two cartridges in the test facility compared to the area of those installed in the plant. Since credit was not taken for near-field settling, the flow through the test facility was also scaled based on the strainer area ratio, to establish a velocity through the strainer openings consistent with what would be present with the installed strainer. The debris and chemical loading was determined using this same scaling ratio.

3.o.2.19.ii Bed Formation
The debris bed formation is described in section 3.f, with a non-prototypic conservative bias used to build a debris bed to generate maximum head loss.

3.o.2.20.i Tank Transport
Since near-field settling was not credited, the transport characteristics of the test facility are not applicable. Debris was added in sequential steps into flowing water with stirring used to maintain material in suspension until it was transported into the strainer cartridges.

3.o.2.21.i 30-Day Integrated Head Loss Test Conditions
Test conditions for the integrated test included the full debris bed loading predicted by the debris generation calculation. Flows were evaluated at bounding maximum values for two-train operation. Chemical precipitate loading equal to greater than 100% of the total mass of precipitates was tested, although sodium aluminum silicate was used to represent the chemical effects. The base WCAP-16530 model predicts that 55% of the precipitates would be sodium aluminum silicate and 45% would be aluminum oxyhydroxide. The test results did not show an increase in maximum head loss after approximately 50% of the chemicals were added in the test flume, with subsequent chemical additions resulting in either no change or a slight decrease in head loss. Ample excess precipitate was visually evident in the test flume, since it could be observed to settle, but stirring did not result in any change to the measured head loss. Comparison of bench-top filter time tests was also performed between the two types of aluminum precipitates. Based on that comparison, the introduction of excess precipitate quantity, and the lack of detrimental results from additional chemical precipitates, the use of a single chemical effects surrogate is acceptable.

The test duration was not 30 days; however, the test did bound a maximum head loss value, with continued operation resulting in a decrease rather than an increase in head loss. The chemical precipitates were also not added in one batch or over one day. Due to the relatively large amount of chemical precipitate predicted by the WCAP-16530 base model, preparation of 100% of the chemical materials was not practical in a short time period. Autoclave test results indicated that most of the precipitate would not be expected to form until sump temperatures began to cool, thus a more gradual addition is considered more prototypic of plant conditions. Chemical precipitates were added in 5% to 10% increments of the total loading. Early additions provided rapid and significant head loss increases, although the last significant increase occurred when the concentration was raised from 30% to 40% of the total and a peak value was reached between 50% and 60% of the total, with slightly declining head loss afterwards. The test facility loop was run for 14 days during the integrated chemical precipitate testing.

The test results provide bounding and conservative values for potential strainer head losses both with and without chemical effects. This is based on conservative application of each of the test inputs. An extensive array of tests were conducted to provide an accurate understanding of the head loss characteristics of various types and quantities of debris as well as of the chemical precipitates that may form in a post-LOCA environment. The combined effects of these materials were tested in a conservative manner with the most limiting results used for acceptance.

3.o.2.21.ii Pressure Drop Curve as a Function of Time
Pressure drop curves will be provided in the final submittal.

3.o.2.22.i Bump-Up Factor
Entergy did not use Alion methodology.

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 2004-02, "Requested Information," Item 2.(e) regarding changes to the plant licensing basis. That is, provide 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 generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10CFR50.59 evaluation for the change to the licensing basis.

The NaOH tank concentration was reduced to a value within the current TS allowable range to support the updated chemical effects analysis and is being administratively controlled until a formal license amendment is requested. A license amendment will be submitted following completion of analysis to support chemical effects testing. Additional changes will be made to the ANO-1 Safety Analysis Report by the end of June 2008.

Attachment 2

0CAN020803

ANO-2 Preliminary Supplemental Response

ANO-2 Preliminary Supplemental Response

1. Overall Compliance

Provide information requested in Generic Letter GL 2004-02, "Requested Information," Item 2(a) regarding compliance with regulations. That is, provide confirmation that the emergency core cooling system (ECCS) and containment spray system (CSS) 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 the licensing basis has been updated to reflect the results of the analysis.

By letter dated December 21, 2007 (0CNA120703), the NRC approved a request for an extension of the completion date prior to the restart from the upcoming ANO-2 spring 2008 refueling outage (2R19) with a licensing basis update within 60 days of completion of 2R19. This was requested in Entergy correspondence dated November 7, 2007, (0CAN110701). In accordance with the NRC's Content Guide, Entergy will submit a final response within 90 days of completion of all actions. For ANO-2 this will be within 90 days of completion of 2R19. Entergy is currently in the process of resolving remaining testing/analyses in order to achieve compliance with GL 2004-02; therefore, confirmation will be provided in the final submittal 90 days subsequent to completion of 2R19.

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). That is, provide a general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this GL.

During the fall 2006 refueling outage (2R18), the original sump screen (154 ft^2) was replaced with a new engineered strainer. The replacement strainer is a modular design and has a surface area of 4837 ft^2.

The following are planned for implementation during spring 2008 refueling outage (2R19):

- Chemical buffer change from trisodium-phosphate (TSP) to sodium-tetraborate (NaTB) to support chemical effects analysis
- Pillow fiberglass insulation replacement
- Calcium-silicate insulation removal
- Calcium-silicate insulation banding to reduce the zone-of-influence (ZOI)
- Ceramic fiber insulation replacement
- Sump plenum hatch stiffener modification to increase the structural qualification of the sump plenum
- Refueling canal drain strainer installation to prevent drain blockage
- Reactor cavity drain check valve screen removal to prevent debris blockage
- Main steam pipe drain line routing modification to terminate outside the sump strainer

3. Specific Information Regarding Methodology for Demonstrating Compliance

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.**

3.a.1 Baseline Break Selection

ANO-2 is a Combustion Engineering two-loop pressurized water reactor (PWR). The system consists of one reactor vessel, two steam generators (SGs), four reactor coolant pumps (RCPs), one pressurizer, and the reactor coolant system (RCS) piping. The nuclear steam supply system (NSSS) is located inside a bioshield (D-ring) consisting of two SG cavities and one reactor cavity. Each SG cavity houses one SG and two RCPs. Additionally, the south SG cavity houses the pressurizer. The outer walls of the D-ring extend from the containment base elevation (El.) 336'-6" to El. 426'-6". The ANO-2 sump is located on the south side of containment on the 336'-6" elevation outside the D-ring.

Using the deterministic break selection methodology described in NEI 04-07 the following breaks were postulated as shown in Figure 3.a.1-1:

- S1 SG-A hot leg at the SG nozzle, El. 371.8 ft., 42-inch inside diameter (ID)
- S2 SG-B hot leg at the SG nozzle, El. 371.8 ft., 42-inch ID
- S3 SG-B cold leg suction line at inlet elbow of RCP C, El. 364.7 ft., 30-inch ID
- S4 Pressurizer surge line at connection to pressurizer, El. 380.8 ft., 10.126-inch ID
- S6 SG-A cold leg suction line at inlet elbow of RCP A, El. 364.7 ft., 30-inch ID

To ensure that the thermal wrap blanket insulation on the top head of the pressurizer is bounded, the following break was also considered:

- S7 Safety injection nozzle at connection to top of pressurizer, El. 412.2 ft., 5.25-inch ID

The alternate methodology described in NEI 04-07 was used to model an additional break.

- S5 LPSI shutdown cooling discharge line connection to SG B hot leg, El. 368.8 ft., 11.5-inch ID

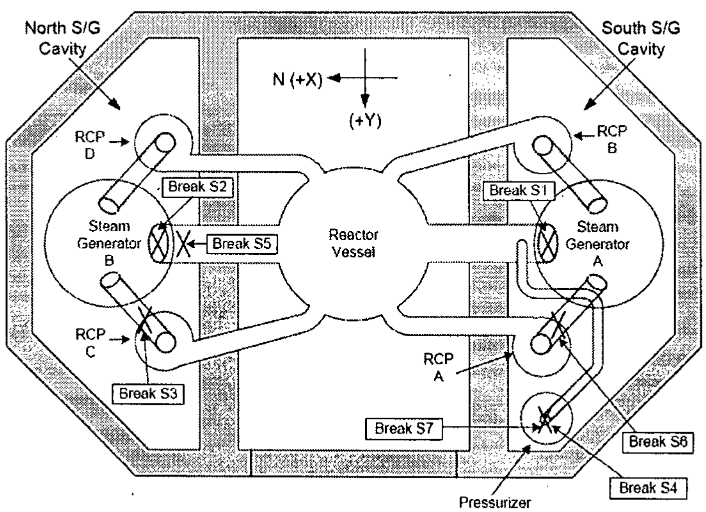


Figure 3.a.1-1 ANO-2 Break Locations

3.a.2 Secondary Line Breaks
Feedwater and main steam line breaks do not require the CSS or ECCS to operate in recirculation; therefore, the piping associated with these systems was not evaluated.

3.a.3 Size and Location Conclusion
The break selections have attempted to maximize the various available debris types. Since no single break produces the largest quantity of all debris sources, different breaks are evaluated to ensure that the fiber and particulate loads are maximized, since these debris types are expected to produce the most limiting strainer head loss.

The hot leg is the largest line (42-inch ID) within the SG cavity and produces the largest ZOI. Placing the break in the same SG cavity as the pressurizer (south cavity) results in the most insulation debris. This break produces the maximum amount of calcium-silicate insulation debris, but not the maximum fiber debris due to the distance from the hot leg to the pressurizer.

The cold leg has a smaller diameter than the hot leg, 30" versus 42", hence producing a smaller ZOI. However, a break in the cold leg suction from SG-B to RCP-C or SG-A to RCP-A could direct flow out of the D-ring along a flow path to the containment sump. In addition the RCP-A cold leg is in closer proximity to the pressurizer, where a source of fiber insulation exists. Therefore, these breaks were analyzed since these locations could result in the transport of the largest quantity of debris to the containment sump.

Thermal wrap blanket fiber insulation is located on the bottom head of the pressurizer and around the inside of the pressurizer skirt. Due to the shield wall around the lower pressurizer, the floor slab below the pressurizer, and the distance from the RCS hot leg or cold legs, this insulation is not a debris source for breaks in those lines. Hence, a break is postulated at the surge line connection to the pressurizer to provide the most limiting quantity of fiber insulation.

A break has been included for the largest nozzle on top of the pressurizer (5.25" ID) due to the thermal wrap blanket insulation on the top head to ensure that a break in this location is bounded by debris types and quantities from other breaks.

3.b Debris Generation/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/safety evaluation (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.**

3.b.1 ZOI Methodology
The guidance provided in NEI 04-07 was used to determine the ZOI radii for applicable insulation materials. Jet impingement testing was conducted by Westinghouse at Wyle Labs to determine the ZOI for two types of insulation not included in the guidance document. This included the following insulation types:

- Calcium-silicate insulation with stainless steel lagging secured with sheet metal screws in place of banding
- Transco thermal wrap blanket

The testing program conducted by Westinghouse at Wyle Labs used a sub-cooled jet representative of the range of temperatures and pressures associated with a large-break loss-of-coolant accident (LBLOCA). A total of four jet impingement tests were conducted. Three tests consisted of exposing Transco thermal wrap to jet impingement force and one test exposing stainless steel jacketed calcium-silicate insulation to jet impingement forces.

3.b.2 Destruction ZOI and Basis
See Table 3.b.2-1.

Table 3.b.2-1 Destruction ZOIs and Basis

Insulation Debris Source	ZOI	Basis
Mirror foil	28.6D	NEI 04-07
Transco reflective metal insulation (RMI) foil	2D	NEI 04-07
Calcium-silicate (unbanded)	25D	Wyle Labs Testing
Calcium-silicate (banded)	5.45D	NEI 04-07
Transco thermal wrap	7D	Wyle Labs Testing

3.b.3 Destruction Testing
As discussed in section 3.b.1, jet impingement testing was conducted to determine the ZOI for the calcium-silicate secured with screws and the thermal wrap blanket. The test was administered through Westinghouse in which the results were documented in WCAP-16836-P, "Arkansas Nuclear One - Jet Impingement Testing of Insulating Materials." The testing involved exposing the insulating material to a pressurized jet of water and steam to simulate the effects of a LOCA.

The following is a brief description of the test procedure used by Westinghouse Wyle Labs and documented in WCAP-16836-P.

A testing program was developed and undertaken with the following objectives:

- Simulate the processes and phenomena associated with jet impingement loading that may result from a postulated PWR blowdown.
- Determine the destructive effects of the resulting jet impingement on the insulation types currently used inside containment.
- Gather the information necessary to define a technically defensible, realistic ZOI for the insulation types of concern currently used inside containment.

The testing program used a facility capable of generating a sub-cooled jet that was representative of the range of temperatures and pressures associated with a LBLOCA. The supply tank fluid was held at 2000 psia prior to and at the initiation of testing (this pressure precluded a reactionary overpressure condition in the supply tank when jet flow was initiated that would have exceeded safety limits). Testing compensated for this slightly lower supply pressure by locating the test articles relative to the jet nozzle such that the stagnation pressure at the point of jet impingement in the test was calculated to be the same as with a supply pressure of 2250 psia.

The placement of the test article away from the jet nozzle was calculated using the ANSI N58.2-1988 jet expansion model. This was accomplished as follows: First, calculate the stagnation pressure isobars for spherical-equivalent ZOI of interest with the supply pressure at 2250 psia. Then, recalculate the same stagnation pressure isobars for spherical-equivalent ZOI with the supply pressure at 2000 psia.

The location of test articles was then taken as the distance between the intersection of the stagnation pressure isobars with the centerline of the jet and the jet nozzle outlet itself. The test articles were prepared in a manner representative of either installed configuration or a prototype modification. A total of four test articles were prepared. The Transco thermal wrap insulation articles and the screw-lagged stainless steel jacketed calcium-silicate were provided in test ready form. No additional assembly or reconfiguration was required. A summary of results is provided in Table 3.b.3-1.

Table 3.b.3-1 Summary of ANO-2 Jet Impingement Tests

Fluid Supply Pressure = 2000 psia Nozzle Size = 3.54 inches Fluid Supply Temperature = 530°F (nominal target value)				
Test Sequence	**Distance from Nozzle (ft)**	**Equivalent ZOI**	**Destruction Pressure (psi)**	**Test Article**
#1	13.48	12.02	10.2	Transco thermal-wrap (seam at 45° to jet)
#2*	13.48	12.02	10.2	Transco thermal-wrap (center at 90° to jet)
#3*	6.70	7.01	19.0	Transco thermal-wrap (center at 90° to jet)
#4	33.82	25.0	3.1	Calcium-silicate pipe (seam at 45° to jet)

* Test article was restrained in the test stand which is non-typical of the actual in-containment Installation.

The conclusions from jet impingement conducted by Westinghouse at Wyle Labs (WCAP-16836-P) are as follows:

- Transco thermal wrap insulating blankets installed at a spherical-equivalent ZOI $\geq$ 7D may be excluded as a debris sources for purposes of post-LOCA sump strainer, downstream, and chemical effects evaluations. If exposed to jet forces due to a postulated LOCA at a distance of 7D, it is expected that the blankets would become dislodged as observed in test #1 but would not sustain damage due to jet impingement such that fibrous internal material would become a debris source.
- Screw-lagged stainless steel jacketed calcium-silicate insulation installed at a spherical-equivalent ZOI of $\geq$ 25D, may be excluded as a debris source for purposes of post-LOCA sump strainer, downstream, and chemical effects evaluations.

3.b.4 Debris Type Quantity

See Table 3.b.4-1 for the four most limiting breaks.

Table 3.b.4-1 Quantity of Each Debris Type Generated for Each Break Location

Insulation Debris Type (within ZOI)	Units	South Break S1	North Break S2	South Break S4	South Break S6
Mirror foil	ft^2	52542	43220	18147	53635
Transco RMI foil	ft^2	6064	6064	0	5094
Calcium-silicate	ft^3	120[1]	90[1]	30[1]	120[1]
Transco thermal wrap	ft^3	0.0	0.0	46.6	0.0

Note: 1 Calcium-silicate insulation volumes are bounding estimates based on banding and removal work scheduled for spring 2008. The final submittal will include as-built totals.

3.b.5 Miscellaneous Materials

The total surface area of signs, placards, tags, tape and similar foreign materials in the containment following efforts to remove these potential debris sources is approximately 35 ft^2, which is well below the 200 ft^2 allowed for foreign material blockage in the strainer qualification tests.

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.**

3.c.1 Size Distribution

Debris characteristics consistent with the guidance provided in NEI 04-07 for the material present in the plant were utilized. The debris types were provided previously in Table 3.b.4-1. RMI is primarily utilized for the RCS piping, SGs, reactor vessel, and pressurizer. There is also thermal wrap fiberglass and calcium-silicate insulation. The material densities provided in NEI 04-07, Table 3-2 were used when converting the volume of debris generated to a mass of debris for testing purposes. The same insulation materials as those installed were used during testing for the thermal wrap and calcium-silicate, although the test materials were new versus thermally-aged material removed from the plant. Coatings debris is discussed later in section 3.h.

3.c.2 Bulk Densities

The bulk densities of materials and debris are consistent with those provided in NEI 04-07.

3.c.3 Surface Areas

Entergy did not use the NUREG/CR-6224 correlation to determine the debris bed head loss, and therefore, the specific surface area is not applicable.

3.c.4 Debris Characterization Deviations
The debris characteristics assumptions utilized do not deviate from the NRC-approved guidance.

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.**
4. **Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.**

3.d.1 Quantity Estimate
Walkdowns were performed to document potential debris in accordance with NEI 02-01.

3.d.2 Basis for Assumptions
Per NEI 04-07, 15% of the latent debris is comprised of fiber, and the remaining 85% is comprised of particulate. It was assumed that the debris is normally distributed for a given sample type. This assumption is supported by plant walkdown observations that debris distribution appeared to be uniform for a given surface type. Walkdown data was not available for grating areas. Hence conservatively, the floor attributes were applied to the grating area.

3.d.3 Evaluation Results
Based on data collected in the walkdowns, the amount of latent debris was estimated to be 47 pounds. Strainer qualification testing used a latent debris loading of approximately 115 pounds, to provide margin to the measured values.

3.d.4 Sacrificial Strainer Surface Area
Strainer qualification testing assumed 200 ft^2 of surface area is blocked by miscellaneous latent debris.

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 (CFD) 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.**
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.**

3.e.1 Debris Transport Methodology
CFD modeling of the containment basement flow was performed to evaluate debris transport conditions. Additional testing was conducted regarding the erosion and debris transport characteristics of calcium-silicate insulation consistent with that installed at ANO-2.

The methodology in Appendices III and VI of the SE associated with NEI 04-07 applies to a plant with a large, dry, cylindrical containment with a hemispherical dome and a four-loop NSSS. Since ANO-2 also has a dry, ambient cylindrical containment, the overall methodology in Appendices III and VI of the SE was considered applicable.

LOCA-generated debris is conservatively deposited on the floor of containment during blowdown, thus washdown is not analyzed in detail. It is recognized that this conflicts with the modeling of all debris entering the sump pool during blowdown transport in this calculation; however, it is conservative and therefore, acceptable. Exclusion of insignificant (small) inactive volumes or hold-up points is conservative.

The basic methodology used for the transport analysis is:

- A three-dimensional CFD model was developed to analyze the flow patterns in the containment sump during post-LOCA recirculation.

- Break S6 was chosen for CFD analysis since it was expected to result in the most flow out of the D-rings interior due to the direction of the break flow.

- The CFD scenarios model the minimum post-LOCA containment water level elevation of 343.66 ft. Use of the minimum water level is conservative for debris transport since it leads to higher velocities within the pool. The minimum water level does not impact the velocity through the sump strainer since the strainer is fully submerged at the minimum water level.

- The CFD scenarios model the maximum post-LOCA flow rate of 7,000 gpm through the sump. Use of the maximum flow through the sump maximizes water velocities in the pool.

- A three-dimensional CFD model was developed to analyze the flow patterns in the containment sump during post-LOCA recirculation. Break S6 was chosen for CFD analysis since it results in the most flow out of the D-rings interior due to the direction of the break flow.

- The limitations/observations pertaining to the CFD analysis are:
  a) Major inlet flows significantly affect the flow patterns inside the D-rings and in part of the area outside the D-rings, particularly the area adjacent to the D-rings access opening. This applies to blockage in the area adjacent to the D-rings access opening and near concrete columns D, E, F, and G.
  b) There is a single large opening to the D-rings. If a part of this opening is blocked, the flow patterns in the region adjacent to concrete columns D, E, F, and G would be significantly different.
  c) The simulations presented in the CFD analysis are for a specific water height. For small change in water depth (e.g., a few inches), at the same distribution of flow rates, the flow patterns are expected to be similar, although the magnitudes of the upper velocities would be different. For larger changes in water height, the flow patterns would be different. A higher velocity adjacent to the floor is expected for a lower water level.
  d) The temperature of the water is not a major contributor to the flow patterns in containment.
  e) The presence of the scuppers at the bottom of the D-rings does not significantly affect the major flow patterns in containment.
  f) The flow pattern could change significantly if one side of the sump pit strainer is congested.

The CFD analysis is used in conjunction with erosion and transport tests conducted by Fauske and Associates to quantify the amount of calcium-silicate insulation that could be expected to reach the sump strainer. The erosion tests have indicated that a substantial portion of the large calcium-silicate pieces would not dissolve or erode at the flow rates and temperatures associated with the post-LOCA environment. The transport test results indicate that the calcium-silicate insulation fines are relatively slow to transport to the sump strainer. This information is used with a time-dependent net positive suction head (NPSH) curve and associated sump test data to show that the strainer head loss would remain within the acceptable region throughout the event. This analysis is not complete, and additional detail will be provided in the final submittal.

3.e.2 Deviations

The guidance in NEI 04-07 for calcium-silicate insulation is that 100% of the affected material is disintegrated into small fines and 100% of the small fines are transported to the sump. Exceptions to these assumptions have been taken and are described in section 3.e.6.

3.e.3 CFD Codes

A three dimensional CFD model was developed to analyze the flow patterns in the containment sump during post-LOCA recirculation. This model was created using Fluent CFD software (Version 3d, segregated, standard k-epsilon, Release 6.1.22.). The limiting scenario investigated using the CFD model is shown in Table 3.e.3-1.

Table 3.e.3-1: Scenarios Investigated using CFD

Break	Description	Flow Out of Break
S6	Cold leg suction break (30" ID) at El. 364.7 in south SG cavity	Break flow enters sump pool with a 15.1 in^2 round profile; flow has a horizontal and vertical velocity component.

The CFD scenario models the minimum post-LOCA containment water level elevation of 343.66 ft. Use of the minimum water level is conservative for debris transport since it leads to higher velocities within the pool. The minimum water level does not impact the velocity through the sump strainer since the strainer is fully submerged at the minimum water level.

The CFD scenarios model the maximum post-LOCA flow rate of 7,000 gpm through the sump. The break flow due to HPSI is 1,735 gpm and the total CSS flow distributed throughout containment is 5,265 gpm. Use of the maximum flow through the sump maximizes water velocities in the pool.

3.e.4 Debris Interceptors
No credit was taken in the transport analysis for debris interceptors.

3.e.5 Settling
Guidance in NEI 04-07 assumes that 100% of small fines are assumed to transport to the sump strainer. During initial strainer tests conducted for ANO it was observed that calcium-silicate fines would settle in the test flume. Stirring for significant time periods was necessary to maintain the calcium-silicate fines in suspension long enough for them to enter the strainer cartridges. The test facility flume was not scaled to maintain approach velocities or geometry comparisons to the CFD model predicted conditions in the containment basement, therefore near-field settling of debris was not allowed in the test flume. However, the strong settling propensity of the calcium-silicate fines prompted investigation into test methods to quantify the transport characteristics of calcium-silicate fines under bounding velocity conditions for flows approaching the sump strainers.

Testing was conducted by Fauske and Associates to determine the transportability of calcium-silicate fines. Bounding velocities of the basement flow, taken from the CFD models, of 0.15 fps and 0.25 fps were used in the testing. These velocities exceed those predicted between the SG cavities and the sump strainer. Tests were conducted for 24-hour and 72-hour exposure times for one-inch thick layers of pulverized calcium-silicate fines. Following the exposure time periods, the sample tray was dried and weighed. The before and after weights were then compared to determine the amount of material removed from the tray, including material that settled on the floor downstream of the tray that would not have been transported to the strainers.

The largest percentage mass lost with the 0.25 fps velocity was 5.8% over three days, and with the 0.15 fps velocity was 2.6% over one day. The transported mass values were approximately constant between the one-day and three-day tests. If the three-day result is used as a "rate" of transport, the 30-day transported fraction based on the maximum mass reduction test would be 45%. Testing was conducted at room temperature. To address potential dissolution of calcium-silicate insulation at elevated temperatures as documented in NUREG-6772, additional tests were conducted. These tests did not show a temperature dependency on dissolution of calcium-silicate. The test sample thickness of one inch may not be prototypic, and results would yield a larger relative percentage if a thinner layer were used for testing. However, the results are believed to be conservative relative to the layer thickness due to the velocities present in the containment basement (per CFD analysis) being much lower than even the 0.15 fps lower test value.

Thus, if perfectly distributed across the basement floor the calcium-silicate layer would be significantly thinner than one inch, but the layer would be subjected to much lower velocities than those tested. If the calcium-silicate fines were concentrated near the higher velocity regions, the layer would be closer to or exceed one inch thickness with velocities outside of the affected SG cavity bounded by the lower tested value. The net effect of these two variables indicates that application of the 0.25 fps transport results provide a conservative application. The test data also shows no time dependency with the one-day erosion data being very similar to and between the three-day data. The lack of time dependency indicates that significant conservatism is present when applying a 30-day rate fraction to the results.

Testing was also conducted at Fauske and Associates to determine if erosion of large calcium-silicate pieces would be expected to occur. Tests were conducted at a flow velocity of 0.7 fps with one-inch and two-inch cubes of calcium-silicate insulation. Exposure times of 17, 45, 66, 90, 112, and 135 hours were included. The largest percentage mass reduction was 13.9% for a one inch cube and 8.3% for a two-inch cube. The eroded mass for each sample size was approximately constant (within +/- one standard deviation of the mean value) and was not dependent on exposure interval. Ignoring the lack of time dependency, a conservative 30-day erosion fraction can be determined using the largest percentage mass lost. This results in a 41% and 59% mass loss from the two-inch and one-inch cubes, respectively. Testing was conducted at room temperature based on data from tests similar to those documented in NUREG-6772. These tests showed that a temperature dependency of calcium-silicate erosion/dissolution was not indicated. The tests consistently showed a higher mass-loss percentage for the one-inch cubes compared to the two-inch cubes. This is believed to be based on the surface area to mass ratio.

Most of the "erosion" is thought to be related to disturbed material on the sides of the cubes from the cutting/preparation phase with wash-off of these disturbed edges contributing to most of the observed weight change. Data from the one-inch cubes was used as a conservative value. Data documented in NUREG-6808 provides information regarding size distribution of calcium-silicate insulation debris generated by simulated breaks at varying distances. This data shows that at the distances tested, the mass fraction of released debris pieces less than one inch is small (<25% of mass of pieces released). Thus, the use of the higher erosion values associated with the one-inch test cubes is conservative and bounding. Testing only addressed erosion of fully immersed pieces representative of pieces on the basement floor versus pieces that may be trapped on platform grating in the SG cavity exposed to containment spray droplet impingement. The test velocity of 0.7 fps is conservative since this value greatly exceeds CFD predicted velocities for flow streams between the affected SG cavity and the sump strainer. This velocity is also twice the bulk tumbling velocity of 0.35 fps for calcium-silicate pieces noted in NUREG-6772. Thus, material potentially exposed to higher velocities inside the affected SG cavity would be transported outside of the cavity and settle out in the lower velocity regions between there and the sump strainers.

Application of calcium-silicate erosion data requires establishing an expected ratio of large pieces versus fines and small pieces. A specific ratio is not listed in NEI 04-07 due to the assumption that 100% of the large pieces erode into fines. However, test data documented in NUREG-6808, Table 3-6 provides information on the size distribution of calcium-silicate debris for simulated breaks ranging from 5D to 20D to the target. This data shows that the amount of dust or fines combined with pieces less than one inch ranged from 15% to 30%. Thus, assuming 60% of calcium-silicate debris is large pieces and 40% is fines is considered a conservative distribution.

There are two major periods following a LOCA that must be considered for complete analysis. The first period during the initial 72 hours following the break is when the sump temperatures are at the peak values and NPSH margin is at a minimum. The second period at 30 days is the end of the mission time when debris loading may be at a peak, but considerable NPSH margin is available. Application of the erosion and transport data yields the following information provided in Table 3.e.5-1 (three-day erosion uses 4.7-day erosion data of 13.9%):

Table 3.e.5-1 Erosion and Transport Data

	Initial Fines	**Large Piece Erosion**	**Total**	**Transported**	**Net Fines at Strainer**
3-day	40%	13.9% of 60%	49%	5.8% of 49%	2.9%
30-day	40%	59% of 60%	76%	45% of 76%	35%

While these numbers have been arrived at using relatively conservative treatment of the test data, it is recognized that considerable uncertainty exists when extrapolating laboratory test conditions to a post-LOCA environment. Significant additional margin was applied to these numbers by applying an adjustment to essentially neglect the effects of transport reduction. While this does not invalidate the transport, it does provide a composite correction to further conservatively address uncertainties with both the transport and erosion test data. This results in a very substantial increase (multiple of 16.9x) in the amount of calcium-silicate fines assumed present in the initial 72-hour period (which is modeled to be at the strainer at time zero) and more than doubles the final calcium-silicate to be addressed for the final head loss value.

Table 3.e.5-2 provides the credited calcium-silicate fines at the strainer.

Table 3.e.5-2 Credited Calcium-silicate Fines at Strainer

3-day	49%
30-day	76%

3.e.6 Debris Transport Fractions
See Tables 3.e.6-1 and 3.e.6-2.

Table 3.e.6-1 Debris Transport Fraction

Debris Type	**Size Distribution Fraction**	**Debris Transport Fraction (Break S6)**	**Fraction of Debris at Sump Strainer (Break S6)**
Mirror RMI*			
Fines	0.016	1.00	0.016
Large	0.984	0.00	0.000
Sum	**1.00**	-	0.016
Transco RMI*			
Fines	0.75	1.00	0.750
Large	0.25	0.00	0.000
Sum	1.00	-	0.750
Transco Thermal Wrap**			
Fines	0.08	1.00	0.080
Small	0.25	0.71	0.178
Large	0.32	0.71	0.227
Intact	0.35	0.00	0.000
Sum	1.00	-	**0.485**

*RMI debris source not included in strainer qualification test due to non-conservative impacts on debris bed.
**While analysis indicates only partial transport, all thermal wrap was assumed to transport.

Table 3.e.6-2 Debris Fraction at Sump and Debris Quantity at Sump

Debris Type	**Units**	**Fraction of Debris at Sump**	**Debris Generated**	**Debris Quantity at Sump**
SS Mirror RMI Foil	ft^2	0.016	54,125	866[1]
SS Transco RMI Foil	ft^2	0.75	5,094	3,821[1]
Calcium-silicate (3 day/30 day)	ft^3	0.49 / 0.76	120[2]	58.8 / 91.2[2]
Transco Thermal Wrap	ft^3	0.48	46.6	46.6[3]
Qualified Coatings	ft^3	1.00	8.55	8.55
Unqualified Coatings	ft^3	1.00	0.2	0.2
Foreign Materials	ft^2	1.00	12.3	267[4]
Latent Debris	lb_m	1.00	56.4	115[5]

[1] RMI debris source was not included in strainer testing due to non-conservative impacts on debris bed.
[2] Volume is bounding estimate based on spring 2008 modification work scope.
[3] Credited with full transport in strainer testing.
[4] Foreign material transport of 267 ft^2 is credited in strainer tests for net 200 ft^2 of strainer blockage.
[5] Latent debris quantity was increased in strainer testing above measured values.

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 ECCS and CSS.**
2. **Provide the minimum submergence of the strainer under small-break LOCA (SBLOCA) and 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 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.**

3.f.1 Schematic Diagrams

See Figures 3.f.1-1 and 3.f.1-2.

Figure 3.f.1-1 ANO-2 Schematic of the ECCS as part of the Safety Injection System

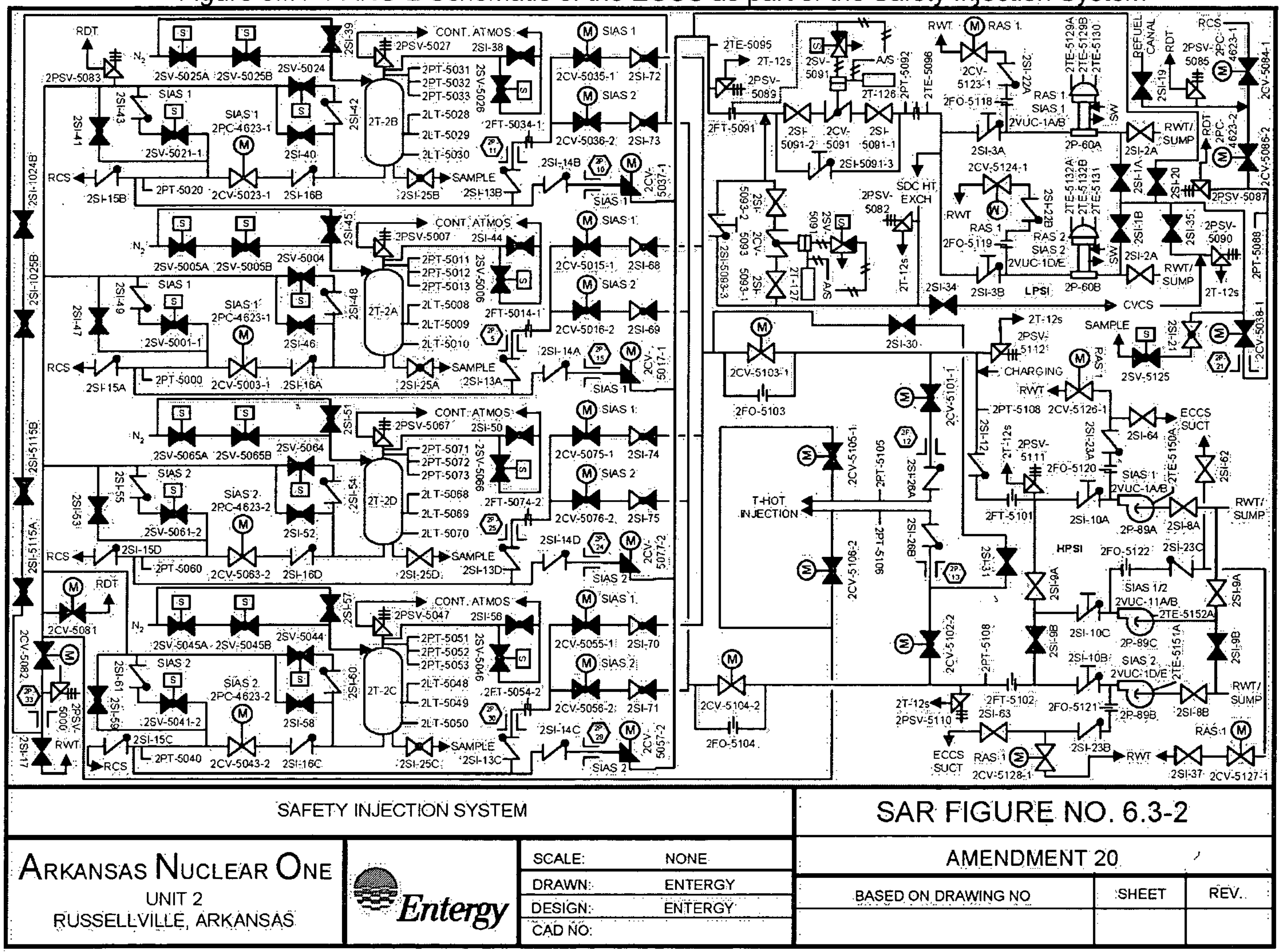
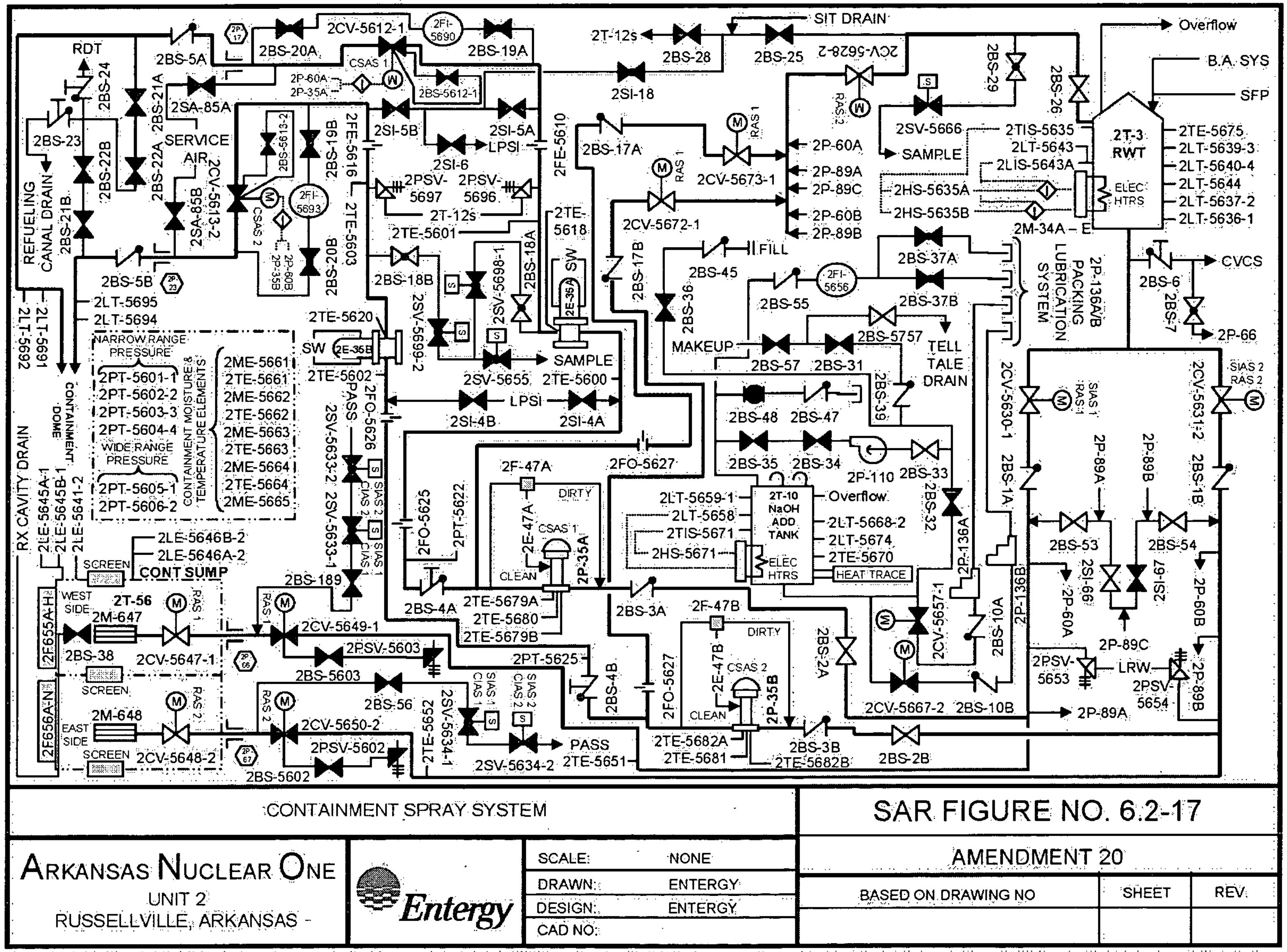


Figure 3.f.1-2 ANO-2 Schematic of the CSS



3.f.2 Minimum Submergence

The minimum containment flood level determines the submergence of the strainer and plenum for both SBLOCAs and LBLOCAs. The strainer submergence is 1.3 ft. The high point of the plenum roof is approximately equal to the minimum flood level (submergence < 0.05 ft.).

3.f.3 Vortexing Evaluation

In addition to the re-designed sump strainer and plenum, the sump also contains grating cages installed around each train's intake piping. The cages are part of the original sump design and were not affected by the recent GSI-191 related modifications. A series of tests were performed by Western Canada Hydraulic Laboratories to qualify the original sump strainer design. This included tests to determine if vortexing would occur within the sump. A number of full scale tests were performed without the strainer in place showing that the grating cage alone prevented the formation of vortices. The tests involved varying submergence height, flow rate, and intake piping hydraulics. The range of tested conditions is noted in section 3.f.8.

3.f.4 Head Loss Testing

Strainer qualification testing was performed at a test flume facility constructed by Fauske and Associates. Initial strainer testing was performed by CCI; however lack of test facility availability resulted in the need to have an additional test facility constructed to support timely completion of testing. Testing was performed with spare strainer cartridges. The surface area ratio between the test facility strainer cartridges and those installed in the plant was used to ratio the flows in the test facility and the debris quantities to be tested. Debris materials consisted of new calcium-silicate insulation consistent with material installed in the plant, new thermal wrap fiberglass, RMI foils (one test only), zinc powder from Carboline used for the inorganic zinc primer, and silicon carbide used as a surrogate for epoxy paints and latent debris. Paint chips of Carboline 890 epoxy were also used. The paint chips were prepared using a sieve to obtain a size small enough to maximize transportability but large enough to potentially block the 1/16" strainer openings. Debris preparation included pulverizing the calcium-silicate into fines, shredding the fiberglass insulation into fines and very small pieces, and shredding/crumpling the RMI foils. The fiber fines were soaked in water prior to their addition into the flume so they would remain in suspension and not float on the surface of the flume. No preparation was required for the zinc powder and silicon carbide as both were supplied in a form representative of the plant materials.

Debris addition was performed in sequences with the fiber material added first and stirred as needed until all material was transported into the strainer. The calcium-silicate insulation was added in discreet weight increments. The silicon carbide, zinc powder and paint chip materials were added separately from the calcium-silicate and fiber. The debris materials were stirred to achieve complete transport into the strainer cartridges, thereby avoiding near-field settling. After head loss stability was achieved, additional calcium-silicate and/or particulate material was added to the flume in some tests to measure more than one debris load condition.

Testing was not conducted for a 30-day period; however, head loss was monitored to ensure maximum values were reached. The debris beds included thin to ultra-thin fiber beds which were sometimes much less than 1/8". The strainer openings are 1/16" perforated plate versus the 1/8" square mesh originally tested that determined an approximate 1/8" fiber layer was needed to achieve thin-bed conditions. Filtering clean-up of the test flume water provided additional confirmation of thin-bed type filtration in addition to the elevated head loss measurements.

Head loss typically remained at or near zero until a threshold was reached creating a deflection point or "knee" in the head loss curve, after which rapid increases in head loss followed small increases in debris loading. After the head-loss "knee" was exceeded, the head loss characteristics of the debris beds produced an initial peak in head loss once all debris was transported into the strainer, but the head loss subsequently decreased over time to a relatively stable value.

Testing addressed two limiting break conditions with one being the surge line break that produced the largest fiber loading and the other being the hot leg break which produced the largest particulate loading (calcium-silicate). Test results are as follows:

Surge Line Break (S4) Debris Head Loss:

- 19.5" measured (9.9" viscosity-corrected) with single LPSI pump and two trains of HPSI and CS
- 11" measured (5.6" viscosity-corrected) with two trains of HPSI and CS

Hot Leg Break (S1):

- 0.25" head loss with LPSI flow and two trains of HPSI and CSS for initial 72-hour debris
- 0.25" head loss with two trains of HPSI and CSS (without LPSI) for 30-day debris (with erosion/transport reduction)
- 11" head loss with 30-day debris (without crediting calcium-silicate erosion/transport)

These test results are preliminary and are based on projected calcium-silicate and fiber load reductions scheduled for the spring 2008 refueling outage (2R19) and a maximum latent debris total of 115 lbs. A very strong sensitivity to additional fiber was noted with the very low fiber (hot leg break) tests. The amount of calcium-silicate debris (which includes fiber fragments) which is required to reach the "knee" decreases significantly with relatively small increases in fiber when an ultra-thin fiber bed is present. This strong sensitivity is believed to be due to the extremely thin fiber bed formed from only latent fiber and the fibers present in the calcium-silicate insulation. The use of shredded fiberglass insulation (thermal wrap) is believed to establish a non-prototypic but conservative fiber bed that consists of more intact (i.e., cross-linked groups) and longer fiber strands than is likely to exist in the "fiber" associated with dust and latent materials in the containment. When the dominant fiber source other than calcium-silicate fibers is from latent debris, this conservatism is considered significant since it is likely to establish a stronger initial fiber bed than would develop from actual latent "fiber".

The planned spring 2008 refueling outage (2R19) scope includes removal of essentially all sources of fiber from the SG cavities that are within the potential ZOI of hot leg or cold leg breaks as well as extensive banding of calcium-silicate to lower the amount of debris generated. Initially, unsatisfactory head loss results were reached with existing fiber (in spite of very small amounts affected by the hot leg/cold leg breaks) and calcium-silicate insulation loading. These results were taken from a series of strainer debris tests and are based on matching projected post-outage debris loads. Final as-built debris values with associated bounding test results and subsequent margins will be documented in the final submittal.

3.f.5 Debris Loading

The strainer cartridges are able to hold the entire debris load predicted by the debris generation calculation. The tests included both calcium-silicate insulation debris quantities both with and without credit for transport and erosion test reductions. The transport/erosion test reductions provided additional margin for the final results. One exception to the debris retention capability is the ability to hold the amount of RMI foils predicted by the debris generation calculation. Since the dominant insulation type is RMI with the RCS and SG insulation being RMI, and the pressurizer except the top and bottom heads (thermal wrap) being RMI, the RMI foil volume would not fit into the strainers. Additionally, it was found to have either non-conservative or negligible effect on strainer head loss. The foil forms a three dimensional layer or pile and does not readily lay flat against the strainer's perforated plate. This pile can act as a "pre-filter" that catches fibers and other debris types, keeping them off of the strainer surface. The RMI foil can also bury other insulation on the floor. If the non-RMI debris is added first and kept in suspension long enough to allow it to enter the strainer (which is non-prototypic) then the problem of burying other insulation types under RMI can be avoided, but even in this configuration the RMI fragments are expected to puncture and disturb the established fiber and particulate debris bed causing a reduction rather than an increase in head loss. Final qualification tests were conducted without RMI foils.

3.f.6 Thin-Bed Effect

Testing has shown that "thin-bed" formation may occur. However, the testing also shows that the effects of thin-bed formation are acceptable. Excluding breaks at the lines connecting to the top and bottom heads of the pressurizer, which includes thermal wrap blanket insulation, the only fiber source (besides the fiber fragments in calcium-silicate insulation) credited in the hot leg break tests was latent fiber. Since the pressurizer surge line and spray line breaks are of much smaller diameter than the hot or cold leg breaks, these breaks had a significantly reduced amount of calcium-silicate insulation generated. Tests were conducted for low fiber (latent)/high calcium-silicate breaks and the high fiber/low particulate breaks. While the fiber loading for the hot leg break was significantly below the 1/8" nominal thickness for thin-bed effects, it did produce thin-bed filtration results. The surge line break below the pressurizer yields fiber loading of approximately 1/8" thickness on the screens. The debris bed formed with the very low initial fiber from the hot leg break exhibited a "knee" response in the head loss with particulate loading up to a certain threshold being very non-linear (near zero) and then rapidly increasing with additional loading, particularly of calcium-silicate insulation. The calcium-silicate insulation includes fiber fragments, which may play a key role helping to complete or augment the fiber bed and associated head loss. Tests with both fiber conditions filtered the test water to an essentially clear condition after sustained operation. This was confirmed by visual observation and stirring of the test flume floor to ensure that the particulate had not simply settled out.

3.f.7 Maximum Head Loss

The strainer design maximum head loss is controlled by three parameters; NPSH margin, structural qualification, and vortex protection. Based on preliminary data, NPSH margin appears to be the limiting parameter, particularly early in the accident response time period. The draft results from the strainer head loss qualification testing combined with the planned outage debris reduction scope show that the strainer head loss remains below the available NPSH margin. The results of the head loss testing will be included in the final response when the post-outage debris load totals are available and the analysis is finalized.

The next limiting parameter is the vortex analysis. Testing of the grating cage showed that vortices were not present at water depths as low as 54 inches above the sump floor (elevation 333.3 ft.). Since the sump is vented, the minimum water level within the sump is a function of the minimum containment flood level (343.7 ft.) and the head loss across the strainer. Since the final head loss analysis is still in progress the vortex margin in Table 3.f.7-1 is shown as a function of head loss.

Table 3.f.7-1 Vortex Margin vs. Strainer Head Loss

Head Loss (ft.)	**Vortex Margin (ft.)**
0	5.9
1.0	4.9
2.0	3.9
3.0	2.9
4.0	1.9
5.0	0.9
5.9	0

The structural qualification possesses the most margin. The plenum is qualified for a maximum differential pressure of 2.65 psi (approximately 6.1 ft. water), pending installation of structural stiffening modifications scheduled for the spring 2008 refueling outage (2R19).

3.f.8 Margins

Some of the more significant margins and conservatisms used in the strainer head loss calculations and strainer testing are as follows:

- Strainers tests were able to achieve much greater uniformity of debris loading than would be expected in the plant. Debris was added at the top of the test flume with flow present and stirring was used to maintain debris suspended throughout the flow path. This allowed a much greater degree of uniform debris distribution than would be expected with strainer assemblies that are slightly over five feet in height and mounted several inches off of the floor. Additionally, the strainers extend outward from the sump in two directions with cartridges mounted on the front and back of these extending arms, which are located in relatively low velocity flow regions per CFD analysis. The majority of the debris would not be expected to remain in suspension during the approximate half-hour period when the basement is filling with water and debris traveling on the floor would have limited ability to lift multiple feet to cover the upper strainer cartridges. Debris that is gradually released through erosion of large pieces would primarily be submerged material on the floor or material remaining in the affected SG cavity (i.e., trapped on grating or sections still on pipe with lagging dislodged). This debris would erode into the basement water and then transport out of the cavity into the low velocity regions outside where settling is expected. Qualification testing intentionally tried to achieve the worst case or most conservative results by maximizing the potential for uniform debris distribution, however, this is considered to be a very conservative and non-prototypic bias applied to the tests given the strainer design.

- 100% of fiber released as debris is treated as fines or small pieces and assumed to transport.

- Calcium-silicate debris generation uses a 25D ZOI for unbanded material, which includes all unbanded calcium-silicate insulation in the SG cavity for hot and cold leg breaks.

- Banded calcium-silicate assumes a 5.45D ZOI based on OPG testing performed with weaker aluminum jacketing, which was the source of failure. The banded calcium-silicate uses stainless steel lagging which includes both banding and sheet metal screws.

- RMI was excluded from the flume testing which is considered a non-prototypic conservatism since the large volume of potentially released RMI would be expected to bury, trap, or filter some of the other debris types and limit the material reaching the strainers.

- No hold-up of debris in inactive flow areas or capture of debris on gratings or similar devices was credited.

- LPSI pump failure to stop single failure was included in strainer flow tests, with 100% of three-day debris loading, even though most such failures could be addressed immediately from the control room, and only a limited failure sub-sets would require securing the pump at the breaker, which is nominally only a 30-minute response time.

- Debris head loss peaks are used for analysis versus lower stable readings, even though peaks occur shortly after non-prototypic debris addition which occurs in a relatively short time period compared to the more gradual debris build-up expected post-LOCA.

- Shadowing of debris sources is not credited in the current results.

Viscosity corrections are applied to the measured head loss equivalent to 75% of the predicted difference in head loss associated with reducing the viscosity from 80°F to 212°F. Actual strainer test conditions were lower than 80°F. The viscosity correction was only applied when a stable debris bed was evident and responded normally to flow changes. The use of only 75% of the projected viscosity correction allows for some uncertainty in spite of these measures (visual and flow change sensitivity) in the ability to detect jetting action through the debris bed which indicate unstable conditions.

The following conservatisms in Table 3.f.8-1 were used during the vortex testing.

Table 3.f.8-1 Conservatism used in Vortex Analysis

	Design	**Tested**
Minimum water depth from sump floor (inches)	143.4	54 to 143.4
Maximum flow (gpm)	3325	4325 to 8636
Water temperature (°F)	210	57 to 184
Maximum circulation(ft^2/sec)	3.2	9.1
Maximum size of circulation cell (ft.)	16	18
Intake pipe Reynolds number	1.5×10^6	0.59 to 3.19×10^6

Since the presence of the sump strainer acts to slow intake velocities, the conclusions from the original testing of the grating cage are bounding and remain valid for the protection against vortex formation.

3.f.9 Clean Strainer Head Loss
The clean head loss of the strainer cartridges themselves is negligible, because the velocities in the screen holes and the cartridge channels are comparatively very low. Once inside the strainer, the flow path to the suction piping does experience head loss. This internal head loss consists of the head loss in the axial flow channel between the cartridges, the connection between the modules and at the end toward the sump.

For the clean head loss without debris, total head loss for various flows are shown in Table 3.f.9-1.

Table 3.f.9-1 Head Loss

Head Loss	Flow
0.265 ft.	6165 gpm (1 HPSI pump, 2 spray pumps)
0.348 ft.	7065 gpm (2 HPSI pumps, 2 spray pumps)
1.1 ft.	12765 gpm (1 LPSI pump, 2 HPSI, and 2 spray pumps)

3.f.10 Debris Head Loss
Debris head loss qualification is based upon field test data. Initial analytical modeling was conducted to assist in sizing the proposed replacement strainers. The final design consisted of installing the maximum possible surface area that could be installed given field constraints and then reducing debris loading until acceptable head loss was achieved. The early modeling of strainer head loss is not intended to be maintained as an active document relative to strainer head loss; therefore, additional information is not presented here.

3.f.11 Submergence/Venting
The sump design consists of a fully submerged structure for all events requiring recirculation with a vent that extends above the maximum containment flood level. No additional failure criteria were applied.

3.f.12 Near-Field Settling
Near-field settling is not credited in the head loss testing.

3.f.13 Scaling
Partial scaling of viscosity (75%) to correct for temperature differences between test and accident conditions was applied to the strainer head loss results for the surge line break test data. Corrections were not applied to the hot leg break test data since head loss values applicable to the elevated temperature period were low and 30 day debris load conditions would be potentially near ambient. Some of the strainer tests with larger head loss exhibited blow-holes or jetting streams of water through the strainer, which tended to affect the head loss response to velocity changes. Velocity changes were made in various tests to evaluate the responsiveness of the debris bed to head loss. If poor responsiveness to velocity change exists, then it is believed that a similar lack of responsiveness to reduced viscosity would also exist, and therefore, the test results for that condition would not be suitable for viscosity correction. The jetting effect was particularly evident with higher head loss conditions (two-plus feet) combined with very thin fiber beds, which is believed to be due to the debris bed reaching a structural limitation at a given head loss with an equilibrium being reached by the development of breaches or perforations in the debris bed.

Most of the lower head loss tests did not exhibit perforated debris bed jetting with head loss remaining responsive to flow changes. These test results are considered acceptable for application of viscosity corrections based on both visual observation and the responsiveness of the debris bed head loss to flow changes. As an additional allowance for uncertainty in detecting jetting or other characteristics that might limit the expected head loss reduction associated with lower viscosity conditions, the correction was limited to 75% of the value predicted for a temperature change from 80°F to 212°F.

3.f.14 Accident Pressure Credit

The sump strainer design includes a vent which equalizes the internal air pressure of the strainer structure with that of containment. Thus, flashing of recirculating fluid would not be present since a change in pressure would not be experienced. The head loss across the strainer would result in only physical level difference between the water inside and out of the sump strainer structure.

3.g Net Positive Suction Head

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a 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.**

3.g.1 Flow Rates, Temperature, and Water Level
See Tables 3.g.1-1 and 3.g.1-2.

Table 3.g.1-1 Pump Flow and Total Recirculation Sump Flow Rates

HPSI pump flow max (only 1 HPSI pump running)	900 gpm
CSS pump flow (per pump)	2632.5 gpm
LPSI pump flow (1 pump)*	5700 gpm
Maximum sump flow rate**	12765 gpm
Maximum sump flow 2 HPSI & 2 spray	7065 gpm
Maximum sump flow 1 HPSI & 2 spray	6165 gpm
Minimum containment water level***	7.16 ft.

*LPSI pump flow included for LPSI fail-to-trip scenario where it is assumed one LPSI pump fails to secure prior to sump recirculation actuation.
**Maximum sump single failure flow rate is the combined flow rate of both trains of CSS and HPSI including the single LPSI pump (fail-to-trip).
***As measured from elevation 336' 6".

Table 3.g.1-2 Sump Temperature vs. Time

Time	**Sump Temperature**
Sec.	°F
2000	224
3000	220
4000	221
5000	222
6000	223
7000	224
8000	224
9000	225
10,000	226
20,000	229
30,000	227
40,000	226
50,000	224
60,000	222
70,000	220
80,000	218
90,000	215
100,000	210
200,000	190
300,000	185
400,000	176
500,000	170
600,000	169
700,000	167
800,000	165
900,000	163
1,000,000	160
2,000,000	150
2,500,000	142

3.g.2 Assumptions

The following assumptions were applied to the parameters in section 3.g.1 at the maximum time-dependent sump temperature.

- The LPSI pump run-out flow was used for the LPSI fail-to-trip scenario.
- Containment minimum water level assumes that RCS inventory does not contribute to flood volume (other than pressurizer volume is credited as offsetting potential hold-up in refuel canal).
- See section 3.g.9 for additional minimum water level assumptions.

3.g.3 NPSHr Basis

The HPSI pump curve with the greatest NPSHr was utilized in the analysis. The specific basis for the NPSHr term provided by the pump vendor (i.e., 3% head drop) was not specified in the vendor technical documents.

3.g.4 Friction and Other Flow Losses

The sump temperature and corresponding fluid density are used to calculate the Reynolds number which subsequently is used to calculate frictional losses in suction piping for both the HPSI and CSS pumps. Frictional losses through the suction piping are calculated by taking pipe dimensions and resistance factors to determine losses through the piping system. Since sump temperature varies with time, frictional loss versus time is calculated and used in the analysis.

3.g.5 System Response

A LOCA begins with the instantaneous break of any piping within the RCS pressure boundary during at power operation. In a LBLOCA, the very rapid depressurization quickly leads to a reactor trip. The engineered safety features actuation system activates the ECCS in response to the reduced RCS pressure and increasing containment pressure. The SBLOCA also begins with a break in the RCS pressure boundary. After the break, RCS pressure drops over a period of time until the RCS low pressure setpoint is reached initiating a reactor trip. With primary system pressure still well above the safety injection tank (SIT) pressure and LPSI pump shutoff head pressure, only HPSI pumps begin to replace RCS inventory.

The RCS response to the LOCA has three major phases of significance to the analysis of core conditions; blowdown, refill, and reflood. These three phases precede long-term core cooling. Long-term core cooling is the final phase considered in the ECCS analyses. System response is determined by break size and resulting RCS and containment pressure characteristics. The HPSI and LPSI pumps are actuated when RCS pressure decreases to 1650 psia. The CSS is in standby during normal plant operation. If containment pressure reaches 18.3 psia, the system is automatically actuated.

3.g.6 Pump Status

The HPSI pumps take suction from the refueling water tank (RWT) and inject borated water into the core through four injection nozzles on the cold legs. When the RWT water level reaches the low level setpoint, the HPSI pump suction is automatically switched from the RWT to the containment sump. Containment sump water is then circulated through the core by the HPSI pumps for long-term cooling.

LPSI pumps start and LPSI injection valves open when a safety injection actuation signal occurs. LPSI injection is automatically discontinued when the RWT water level reaches the low level setpoint.

The CSS is designed to spray borated water into the containment in the event of a LOCA in order to reduce containment pressure and temperature. The CSS is automatically actuated on a high pressure condition in the containment building. Spray flow is initiated from the RWT to the spray headers and nozzles in the containment building. When the RWT is depleted, spray water is obtained from the containment sump via automatic transfer of pump suction valve alignment.

3.g.7 Single Failure Assumptions
ECCS and containment cooling are designed to assure system function can be accomplished assuming a single active failure. NPSH analysis considers both single-train and two-train operation of HPSI and CSS pump configurations to determine the most limiting flow and NPSH conditions.

The failure of a LPSI pump to trip after RAS has been evaluated for potential adverse impacts to the other operating train due to increased flow through the sump strainers. The existing ANO-2 procedure guidance, combined with the available control room indication is sufficient to properly respond to a potential failure of a LPSI pump to trip upon RAS. However this response may require up to 30 minutes in order to complete if action outside of the control room is necessary to respond to the event. Sump strainer qualification tests have conservatively included the potential additional flow that may exist early in the recirculation period associated with this single failure, even though the debris loading on the strainer would be expected to be low at the start of sump recirculation and the condition being terminated prior to the first volume turnover. The train opposite of the running LPSI pump is evaluated for NPSH, as well as the strainer structural limitations and vortex protection limits.

3.g.8 Sump Water Level
The minimum containment sump water level is determined by calculating three parameters:

- Gross available volume in the lower elevations of containment
- Volume of structures, systems, and components (SSCs) which offset the available volume
- Volume of water which comprises the sump water inventory

Using MathCAD computing software, the three parameters are determined as a function of water level within containment. In determining the volume offset by SSCs, credit was taken for volumes occupied by various tanks, supports, concrete walls, piping, and miscellaneous steel, concrete, pipes, pumps, elevator etc. To determine the conservative minimum amount of sump inventory, borated water injection was equal to the design minimum, water vapor was maximized, and surfaces assumed to be wetted.

3.g.9 Conservative Assumptions
The following are assumptions used to conservatively determine the minimum containment water level.

- Reactor cavity water level is assumed to be in equilibrium with the containment level as if the reactor cavity drain check valve were not present.
- For a LOCA, the break is assumed to be on the top of the reactor such that RCS contribution to containment flood volume is zero.
- Boric Acid Makeup Tank (BAMT) volume is assumed to be zero.
- RWT level is assumed to be minimum TS-allowable at the maximum allowable temperature.
- SIT volume is set equal to the technical specification (TS) minimum value.
- For minimum flood level reactor vessel supports only go up 8'7".
- Volume of water in air is maximized.

- Both CSS pumps run at full flow.
- Maximum mass of water vapor is used.
- Wetted surfaces are assumed maximum.

3.g.10 Volumes
The minimum water level calculation accounted for water droplets using an average droplet size of 880 micron for the CSS design flow rate during recirculation. Drag forces were calculated to determine the terminal velocity of the water droplets. An average fall height was determined based on the containment dome elevation rise and spray header locations. Condensation and holdup on surfaces is calculated using an assumed film thickness of 1/8 inch on the entire containment surface area, approximately 200,000 ft^2.

3.g.11 Water Displacement
The following equipment is credited with displacing pool volume:

- Elevator 2M6 walls (elevator is assumed parked at personnel hatch elevation)
- Tank 2T68, assumed to be 90% submerged at 84 inches.
- SG base supports
- Concrete walls (primary, secondary, access shielding walls)
- Containment sump strainer and plenum
- Sump piping
- Tanks 2T109 and 2T110
- Miscellaneous steel, concrete pipes, pumps, etc.

3.g.12 Water Sources
See Table 3.g.12-1 and assumptions in section 3.g.9.

Table 3.g.12-1 Water Sources Assumed for Minimum Containment Water Level

Source	**Gal.**
RCS Inventory	0[1]
RWT	384,000
BAMT	0
SIT	42,279

Notes: [1] Pressurizer volume is credited to offset potential holdup of water in refueling canal.

3.g.13 Containment Accident Pressure
No credit is taken for containment accident pressure in determining available NPSH.

3.g.14 Containment Accident Pressure Assumptions
This is not applicable since containment accident pressure is not credited.

3.g.15 Vapor Pressure
Pump NPSH margins were calculated by subtracting the NPSH required from the NPSH available. The minimum post-accident containment pressure was set equal to the minimum pressure allowed by TS (13.2 psia). The saturation temperature corresponding to this minimum containment pressure (206.6°F) was then established as the limiting sump pool temperature for purposes of determining NPSH available. For sump pool temperatures above the limiting temperature, containment pressure is set equal to the saturation pressure (i.e., vapor pressure) corresponding to the sump pool temperature. For sump pool temperatures at or below the limiting temperature, containment pressure is set equal to the minimum post-accident containment pressure (13.2 psia).

3.g.16 NPSH Margin Results

The results shown in Tables 3.g.16-1, 3.g.16-2, 3.g.16-3, 3.g.16-4 and 3.g.16-5 represent the worst case NPSH margin for various alignments using only clean strainer head loss. Thus, debris losses are not factored into these results.

Table 3.g.16-1 Single Train Operation - Normal A Train Alignment

	Pump Flow (gpm)	Total Header Flow (gpm)	Total Sump Flow (gpm)	NPSH Margin (feet)
CSS 2P-35A	2632.5	3532.5		8.72
HPSI 2P-89A	900			2.66

Table 3.g.16-2 Single Train Operation - Normal B Train Alignment

	Pump Flow (gpm)	Total Header Flow (gpm)	Total Sump Flow (gpm)	NPSH Margin (ft.)
2P-35B	2632.5	3532.5		8.63
2P-89B	900			2.06

Table 3.g.16-3 Single Train Operation – Alternate A Train Alignment*

	Pump Flow (gpm)	Total Header Flow (gpm)	Total Sump Flow (gpm)	NPSH Margin (ft.)
2P-35A	2632.5	3532.5		8.72
2P-89C	900			1.39

*Alignment of HPSI Pump 2P-89C to the A Train header results in greater frictional losses than when aligned to the B Train header.

Table 3.g.16-4 Two-Train Operation – Alternate A Train and Normal B Train Alignments

	Pump Flow (gpm)	Total Header Flow (gpm)	Total Sump Flow (gpm)	NPSH Margin (ft.)
2P-35A	2632.5	3502.5	7005	8.46
2P-89C	870			1.92
2P-35B	2632.5	3502.5		8.37
2P-89B	870			3.10

Table 3.g.16-5 Two-Train Operation with LPSI with LPSI Fail-to-Trip*

	Pump Flow (gpm)	Total Header Flow (gpm)	Total Sump Flow (gpm)	NPSH Margin (ft.)
2P-35A	2632.5	3502.5	12705	7.65
2P-89C	870			1.11
2P-35B	2632.5	9202.5		3.48
2P-89B	870			1.06
LPSI	5700			-

*Analyzed for alternate A train and normal B train alignments with B train LPSI failure.

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.**

3.h.1 Coating Systems in Containment

Table 3.h.1-1 lists the various qualified coatings that may exist within containment.

Table 3.h.1-1 Qualified Coatings within Containment

COATING DESCRIPTION	COATING TYPE
Liner Steel Coatings	
Primer Coat	Carboline CZ-11 Carboline 890 Carboline 954
Intermediate Coat	Ameron Amercoat 90 Carboline 890 Carboline 954
Final Coat	Ameron Amercoat 90 Carboline Phenoline 305
Equipment/Support and Piping Steel Coating	
Primer Coat	Ameron Amercoat 90 Ameron Dimecote 6 Carboline CZ-11 Carboline 890 Carboline 954
Intermediate Coat	Ameron Amercoat 90 Carboline 890 Carboline 954
Final Coat	Ameron Amercoat 90

Concrete Floor	
Primer Coat	Carboline Phenoline 306 TG Carboline 890 Carboline 954 Carboline 1340 Clear Stonhard Stonliner #5
Intermediate Coat	Carboline Starglaze 2011S
Final Coat	Carboline Modified Phenoline 306 TG with Special Silica Filler No. 2 Carboline Phenoline 306 TG Carboline 890 Carboline 954 Tnemec Series 66

Unqualified coatings exist on a variety of components inside containment such as valves, valve actuators, instrumentation, etc. The potential volume of this material has been calculated and included in the debris total for coatings debris generation. All of the unqualified coatings are assumed to fail. No credit is taken for the Electric Power Research Institute (EPRI) original equipment manufacturer (OEM) coatings testing program.

3.h.2 Assumptions in Post-LOCA Paint Debris Transport
ANO-2 testing assumed 100% transport of all coating debris materials to the sump strainer. Near-field settling was not credited. Continued agitation of the test facility water was performed until essentially all of the debris was entrained in the strainer cartridges.

3.h.3 Suction Strainer Head Loss Testing
Strainer head loss testing was not performed exclusively for coatings materials. Strainer qualification testing and head loss results are discussed in 3.f.4.

NEI 04-07 section 3.4.3.6 describes the debris characteristics for use in debris transport and head loss testing. Coatings materials were represented with either zinc filler material or 600 mesh black silicon carbide grit. The zinc filler material was provided by Carboline and is the actual zinc constituent material used in the inorganic zinc primer and thus is not considered a surrogate, but a direct representation of the potential primer coating material. The particulate size is in the 10 micron range as stated in NEI 04-07 within the quality control limits established by Carboline for this material. Unqualified coatings and qualified coatings (epoxy top coat) were modeled with 600 mesh silicon carbide, which is approximately a 9 micron size particle and is generally consistent with the 10 micron characteristic particle size recommend to represent the coatings particles. The measured material density for the silicon carbide was 167 lb/ft^3 or a specific gravity of approximately 2.7, which is higher than the coating material density of 94-98 lb/ft^3 noted in NEI 04-07 Table 3-3 for epoxy and alkyd coatings. The coating densities are applicable to the cured or finished product; however, the particulate pigment densities that formulate the coatings are somewhat higher. The cured coating density includes the affect of the lighter resin binder material. For coatings that are destroyed or disintegrated into fines (i.e., 10 micron particles) the lighter binding agent is lost leaving the pigments as debris, which has a higher particle density than the cured paint. Entergy selected the silicon carbide material as a surrogate material based on its availability in the small particle product size, density that is near that of paint pigments, and it not being chemically reactive with other debris sources in the test facility (which included consideration of chemical precipitates at the time of selection).

The selection of particulate debris to create the greatest head loss impact is based on the formation of thin-bed filtration conditions during the testing per guidance in NEI 04-07. Tests for strainer qualification were consistently able to establish particulate filtering thin-beds, thus, the use of particulates was considered conservative. An additional portion of paint chips (approximately equivalent to one cubic-foot of paint chips in the reactor building, scaled to the flume test size) was also added to the test facility beyond the amount predicted by the debris generation calculation. It is not considered credible that all coating debris would be generated as particulate, particularly degraded qualified coatings outside the ZOI, which are assumed to fail. While the transport of paint chips is significantly less likely than the small particulate material, the addition of some portion of paint chips was done as an additional conservative measure or margin that may be credited if needed to address future coating degradation or other sources.

3.h.4 Surrogates
See section 3.h.3 for bases for choice of surrogates.

3.h.5 Coatings Debris Generation Assumptions
Entergy utilized WCAP 16568-P, "Jet Impingement Testing to Determine the ZOI for DBA-Qualified/Acceptable Coatings" for determining qualified coatings ZOI values. From this report Entergy has applied a ZOI of 4D for qualified epoxy coatings and a ZOI of 5D for qualified inorganic zinc coatings. The associated break models have assumed that qualified coatings within the 4D ZOI region have both primer (inorganic zinc) and top coat (epoxy) coatings to maximize the coating debris quantity within this region. Since only zinc primer coatings are affected in the region between the 4D and 5D ZOIs, qualified coating steel surfaces are assumed to have only primer in this region.

For areas where the actual coating thickness was not available, the coating thickness was conservatively taken as the maximum of the possible coating thickness values specified by ANO Coating Specification A-2437. For floor and wall coatings, the 4D ZOI radius is truncated at the intersection with the floor or wall in accordance with reference NEI 04-07 and its SE section 3.4.2.3. The area projected on the floor or wall and the total volume of qualified coating debris generated by each break is calculated

3.h.6 Debris Characteristic Assumptions
See section 3.h.3 for bases for debris characteristic assumptions.

3.h.7 Coating Condition Assessment Programs
Entergy realizes that control of potential debris sources inside containment is very important and that debris sources that are introduced to containment need to be identified and assessed. Entergy currently implements the following controls for coating. The majority of the coatings inside of containment were procured and applied as qualified coatings. Qualified coatings are controlled under site procedures. In addition, the debris generation calculation includes margin for potential detachment or failure of limited quantities of qualified coatings.

Unqualified coatings have been identified by location, surface area, and thickness. The majority of unqualified coatings inside of containment are component OEM coatings. New or replacement equipment is evaluated for the potential of unqualified coatings. Entergy ensures that unqualified coatings introduced to containment are identified. Programs and procedures are in place to ensure that the quantity of unqualified coatings in the debris generation calculation is not exceeded.

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 2004-02 Requested Information Item 2(f) regarding programmatic controls taken to limit debris sources in containment. That is, provide 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. Specifically, 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 10CFR50.46 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, 10CFR50.65**

If any of the following suggested design and operational refinements given in the guidance report (section 5) and 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**

3.i.1 Containment Debris Generation Assumptions

As part of the containment walkdowns used to identify potential debris sources, measurements were taken to conservatively determine the amount of latent dirt and dust inside containment. These measurements were taken at a point during the respective refueling outage where the level of dirt and dust was much higher than during normal power operation. Subsequent to the measurements being taken but prior to unit startup, extensive cleaning was performed. These cleaning activities are consistent with normal housekeeping practices and associated administrative requirements. Entergy also has a very robust reactor building cleanliness procedure.

3.i.2 Foreign Material Exclusion Programmatic Controls
Maintenance housekeeping procedures are in place to control how and what kind of materials are used within containment. These procedures act to minimize the creation of foreign materials. In addition, following refueling outages, a containment closeout procedure is in place to inspect the containment building to ensure that foreign materials are not present (including the sump). Entergy also has a very robust foreign material exclusion procedure.

3.i.3 Permanent Plant Changes Inside Containment
The Entergy procedure for control of design modifications includes a list of design input considerations. This list includes specific items to address insulation and coatings in containment and modifications which may affect sump performance to ensure the plant continues to meet 10CFR50.46.

3.i.4 Maintenance Rule
Maintenance activities are planned, scheduled, and implemented within the bounds of 10CFR50.65. Maintenance involving insulation or coating is performed in accordance with engineering-approved specifications. Temporary modifications are controlled using the same design input considerations a permanent modification uses.

3.i.5 Containment Insulation Change-Outs
During upcoming refueling outage 2R19, actions are planned to further reduce potentially detrimental insulation types in the SG cavities by removing the remaining fiber insulation not associated with the pressurizer as described in section 2. Previous insulation change-out occurred during SG replacement with RMI type insulation replacing significant amounts of calcium-silicate insulation (shell of SG was calcium-silicate other than at channel heads) on the SGs and connected main steam and feedwater piping.

3.i.6 Existing Insulation Modification
During upcoming refueling outage 2R19, efforts to further reduce insulation debris in the SG cavities are planned to continue by adding banding to portions of the remaining calcium-silicate insulation to reduce the ZOI for this insulation type.

3.i.7 Equipment/System Modification
See section 3.i.6.

3.i.8 Containment Coatings Program Modification
A site procedure controls ANO commitments related to its safety-related coatings program. This procedure provides the minimum requirements at ANO to ensure that coatings are properly selected, applied, and maintained so the coatings can perform their intended function without negatively impacting the safety functions of other SSCs. This procedure addresses the activities related to service-level I coatings inside containment where the coating failure could adversely affect the operation of the post-accident fluid systems and thereby impair safe shutdown.

3.j Screen Modification Package
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.**

3.j.1 Sump Screen Design Modification

The original sump screen was replaced with a new modular strainer system furnished by CCI. The new CCI strainer contains 4837 ft^2 of surface area. This replaced the original screen structure (containing 154 ft^2) located over the sump. Two banks of new screens extend from the east and west side of the sump. The east side consists of fourteen screen modules and the west side consists of eight screen modules. The screen openings are 1/16" diameter holes. The screens connect to a new plenum installed over the sump. The east screen portion is approximately 55.4 ft. long and the west portion is approximately 31.6 ft. long.

The new sump plenum with an internal divider plate and screen was fabricated from stainless steel to preclude corrosion and eliminate the need for protective coatings. Screened openings at the bottom of the plenum walls were provided to allow water on the containment floor to enter the sump for leakage detection purposes, while excluding debris greater than 1/16" in size.

The plenum incorporates two pipe vents on the top surface. The purposes of the vents are to allow air contained inside the plenum to escape as the plenum fills with water and to limit internal pressurization due to pressure transmitted through the floor drains entering the sump. The vents extend above the high containment water level and are provided with 12 x 12 mesh (with 0.047" diameter wire) woven screens to prevent debris entry.

Two track-mounted, sliding doors are provided for personnel access to each side of the sump. Connection points for the screen ducts into the sump are provided on both the east and west walls of the plenum. The duct connections are bolted to the walls of the new plenum.

Two box screens were mounted inside the sump on the northeast and northwest walls to capture debris entering the sumps via floor drains that bypass the containment sump screen. The screens inside the original box screens were replaced stainless steel mesh (0.047" diameter wire) to prevent the introduction of particles greater than 1/16" through the floor drains.

The new internal trash rack/screen configuration consists of modular assemblies interconnected with ductwork directing the flow of water to the new sump plenum. Two banks of screen modules were installed in the annular space between the secondary shield wall and the containment wall on both the east and west sides of the sump. In addition, several miscellaneous pieces of equipment were relocated to accommodate the area for the new strainer.

The cartridge cassette design provides for opposing grids of deep pockets located on the horizontal axis that maximize effective screen surface area within the allowable space. The pockets are made of perforated stainless steel plates. The pocket design leads to favorable conditions for the water flow; the water passes through the volume of each cavity in five directions. This shortens the water flow path through the debris bed and minimizes the penetrating velocities and the associated head loss.

3.j.2 Related Modifications

See sections 2 and 3.j.1.

3.k Sump Structural Analysis

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 Requested Information Item 2(d)(vii). That is, provide 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 back-flushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.**

3.k.1 Design Inputs, Design Codes, Loads, and Load Combinations

The sump strainer modules were structurally qualified using finite element software. Stresses due to normal and upset loads were limited to American Institute of Steel Construction (AISC) allowables when compared to yield and ultimate material strength. Increased allowable stresses were used for faulted loads. Local deflections were checked in members to ensure that no openings greater than 1/16" would occur.

The sump strainer modules are floor-mounted and connected to the plenum with a common duct. Struts have been added to the screens to resist lateral loads such as seismic and water sloshing. The sump plenum with internal divider plate and screen is fabricated from stainless steel. Screened openings at the bottoms of the plenum walls are provided to allow water on the containment floor to enter the sump for leakage detection purposes. Two removable access panels are provided on the roof of the plenum to allow for equipment removal. Handrails are provided around the perimeter of the plenum roof and access ladder on the south plenum wall to allow for its use as a work platform.

The following provides the design inputs and loads used in the qualification of the structures. Material properties are summarized in Table 3.k.1-1, 3.k.1-2, and 3.k.1-3 (F_y = specified minimum yield strength, F_u = specified minimum tensile strength, E = modulus of elasticity, and α = average coefficient of thermal expansion between 20°C and the temperature).

Table 3.k.1-1 SA 240 Type 304 Plate

Temperature °F	F_y (ksi)	F_u (ksi)	E ($X10^6$ psi)	α ($X10^{-6}$ in/in/°F)
70	30.0	75.0	28.3	8.5
100	30.0	75.0	28.1	8.6
150	26.7	73.0	27.8	8.8
200	25.0	71.0	27.5	8.9
250	23.6	68.6	27.25	9.1
300	22.4	66.2	27.0	9.2

Table 3.k.1-2 SA-240 Type 30L Plate

Temperature °F	F_y (ksi)	F_u (ksi)	E ($X10^6$ psi)	α ($X10^{-6}$ in/in/°F)
70	25.0	70.0	28.3	8.5
100	25.0	70.0	28.1	8.6
150	22.7	68.1	27.8	8.8
200	21.4	66.1	27.5	8.9
250	20.2	63.7	27.25	9.1
300	19.2	61.2	27.0	9.2

Table 3.k.1-3 SA-36 Carbon Steel

Temperature °F	F_y (ksi)	F_u (ksi)	E ($X10^6$ psi)	α ($X10^{-6}$ in/in/°F)
70	36.0	58.0	29.5	6.4
100	36.0	58.0	29.338	6.5
150	33.8	58.0	29.07	6.6
200	33.0	58.0	28.8	6.7
250	32.4	58.0	28.55	6.8
300	31.8	58.0	28.3	6.9

Design temperatures for the sump structures are:

- Minimum sump water temperature during recirculation = 60°F
- Maximum sump water temperature during recirculation = 233°F
- Maximum containment air temperature, Normal = 120°F
- Maximum containment air temperature, accident = 285°F
- Ambient temperature during installation = 80°F

The differential pressure loading (Δp loads) are limited to 2.65 psi (pending installation of plenum access door/hatch stiffeners in 2R19).

The design codes are as follows:

Design Codes

Input Document	Description of Input
ANO-2 Specification APL-C-2501, Rev. 3, Earthquake Resistant Design of Structures and/or Components Located in the ANO-2 Reactor Building	Seismic response spectra for the sump screen structure.
AISC, "Manual of Steel Construction, Allowable Stress Design," 7th Edition	Provided allowable stresses for normal and upset conditions. Faulted stresses were limited to the following: $0.90 \cdot F_y$ for tension and bending $0.50 \cdot F_y$ for shear
2004 ASME Boiler and Pressure Vessel Code, Section II, Part D	Provided yield and ultimate stresses for materials used based on design temperature for each load case.
ANO Design Guide, SES-18, Rev. 1, "Concrete Anchor Bolt Design Criteria"	Provided allowable anchor bolt loads.

The following list provides major source qualification documents for this calculation:

Input Document	Description of Input
ANO-2 Specification APL-C-2501, Rev. 3, Earthquake Resistant Design of Structures and/or Components Located in the ANO-2 reactor building	Seismic response spectra for the sump screen structure.
AISC, "Manual of Steel Construction, Allowable Stress Design," 7th Edition	Provided allowable stresses for normal and upset conditions. Faulted stresses were limited to the following: $0.90 \cdot F_y$ for tension and bending $0.50 \cdot F_y$ for shear
2004 ASME Boiler and Pressure Vessel Code, Section III; Appendices	Provided yield and ultimate stresses for materials used based on design temperature for each load case.
ANO Design Guide, SES-18, Rev. 2, "Concrete Anchor Bolt Design Criteria"	Provided allowable anchor bolt loads.

The following load combinations were used for the sump screen structure:

Load Case	Temperature (°F)	Load Combination	Load Category	Stress Limit Factor
1	284	DL	NORMAL	1
2	120	DL+ E	UPSET	1
3	284	DL+ E'	FAULTED	1.5
4	255	DL+ E' + SLOSH	FAULTED	1.5
5	60-255	DL+ DL_D + E' + Δp + SLOSH	FAULTED	1.5
6	80-87	DL + SHLD	NORMAL	1

Nomenclature:

DL	Dead Load
E	Operating Basis Earthquake (OBE)
E'	Design Basis Earthquake (DBE)
SLOSH	Water sloshing due to E'
Δp	Pressure differential across the screen
DL_D	Debris Load
SHLD	Temporary shielding (outages)

OBE and DBE loads were determined using site response spectra for the appropriate elevation. In addition to these load cases, the effects of temperature, differential seismic movement, hydrodynamic water masses, and buoyancy were addressed in the calculation.

3.k.2 <u>Structural Qualification Results</u>
From the results of the analysis performed, it is concluded the bracing and anchorage for the strainers is structurally adequate. Due to the added braces, seismic stresses are approximately half the allowable limits for the strainer structure. Additionally, the overall displacements of the strainers subjected to accident and seismic loading have been shown to be less than 1/16" inch, and therefore, it is concluded that no greater than 1/16" gaps would occur between the strainer/filter components.

3.k.3 <u>Dynamic Effects</u>
Calculations conclude that the identified high-energy line break concerns have been evaluated and found acceptable. There were no credible pipe whip effects to the sump. See section 3.k.1 for additional evaluations performed for dynamic effects.

3.k.4 <u>Back-flushing</u>
A back-flushing strategy was not credited for ANO-2.

3.l <u>Upstream Effects</u>

The objective of the upstream effects assessment is to evaluate the flow paths 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, "Requested Information," Item 2(d)(iv) including 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 flow paths.

1. **Summarize the evaluation of the flow paths from the postulated break locations and containment spray wash-down 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 was evaluated, including likelihood of blockage and amount of expected holdup.**

3.I.1 Choke Points

The flow paths from the postulated breaks are from the SG compartments into the basement region of the reactor building outside of the D-rings and into the sump strainer. CSS washdown would fall through gratings to the basement from areas inside and outside the SG compartments. The refueling canal reactor cavity drainage paths have been evaluated for potential debris blockage. Spray flow falling into the refueling canal drains to the basement through one of the two 8" drains lines discussed in section 3.I.2. The reactor cavity drains through a 10 inch drain line with a check to prevent backflow into the cavity. As discussed in section 3.I.2, upon removal of the check valve screen, no choke point will exist in the reactor cavity drain line. There are no curbs on the containment floor and no credit has been taken for floor drains. Upon implementation of the minor modification identified in 3.I.2, no choke points will exists in the ANO-2 containment.

3.I.2 Choke Point Mitigation

The refueling canal has two deep end portions, each of which is drained by a single 8" drain that is flush with the floor with a metal grate type cover over the drain opening. While obstruction of this drain path was not considered likely, a modification to the drain cover will be installed during the 2R19 refueling outage to increase the size of the drain cover to provide additional margin for potential debris loading while still maintaining drainage from the refueling canal. The reactor cavity drain design is also being changed to address the potential for blockage of the current flow path which is through a screened check valve. These actions will provide further assurance that upstream effects do not impair the containment level and associated sump screen head loss margin.

3.I.3 Water Holdup

No curbs and/or debris interceptors are present in containment.

3.I.4 Reactor/Refueling Cavity Drain Blockage

The refueling canal drain flow rate was determined based on CSS flow rates and the refueling canal area in proportion to the containment area. The head loss for the refueling canal drains was determined using standard hydraulic analysis methods for the maximum drain flow rate. The water holdup in the refueling canal is 4310 gallons in the east deep end and 2270 gallons in the west deep end.

3.m Downstream Effects - Components and Systems

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 2004-02, "Requested Information," 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 by explaining 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 flow paths 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. Also, provide

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, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191", with accompanying NRC SE) briefly summarize the application of the methods.**
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.**

3.m.1 <u>NRC-Approved Methods</u>
The approved methodology as documented in WCAP-16406-P and the accompanying SE is being utilized for the downstream effects analysis which is still in progress. Adverse blockage of downstream components has been evaluated by considering opening or gap sizes for components compared to the extremely fine (1/16") screen mesh size used in the sump strainer. Blockage and wear concerns are being evaluated, and preliminary results indicate no problems requiring additional modification to the plant.

3.m.2 <u>Downstream Evaluations</u>
Analysis to evaluate downstream effects is currently in progress. However, preliminary results show no unacceptable conclusions for evaluated components.

3.m.3 <u>Design/Operational Changes</u>
Although analysis of downstream effects is in progress there are neither design nor operational changes anticipated. This conclusion is based upon analysis per WCAP-16406-P prior to the NRC's SE of that document and draft results from the ongoing revision to that analysis.

3.n <u>Downstream Effects - Fuel and Vessel</u>
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, "Evaluation of Long Term Cooling Considering Particulate and Chemical Debris in the Recirculation Fluid"), as modified by NRC comments on that document. Provide a basis for any exceptions. Briefly summarize the application of methods. Indicate where the WCAP methods were not used or exceptions were taken, and summarize the evaluation of those areas.**

3.n.1 <u>In-vessel Effects</u>
The effects analysis for fuel and reactor vessel flow paths is in progress at this time.

3.o <u>Chemical Effects</u>
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. **Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425).**

2.1 Sufficient 'Clean' Strainer Area

i. 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.

2.2 Debris Bed Formation

i. 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.

2.3 Plant Specific Materials and Buffers

i. 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.

2.4 Approach to Determine Chemical Source Term (Decision Point)

i. Licensees should identify the vendor who performed plant-specific chemical effects testing.

2.5 Separate Effects Decision (Decision Point)

i. State which method of addressing plant-specific chemical effects is used.

2.6 AECL Model

2.7 WCAP Base Model

i. For licensees proceeding from block 7 to diamond 10 in the Figure 1 flow chart [in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425)], 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.

ii. List the type (e.g., aluminum oxyhydroxide (AlOOH)) and amount of predicted plant-specific precipitates.

2.8 WCAP Refinements: State whether refinements to WCAP-16530-NP were utilized in the chemical effects analysis.

2.9 Solubility of Phosphates, Silicates and Aluminum Alloys

i. Licensees should clearly identify any refinements (plant-specific inputs) to the base WCAP-16530 model and justify why the plant-specific refinement is valid.

ii. 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.

iii. **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.**

iv. **Licensees should list the type (e.g., AlOOH) and amount of predicted plant specific precipitates.**

2.10 Precipitate Generation (Decision Point)

i. **State whether precipitates are formed by chemical injection into a flowing test loop or whether the precipitates are formed in a separate mixing tank.**

2.11 Chemical Injection into the Loop

i. **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.**

ii. **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.**

iii. **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).**

2.12 Pre-Mix in Tank

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

2.13 Technical Approach to Debris Transport (Decision Point)

i. **State whether near-field settlement is credited or not.**

2.14 Integrated Head Loss Test with Near-Field Settlement Credit

i. **Licensees should provide the one-hour or two-hour precipitate settlement values measured within 24 hours of head loss testing.**

ii. **Licensees should provide a best estimate of the amount of surrogate chemical debris that settles away from the strainer during the test.**

2.15 Head Loss Testing Without Near-Field Settlement Credit

i. **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.**

ii. **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).**

2.16 Test Termination Criteria

i. **Provide the test termination criteria.**

2.17 Data Analysis:

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

ii. **Licensees should explain any extrapolation methods used for data analysis.**

2.18 Integral Generation (Alion)

2.19 Tank Scaling/Bed Formation

- **i. Explain how scaling factors for the test facilities are representative or conservative relative to plant-specific values.**
- **ii. Explain how bed formation is representative of that expected for the size of materials and debris that is formed in the plant specific evaluation.**

2.20 Tank Transport

- **i. Explain how the transport of chemicals and debris in the testing facility is representative or conservative with regard to the expected flow and transport in the plant-specific conditions.**

2.21 30-Day Integrated Head Loss Test

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

2.22 Data Analysis Bump-Up Factor

- **i. 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.**

3.o.1 Evaluation Results

The existing chemical buffer, TSP, is being replaced with NaTB during the upcoming 2R19 refueling outage (spring 2008). By replacing the chemical buffer with NaTB, the only potential precipitate types are aluminum based. The effects of this planned modification have been factored into testing which shows a very limited amount of precipitates or chemical effects are present in the post-LOCA environment, and that those effects are only present after the containment sump has cooled to near ambient temperatures.

The ANO-2 approach to chemical precipitate analysis is two-fold. Testing has been conducted with the strainer test flume by Fauske and Associates to determine the combined effects of chemical precipitates and insulation debris. Testing has also been conducted by Westinghouse in an autoclave to assist in refining the quantity and timing of chemical precipitates that may form.

The results of the combined debris and chemical precipitate tests indicate that for two-train full flow unacceptably high head loss may be develop if the chemical loading is assumed to be present when sump temperatures are elevated (and sump head loss margin is most limited). However, the autoclave test results show that the chemical precipitates result later in the accident response period when the sump temperatures are reduced.

The occurrence of chemical precipitates after the sump temperatures are lowered is significant since considerable NPSH margin will be present with lower sump temperatures due to the vapor pressure difference between the sub-cooled water and reactor building pressure. Since credit is not taken for increased containment pressure following a LOCA when determining available NPSH, the vapor pressure margin is assumed to be zero when sump temperatures are at or above 206.6°F (the saturation temperature at the minimum TS-allowed containment pressure of 13.2 psia). Below this temperature the difference in vapor pressure adds substantial NPSH margin such that the principal head loss limitations are related to the level inside the strainer needed to protect vortex suppression as noted in section 3.f.7.

The Westinghouse autoclave test results show that chemical precipitates develop after sump temperatures are reduced and level limitations inside the strainer plenum are the limiting term. The chemical effects tests show acceptable results relative to this limit.

3.o.2.1.i Sufficient 'Clean' Strainer Area
A simplified chemical effects analysis was not applied.

3.o.2.2.i Debris Bed Formation
Debris bed formation is addressed in section 3.e.5.

3.o.2.3.i Plant-Specific Materials and Buffers
The ANO-2 analysis was performed based on the pending buffer change to NaTB. The only chemical precipitate predicted by the WCAP-16530 model is associated with aluminum (sodium aluminum silicate); therefore, the potential formation of aluminum precipitates as refined by autoclave testing is being addressed.

The pH evaluated for ANO-2 chemical effects is from a maximum of 8.0 to a minimum of 7.0. These limits are supported by analysis as limitations for the post-LOCA environment. Published data, as well as results of autoclave testing, show that aluminum corrosion is affected by pH, with corrosion rates increasing as pH increases. On the other hand, aluminum solubility decreases significantly as pH is lowered. Temperatures produce similar impacts on aluminum corrosion (higher at high temperatures) and solubility (lower at low temperatures).

Since the WCAP-16530 model does not assume any solubility of aluminum it was conservatively modeled with the maximum pH and the maximum equipment qualification (EQ) temperature profile, since those inputs produce the largest amount of predicted aluminum corrosion and therefore the greatest amount of precipitates.

The integrated tests run in the autoclave required more complex inputs due to the conflict created by trying to conservatively maximize both aluminum corrosion, which requires high pH and temperatures, and maximize precipitation (or minimize solubility), which requires minimum pH and temperatures. The allowed pressure drop across the sump strainer is limited by NPSH margin conditions at elevated temperatures and by strainer internal level considerations needed to prevent vortexing at reduced temperatures. The autoclave tests were run with the maximum EQ temperature profile to produce the greatest aluminum corrosion, except near the end of the test when the temperature was reduced to near ambient conditions (approximately 80°F) to lower solubility.

The sump pH can range between 7.0 and 8.0. The autoclave test was run at the higher pH of 8.0 to maximize aluminum corrosion. To determine the impact of possible reductions in sump pH due to acids generated in the post-LOCA environment, autoclave samples were tested for filterability effects at the test pH of 8, as well as samples that were buffered to lower pH values of 7.5 and 7.0. This maximized the potential for aluminum corrosion while still allowing comparison of the effects of possible pH reduction at various temperatures on the amount of precipitate formed.

Samples were drawn for chemical analysis and filtration effects testing to determine if chemical precipitates existed at time periods of one day, two days, three days, five days, and seven days. Earlier autoclave tests run for 30 days indicated that the aluminum corrosion occurred during elevated temperature conditions with data in the lower temperature region showing no continued release of this material. The containment sump temperatures after five days are significantly sub-cooled (even with single train response), therefore the autoclave temperature profile was adjusted to ramp temperatures down to approximately 80°F over the last two days (i.e., after the day-five samples) to provide a somewhat gradual temperature reduction, but still significantly accelerated compared to the three-plus weeks associated with the 30-day mission time.

Containment spray is conservatively assumed to remain in operation for the full 30-day mission time. Emergency operating procedure guidance is provided for securing spray upon meeting specified conditions. While these conditions are highly likely to be met well before the end of the 30-day period, no credit is taken for securing spray or even reducing to single train operation for sump analysis. Materials evaluated for chemical response were based on the inputs to the WCAP-16530 model.

3.o.2.4.i Chemical Source Term
Westinghouse performed unit-specific autoclave testing. Chemical effects head loss testing was performed by Fauske and Associates.

3.o.2.5.i Separate Effects Decision
See section 3.o.1

3.o.2.6 AECL Model
Entergy used CCI as the strainer vendor.

3.o.2.7.i WCAP Base Model
The base model of WCAP-16530 was used to predict the amount of chemical precipitate produced for ANO-2. However, as noted in section 3.o.1, the results of autoclave testing were also used to determine when this chemical precipitate loading would occur. Strainer testing was conducted that bounds the full WCAP-16530 predicted chemical precipitate loading. The autoclave test results establish that the chemical loading does not occur early in the accident response period when pump NPSH margin is the limiting factor for strainer head loss, but after sump temperatures have been sub-cooled. Therefore, the strainer head loss associated with the WCAP-16530 chemicals is compared against the strainer head loss margin for vortex suppression, which is limiting at lower temperatures as noted in 3.f.7.

3.o.2.7.ii WCAP Base Model Precipitates
The predicted chemical precipitate using the WCAP-16530 base model is 60 kg of sodium aluminum silicate ($NaAlSi_3O_8$).

3.o.2.8.i WCAP Refinements
The refinements provided in the WCAP were not utilized.

3.o.2.9.i Solubility Refinements

Refinements to the overall approach from a simple direct application of the base WCAP-16530 predicted chemical precipitates have been applied. The basis for the refinements is to reduce the very significant conservatism present in the WCAP-16530 model with regard to the timing of precipitate formation. The model is overly conservative due to ignoring solubility affects. As an example, the WCAP-16530 model predicts in the case of ANO-2 that over one third of the chemical precipitates will have been formed in the first 24 hours and almost half within the first 48 hours when temperatures start to sub-cool. Given the very low total aluminum mass available in the ANO-2 containment, the aluminum released after 48 hours amounts to a concentration of approximately one ppm, which is below published solubility limits for this material. While it is true that aluminum corrosion rates will be high during the elevated temperatures, this same condition also support higher aluminum solubility, with much higher concentrations supported than the values that would exist in ANO-2.

The timing of the chemical precipitate formation is the principal refinement that is being applied based on testing conducted for ANO site-specific conditions. The formation of precipitates after the sump temperature has decreased is a more realistic condition that is supported by integrated site specific test results. This shift in precipitate formation timing is significant due to the additional NPSH margin that exists with a sub-cooled sump.

3.o.2.9.ii Crediting Aluminum Inhibition

This is not applicable since credit was not taken for aluminum inhibition in the WCAP-16530 base model used to predict aluminum precipitates.

During the autoclave testing, calcium and silicon concentrations were lower than the values predicted by the WCAP-16530-NP model. It should be noted that the silicon concentrations remained below 50 ppm so that the silica in solution could not be used to lower the aluminum corrosion rate predictions.

3.o.2.9.iii Solubility Credit

Solubility credit is being taken for the primary purpose of the timing of chemical precipitate formation. The series of autoclave tests conducted by Westinghouse establishes that chemical precipitate formation is only occurring after the sump temperatures have decreased to ambient conditions. The tests used upper bounding values to conservatively maximize aluminum corrosion and also simulated conservative reductions in those conditions to maximize precipitate formation. The testing included simulation of pH buffering at various temperatures throughout the test period to ensure that the impact of potential pH reduction occurring at any time during the post-accident mission time are addressed. Since it is not possible to have both the maximum and minimum conditions of temperature and pH occurring simultaneously, it is appropriate to consider the impact of variation of these variables on chemical effects formation.

The overall chemical effects evaluation remains significantly conservative with the composite head loss analysis that considers both debris and chemical effects being even more conservative. The overall analysis includes a large number of stacked conservative inputs, which are assumed concurrently. ANO-2 has a very small potential source term for aluminum corrosion. Autoclave tests have produced aluminum concentrations of only one ppm, while the WCAP-16530 model predicts less than 2.5 ppm after 30 days. These very low concentrations provide ample support for solubility at elevated temperatures, with multiple integrated tests confirming this conclusion. Sources of conservatism relative to the debris generation and head loss testing have been noted previously in section 3.f.8. In addition to those conservative approaches, the composite evaluation of margin with chemical effects contains additional conservatisms, including the following:

- Most aluminum corrosion occurs at elevated temperatures. Autoclave and WCAP-16530 model inputs for post-accident temperature profiles are based upon an assumed single failure of a train of equipment in order to achieve the most conservative (i.e., highest) temperature profile. Strainer testing is based upon assumptions of two trains of HPSI and CSS in service at maximum flow. Reduced time at elevated temperatures would result from modeling two-train accident response, or if single train flow through the sump were assumed, the head loss would be significantly reduced by the lower flow rate.

- Sump flows assumed for chemical effects head loss testing are not reduced from initial peak values. Securing of one or both spray pumps as well as one train of HPSI is a reasonably expected operator response prior to reaching near ambient temperature conditions, but is not credited. Therefore maximum flows continue to be evaluated.

- Chemical surrogates were added in the test flume directly in front of the strainer cartridges and stirring of the water in the test flume was performed after addition to maintain the precipitates in solution to maximize transport into the strainer. The assumed full transport of the chemical precipitate material as well as mixing to minimize near-field settling type behavior is believed to be a conservative treatment of the material.

- Pump flows for both NPSH considerations and sump flow head losses are all taken at conservative maximum bounding values including potential instrument errors.

3.o.2.9.iv Predicted Plant Specific Precipitates
The approximate precipitate formed over the 30 days is 60 kg of sodium aluminum silicate ($NaAlSi_3O_8$).

Using TSP as a buffering agent produces more chemical precipitates than the NaTB buffering agent. Particularly, calcium-phosphate is formed using TSP because of the reaction between the calcium-silicate insulation and the phosphate in TSP. To avoid this precipitate formation, the buffer is being changed from TSP to NaTB during the spring 2008 outage (2R19).

3.o.2.10.i Precipitate Generation
Precipitates for strainer head loss testing were formed outside the test facility loop in accordance with guidance with the WCAP documents and adjusted settling criteria defined by the SE.

3.o.2.11.i Chemical Injection Precipitate Volume
The one hour settled volumes for sodium aluminum silicate precipitates were 8.5-9 ml for a 10 ml sample which remained cloudy. Preparation was in accordance with WCAP-16530.

3.o.2.11.ii Injected Chemicals
Plant specific chemical injection tests were not conducted versus preparation per WCAP-16530 guidance.

3.o.2.11.iii Added Precipitate
Chemical effects testing included addition of a scaled amount of aluminum precipitate that bounds the 100% value predicted by the base WCAP methodology (i.e., 60 kg).

3.o.2.12.i Pre-Mix in Tank

No exceptions were taken to the procedure recommended for surrogate precipitate formation in WCAP-16530.

3.o.2.13.i Settlement

Near-field settlement was not credited in the strainer test facility. Stirring of the flowing test flume water was performed as-needed to achieve transport of the debris into the strainer cartridges. Acceptance was based on visual observation through the clear panels of the flume to confirm that only trace amounts of particulates or isolated paint chips remained outside the strainer.

Chemical precipitates were poured into a flowing test loop and stirring was used to maintain precipitates in suspension similar to the treatment of particulate debris. Since visual observation was not a suitable indicator for settling of chemical precipitates, when continued stirring no longer produced any evident impact on head loss, the chemical precipitate was determined to be sufficiently transported to the strainer cartridges.

3.o.2.14.i Near-Field Settlement Values

This is not applicable since near-field settling was not credited.

3.o.2.14.ii Surrogate Chemical Debris Settlement

Near field settlement was not credited during the strainer testing.

3.o.2.15.i Debris/Precipitate Without Near Field Settlement Credit

See section 3.o.2.13.i.

3.o.2.15.ii Precipitate Values Without Near Field Settlement Credit

The one hour settled volumes for sodium aluminum silicate precipitates were 8.5-9 ml for a 10 ml sample which remained cloudy. Testing was performed within 24 hours of precipitate mixing with preparation in accordance with WCAP-16530.

3.o.2.16.i Test Termination Criteria

See section 3.f.4 for debris-only strainer testing and duration. The chemical precipitate head loss testing for ANO-2 credits two tests to bound the two break conditions of interest (surge line and hot leg). The surge line break produces the most fiber debris but a limited amount of calcium-silicate insulation due to the smaller break size. The ANO-1 debris loading bounds this break, therefore credit is taken for the ANO-1 chemical effects head loss test (up through the chemical addition of 25% of ANO-1 total chemical) which bounds the amount of chemical precipitate generated by ANO-2. This head loss was measured at 110 gpm test facility flow rate, which is 30% greater than the 84 gpm test flow rate that is equivalent to the ANO-2 velocity. The chemical precipitate debris bed remained responsive to flow changes, as evidenced by the series of flow adjustments done at the 25% chemical loading. Therefore, the actual ANO-2 head loss for this condition is projected to be at least 30% lower than the measured value. The credited data point was already at stable head loss readings, but the use of the as-measured head loss of approximately 25 inches at the elevated flow provides ample conservative margin to address any minor deviations in head loss associated with test termination criteria for this test.

The ANO-2 hot leg break does not produce any fiber debris loading beyond latent fiber but releases a significant volume of calcium-silicate insulation. A plant-specific chemical effects test provides a bounding debris and chemical loading. The maximum head loss for this condition was approximately 13 inches based on a peak value with the head loss trend subsequently declining. Since the surge line break chemical effects head loss significantly exceeds this value, any minor variation in the termination criteria for this test is bounded by the more limiting results of the surge line break.

3.o.2.17.i Pressure Drop Curve as a Function of Time

Pressure drop curves will be provided in the final submittal. Test documents are still in draft format at this time.

3.o.2.17.ii Extrapolation Methods

Since the peak chemical loading is expected to occur when temperatures are lowered to near ambient, no viscosity corrections are applicable. No extrapolation techniques were applied.

3.o.2.18.i Integral Generation

Entergy did not utilize Alion methodology.

3.o.2.19.i Scaling Factors

The test facility scaling factors were determined from the ratio of surface area of strainer in the test facility to surface area of strainer installed in the plant (minus area allowance for foreign material debris blockage of 200 ft^2). The tested strainer cartridges are identical to those installed at ANO-2, other than the total height of the assembly (i.e., test facility module is 10 strainer pockets tall compared to 13 pockets in the ANO-2 strainers), therefore the only scaling of the strainer was associated with the area of the two cartridges in the test facility compared to the area of those installed in the plant. Since credit was not taken for near-field settling, the flow through the test facility was also scaled based on the strainer area ratio, to establish a velocity through the strainer openings consistent with what would be present at the installed strainer. The debris and chemical loading was determined using this same scaling ratio.

3.o.2.19.ii Bed Formation

The debris bed formation is described in section 3.f, with a non-prototypic conservative bias used to create a debris bed to generate maximum head loss.

3.o.2.20.i Tank Transport

Since near-field settling was not credited, the transport characteristics of the test facility are not applicable. Debris was added in sequential steps into flowing water with stirring used to maintain material in suspension until it was transported into the strainer cartridges.

3.o.2.21.i 30-Day Integrated Head Loss Test Conditions

Test conditions for the integrated test included the full debris bed loading predicted by the debris generation calculation. Flows were evaluated at bounding maximum values for two-train operation. Chemical precipitate loading equal to greater than 100% of the total mass of precipitates was tested.

The test duration was not 30 days; however, the test results are conservatively applied to address any uncertainty in maximum head loss for a 30 day period. The limiting test was conducted at flows approximately 30% higher than the maximum two-train flow through the sump strainer. The test data is used for comparison against acceptance values without correction for this larger flow condition. The test head loss had reached a relatively stable condition after 20 hours of operation following the last change in chemical loading. The debris and chemical loading in the test facility also exceeded the amounts predicted for the break being evaluated.

The test results provide bounding and conservative values for potential strainer head losses both with and without chemical effects. This is based on conservative application of each of the test inputs. An extensive array of tests were conducted to provide an accurate understanding of the head loss characteristics of various types and quantities of debris as well as of the chemical precipitates that may form in a post-LOCA environment. The combined effects of these materials were tested in a conservative manner with the most limiting results used for acceptance.

3.o.2.21.ii Pressure Drop Curve as a Function of Time
Pressure drop curves will be provided in the final submittal.

3.o.2.22.i Bump-Up Factor
Entergy did not use Alion methodology.

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 2004-02, "Requested Information," Item 2.(e) regarding changes to the plant licensing basis. That is, provide 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 generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10CFR50.59 evaluation for the change to the licensing basis.

3.p Licensing Basis
The TSP chemical buffer will be replaced with a NaTB buffer to support the chemical effects analysis. This change requires a license amendment to the ANO-2 TS which has been submitted in correspondence dated October 5, 2007 (2CAN100703), and is currently under NRC review. Additional changes will be made to the ANO-2 Safety Analysis Report within 60 days of completion of 2R19.

Attachment 3

0CAN020803

List of Regulatory Commitments

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check One) ONE-TIME ACTION	CONTINUING COMPLIANCE	SCHEDULED COMPLETION DATE (If Required)
Provide final supplemental response	X		July 30, 2008 for ANO-1 90 days after completion of 2R19 for ANO-2
A license amendment will be submitted for ANO-1 NaOH tank concentration change.	X		Following completion of analysis to support chemical effects testing